National Marine Fisheries Service
Endangered Species Act Section 7 Consultation Biological Opinion

Agencies:	The United States Navy (U.S. Navy) and NOAA's National Marine Fisheries Service (NMFS)
Activities Considered:	The U.S. Navy's military readiness activities on the Northwest Training Range Complex (NWTRC); and NMFS's promulgation of regulations pursuant to the Marine Mammal Protection Act (MMPA) regarding U.S. Navy's "take" of marine mammals incidental to military readiness activities on the NWTRC for a five-year period (November 2010 to November 2015); and NMFS's issuance of a Letter of Authorization for the U.S. Navy to "take" marine mammals incidental to the military readiness activities on the NWTRC (November 2012 to November 2015).
Consultation Conducted by:	NMFS' Office of Protected Resources, Endangered Species Act Interagency Cooperation Division
Approved by:	Donna S. Wieting Director, Office of Protected Resources
Date:	AUG 0 1 2014

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1536(a)(2)) requires each federal agency to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action "may affect" a protected species, that agency is required to consult formally with the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR § 402.14(a)). Federal agencies are exempt from this general requirement if they have concluded that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS or the U.S. Fish and Wildlife Service concur with that conclusion (50 CFR § 402.14(b)).

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BIOLOGICAL OPINION

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List of Acronyms

A-A Air-to-Air
A-G Air-to-Ground
A-S Air-to-Surface
AAMEX Air-to-Air Missile Exercise
AAW Anti-Air Warfare
ACM Air Combat Maneuvering
AMW Amphibious Warfare
ASUW Anti-Surface Warfare
ASW Anti-Submarine Warfare
ATC air traffic control
BA Biological Assessment
BE Biological Evaluation
BMP Best Management Practice
BO Biological Opinion
BOMBEX Bombing Exercise
BUD/S Basic Underwater Demolition/SEAL
CNO Chief of Naval Operations
CNRNW Commander, Navy Region Northwest
COMNAVSURFPAC Commander, Naval Surface Force, U.S. Pacific fleet
COMPACFLT Commander, U.S. Pacific Fleet
COMPTUEX Composite Training Unit Exercise
COMSUBPAC Commander, Submarine Force U.S. Pacific Fleet
CPF Commander, Pacific Fleet
CPRW-10 Commander, Patrol and Reconnaissance Wing TEN
CSG Carrier Strike Group
CV Coefficient of Variation
dB Decibel
dB/km Decibel Per Kilometer
DICASS Directional Command Activated Sonobuoy System
DIFAR Directional Frequency and Ranging
DOC Department of Commerce
DoD Department of Defense
DoN Department of Navy
DOPAA Description of Proposed Action and Alternatives
DPU Distinct Population Unit
(2) Environmental Assessment
EC Electronic Combat
EER Extended Echo Ranging
EEZ Exclusive Economic Zone
EIS Environmental Impact Statement
EO Executive Order
EOD Explosive Ordnance Disposal
EODMU-11 Explosive Ordnance Disposal Mobile Unit Eleven
ESA Endangered Species Act
ESG Expeditionary Strike Group
ESU Evolutionary Significant Unit
EXTORP Running Torpedo Exercise
°F Degrees Fahrenheit
FONSI Finding of No Significant Impact
ft Feet
ft^2 Square Feet
GUNEX Gun Exercise
HARMEX High-Speed Anti-Radiation Missile Exercise
HE High Explosive
IEER Improved Extended Echo Ranging
INRMP Integrated Natural Resources Management Plan
JTFEX Joint Task Force Exercise
kHz Kilohertz
Km Kilometer
kts Knots
lb Pound
LMRS Long-term Mine Reconnaissance System
LOA Letter of Authorization
m Meter
m^2 Square Meter
MFA Mid-Frequency Active
min Minute
MINEX Mine Laying Exercise
MIW Mine Warfare
MMA Multi-mission Maritime Aircraft
MMPA Marine Mammal Protection Act
ms Millisecond

MSL	Mean Sea Level
NAVFAC NW	Naval Facilities Engineering Command Northwest
NAVFAC PAC	Naval Facilities Engineering Command Pacific
NAVSEA	Naval Sea Systems Command
NAVSPECWARCOM	Naval Special Warfare Command
NEPA	National Environmental Policy Act
NEW	Net Explosive Weight
Nm	nautical miles
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NOTAM	Notice to Airmen
NUWC	Naval Undersea Warfare Center
OEIS	Overseas Environmental Impact Statement
OPNAV	Office of the Chief of Naval Operations
PACFLT	Pacific Fleet
PACNW	Pacific Northwest
pH	Alkalinity
PTS	Permanent Threshold Shift
PUTR	Portable Undersea Tracking Range
RDT&E	Research, Development, Test and Evaluation
RF	Radio Frequency
RHIB	Rigid Hull Inflatable Boats
RIMPAC	Rim of the Pacific Exercise
ROD	Record of Decision
S-A	Surface-to-Air
S-S	Surface-to-Surface
SAM	Surface-to-Air Missile
SAMEX	Surface to Air Missile Exercise
SAR	Search and Rescue
SBUs	Special Boat Units
SEAL	Sea, Air, Land
SINKEX	Sinking Exercise
SME	Subject Matter Experts
SONAR	Sound Navigation And Ranging
SOP	Standard Operating Procedure
SPAWAR	Space and Naval Warfare Systems
STW	Strike Warfare
SUA	Special-Use Airspace
SUBASE	Submarine Base
SURTASS	Surveillance Towed Array Sensor System
TORPEX	Torpedo Exercise
TRACKEX	Tracking Exercise
TTS	Temporary Threshold Shift
TM	Tympanic Membrane
UNDET	Underwater Detonation
USFF	United States Fleet Forces
USN	United States Navy
USW	Undersea Warfare
USWTR	Undersea Warfare Training Range

Glossary

Acoustics. The scientific study of sound, especially of its generation, transmission, and reception.

Active sonar. Detects objects by creating a sound pulse, or ping, that transmits through the water and reflects off the target, returning in the form of an echo. This is a two-way transmission (source to reflector to receiver).

Alert Area. Airspace which may contain a high volume of pilot training activities or an unusualtype of aerial activity, neither of which is hazardous to aircraft. Nonparticipating pilots are advised to be particularly alert when flying in these areas. All activities shall be conducted in accordance with applicable sections of Title 14 CFR, without waiver.

Alternative. A different method for accomplishing the Proposed Action. An alternative can consist of the same action in a different location, or a modification to the Proposed Action.

Ambient noise. The typical or persistent environmental background noise present in the ocean.

Anadromous. Species of fish that are born in freshwater, migrate to the ocean to grow into adults, and return to freshwater to spawn.

Anthropogenic noise. Noise related to, or produced by, human activities.

Antisubmarine warfare (ASW). Naval operations conducted against submarines, their supporting forces, and operating bases.

Baleen. In some whales (see Mysticete below), the parallel rows of fibrous plates that hang from the upper jaw and are used for filter feeding.

Bathymetry. The measurement of water depth at various places in a body of water; the information derived from such measurements.

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

Benthic. Referring to the bottom-dwelling community of organisms that creep, crawl, burrow, or attach themselves to either the sea bottom or such structures as ships, buoys, and wharf pilings (e.g., crabs, clams, worms).

Biologically important activities/behaviors. Those activities or behaviors essential to the continued existence of a species, such as migration, breeding/calving, or feeding.

Cetacean. An order of aquatic mammals such as whales, dolphins, and porpoises.

Critical Habitat. Critical habitat is defined in section 3 of the Endangered Species Act (ESA) as (1) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the ESA, on which are found those physical or biological features (i) essential to the conservation of the species and (ii) that may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species.

Cumulative impact. The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions.

Decibel (dB). A unit used to express the relative difference in power, usually between acoustic or electrical signals, equal to 10 times the common logarithm of the ratio of the two levels. Since the decibel scale is exponential and not linear, a 20-dB sound is 10 times louder than a 10-dB sound, a 30-dB sound is 100 times louder than a 10-dB sound.

Demersal. Living at or near the bottom of a waterbody, but having the capacity for active swimming. Term used particularly when describing various fish species.

Distinct population segment (DPS). A vertebrate population or group of populations that is discrete from other populations of the species and significant in relation to the entire species. The ESA provides for listing species, subspecies, or distinct population segments of vertebrate species.

Endangered species. Any species that is in danger of extinction throughout all or a significant portion of its range (ESA §3[6]).

Energy flux density level (EFDL). The energy traversing in a time interval over a small area perpendicular to the direction of the energy flow, divided by that time interval and by that area. EFDL is stated in dB re 1 μPa2-s for underwater sound.

Epifauna. Organisms living on the surface of the sediment/sea bed/substrate.

Essential fish habitat (EFH). Those waters and substrate that are defined within Fishery Management Plans for federally-managed fish species as necessary to fish for spawning, breeding, feeding, or growth to maturity.

Evolutionary Significant Unit (ESU). A stock that is reproductively isolated from other stocks of the same species and which represents an important part of the evolutionary legacy of the species. An ESU is treated as a species for purposes of listing under the ESA. NMFS uses this designation.

Exclusive Economic Zone (EEZ). A maritime zone adjacent to the territorial sea that may not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured.

Expended Materials. Those munitions, items, devices, equipment and materials which are uniquely military in nature, and are used and expended in the conduct of the military training mission, such as: sonobuoys, flares, chaff, drones, targets, bathymetry measuring devices and other instrumentation, communications devices, and items used as training substitutes. This definition may also include materials expended (such as propellants, weights, guidance wires) from items typically recovered, such as aerial target drones and practice torpedoes.

Federal Register. The official daily publication for actions taken by the Federal government, such as Rules, Proposed Rules, and Notices of Federal agencies and organizations, as well as Executive Orders and other Presidential documents.

Foreseeable. Lying within the range for which sound forecasts or predictions are possible; in the reasonably foreseeable future.

Frequency. Description of the rate of disturbance, or vibration, measured in cycles per second. Cycles per second are usually referred to as Hz, the unit of measure.

Harassment. As defined in this document, harassment is intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering.

High frequency. As defined in this document, frequencies greater than 10 kHz.

Hydrography. The characteristic features (e.g., flow, depth) of bodies of water.

Hydrophone. An underwater receiver used to detect the pressure change caused by sound in the water. That pressure is converted to electrical energy. It can then be translated to something that can be heard by the human ear. Sometimes the detected acoustic pressure is outside the human range of hearing.

Infauna. Animals living within the sediment.

Isobath. A line on a chart or map connecting points of equal depths; bathymetric contour.

Letter of authorization (LOA). The Marine Mammal Protection Act provides for a "small take authorization" (i.e., letter of authorization) for maritime activities, provided NMFS finds that the takings would be of small numbers (i.e., taking would have a negligible impact on that species or stock), would have no more than a negligible impact on those marine mammal species not listed as depleted, and would not have an unmitigable adverse impact on subsistence harvests of these species.

Level A harassment. Level A harassment includes any act that has the potential to injure a marine mammal or marine mammal stock in the wild. Injury is identified as the destruction or loss of biological tissue.

Level A harassment zone. Extends from an acoustic or impulsive source out to the distance and exposure at which the slightest amount of injury is predicted to occur. The acoustic exposure that produces the slightest degree of injury is therefore the threshold value defining the outermost limit of the Level A harassment zone.

Level B harassment. Level B harassment includes all actions that have the potential to disturb a marine mammal or marine mammal stock in the wild through the disruption of natural behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild.

Level B harassment zone. Begins just beyond the point of slightest injury and extends outward from that point. It includes all animals that may potentially experience Level B harassment. Physiological effects extend beyond the range of slightest injury to a point where slight temporary distortion of the most sensitive tissue occurs, but without destruction or loss of that tissue. The animals predicted to be in this zone experience Level B harassment by virtue of temporary impairment of sensory function (altered physiological function) that can disrupt behavior.

Low frequency. As defined in this document, frequencies less than 1 kilohertz (kHz).

Masking. The obscuring of sounds of interest by interfering sounds, generally at the same frequencies.

Mid-frequency. As defined in this document, frequencies between 1 and 10 kHz.

Military Operations Area (MOA). A Military Operations Area (MOA) is airspace established outside positive control area to separate/segregate certain nonhazardous military activities from IFR traffic and to identify for VFR traffic where these activities are conducted.

Mitigation measure. Measures that will minimize, avoid, rectify, reduce, eliminate, or compensate for significant environmental effects.

Munitions (Military). All ammunition products and components produced or used by or for the U.S. Department of Defense, or the U.S. Armed Services for national defense and security, including military munitions under the control of the Department of Defense, the U.S. Coast Guard, the U.S. Department of Energy, and the National Guard.

Mysticete. Any whale of the suborder Mysticeti having plates of whalebone (baleen plates) instead of teeth. Mysticetes are filter-feeding whales, also referred to as baleen whales, such as blue, fin, gray, and humpback whales.

Notice of intent (NOI). A written notice published in the Federal Register that announces the intent to prepare an EIS. Also provides information about a proposed federal action, alternatives, the scoping process, and points of contact within the lead federal agency regarding the EIS.

Odontocete. Any toothed whale (without baleen plates) of the suborder Odontoceti such as sperm whales, killer whales, dolphins, and porpoises.

Onset permanent threshold shift (onset PTS). PTS (defined below) is non-recoverable and, by definition, must result from the destruction of tissues within the auditory system. PTS therefore qualifies as an injury and is classified as Level A harassment under the wording of the Marine Mammal Protection Act. In this Opinion, the smallest amount of PTS (onset PTS) is taken to be the indicator for the smallest degree of injury that can be measured. The acoustic exposure associated with onset PTS is used to define the outer limit of the Level A harassment zone

Onset temporary threshold shift (onset TTS). TTS (defined below) is recoverable and is considered to result from the temporary, non-injurious distortion of hearing-related tissues. In the EIS/OEIS, the smallest measurable amount of TTS (onset TTS) is taken as

the best indicator for slight temporary sensory impairment. Because it is considered non-injurious, the acoustic exposure associated with onset TTS is used to define the outer limit of the portion of the Level B harassment 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, the potential for TTS qualifies as a Level B harassment that is mediated by physiological effects upon the auditory system.

Ordnance. Explosives, chemicals, pyrotechnics, and similar stores (e.g., bombs, guns and ammunition, flares, smoke, or napalm).

Passive sonar. Detects the sound created by an object (source) in the water. This is a one-way transmission of sound waves traveling through the water from the source to the receiver.

Pelagic. Pelagic is a broad term applied to species that inhabit the open, upper portion of marine waters rather than waters adjacent to land or near the sea floor.

Permanent threshold shift (PTS). Exposure to high-intensity sound may result in auditory effects such as noise induced threshold shift, or simply a threshold shift (TS). If the TS becomes a permanent condition, generally as a result of physical injury to the inner ear and hearing loss, it is known as PTS.

Physiological effect. Defined in the EIS/OEIS as a variation in an animal's physiology that results from an anthropogenic acoustic exposure and exceeds the normal daily variation in physiological function.

Ping. Pulse of sound created by a sonar.

Pinger. A pulse generator using underwater sound transmission to relay data such as subject location.

Pinniped. Any member of a suborder (Pinnipedia) of aquatic carnivorous mammals (i.e., seals and sea lions) with all four limbs modified into flippers.

Platform. A vessel, pier, barge, etc. from which test systems can be deployed.

Predation. A biological interaction where a predator organism feeds on another living organism or organisms known as prey. The act of predation results in the ecologically significant death of the prey.

Received level. The level of sound that arrives at the receiver, or listening device (hydrophone). The received level is the source level minus the transmission losses from the sound traveling through the water.

Record of Decision (ROD). A concise summary of the decision made by the project proponent (e.g., Navy) from the alternatives presented in the Final EIS. The ROD is published in the *Federal Register*.

Resonance. A phenomenon that exists when an object is vibrated at a frequency near its natural frequency of vibration – the particular frequency at which the object vibrates most readily. The size and geometry of an air cavity determine the frequency at which the cavity will resonate.

Restricted Area. Special use airspace designated under 14 CFR Part 73 within which the flight of aircraft, while not wholly prohibited, is subject to restriction.

Scoping. An early and open process with federal and state agencies and interested parties to identify possible alternatives and the significant issues to be addressed in an EIS.

Sonobuoy. A device launched from an aircraft to determine environmental conditions for determination of best search tactics, to communicate with friendly submarines, and to conduct search, localization, tracking, and, as required, attack of designated hostile platforms. Sonobuoys provide both a deployable acoustical signal source and reception of underwater signals of interest.

Sound Exposure Level (SEL). The logarithmic measure of the A-weighted , Sound Pressure Level squared and integrated over a stated period of time or event, relative to a reference sound pressure value. The units are the decibel (dBA). In practice the SEL normalized to a 1 second period was found to be extremely useful when comparing noise levels so this is now commonly used and also referred to as the Sound Exposure Level.

Sound Navigation and Ranging (Sonar). Any anthropogenic (man-made) or animal (e.g., bats, dolphins) system that uses transmitted acoustic signals and echo returns for navigation, communication, and determining position and bearing of a target. There are two broad types of anthropogenic sonar: active and passive.

Sound pressure level (SPL). A measure of the root-mean square, or "effective," sound pressure in decibels. SPL is expressed in dB re 1 μPa for underwater sound and dB re to 20 μPa for airborne sound.

Source level. The sound pressure level of an underwater sound as measured one meter from the source.

Special Use Airspace (SUA). Airspace of defined dimensions identified by an area on the surface of the earth wherein activities must be confined because of their nature, or wherein limitations are imposed upon aircraft operations that are not a part of those activities, or both.

Substrate. Any object or material upon which an organism grows or to which an organism is attached.

Tactical Sonar. A category of sonar emitting equipment that includes surface ship and submarine hull-mounted active sonars, sonobuoys, torpedoes, and helicopter dipping sonar.

Take. Defined under the MMPA as "harass, hunt, capture, kill or collect, or attempt to harass, hunt, capture, kill or collect."

Temporary threshold shift (TTS). Exposure to high-intensity sound may result in auditory effects such as noiseinduced threshold shift, or simply a threshold shift (TS). If the TS recovers after a few minutes, hours, or days it is known as TTS.

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 (ESA §3[20]).

Transmission loss. Energy losses that occur as the pressure wave, or sound, travels through the water. The associated wavefront diminishes due to the spreading of the sound over an increasingly larger volume and the absorption of some of the energy by water.

Warning Area. A nonregulatory warning area is airspace of defined dimensions designated over international waters that contains activity which may be hazardous to nonparticipating aircraft. The purpose of such warning areas is to warn nonparticipating pilots of the potential danger.

1 INTRODUCTION

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1536(a)(2)) requires each Federal agency to insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a Federal agency's action "may affect" a protected species, that agency is required to consult formally with the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR § 402.14(a)). Federal agencies are exempt from this general requirement if they have concluded that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS or the U.S. Fish and Wildlife Service concurs with that conclusion (50 CFR § 402.14(b)).

In this document, the action agencies are the United States Navy (U.S. Navy), which undertakes military readiness activities at the NWTRC (NWTRC) and NMFS's Office of Protected Resources, Permits and Conservation Division, which has (1) promulgated regulations under the Marine Mammal Protection Act (MMPA) governing the U.S. Navy's "take" of marine mammals incidental to those military readiness activities from November 2010 to November 2015 and (2) has issued a Letter of Authorization (LOA) pursuant to the regulations, as amended, that authorizes the U.S. Navy to "take" marine mammals incidental to those military readiness activities through November 2015. The consulting agency for these proposals is NMFS's Office of Protected Resources, Endangered Species Act (ESA) Interagency Cooperation Division.

The biological opinion and incidental take statement were prepared by NMFS's Endangered Species Act Interagency Cooperation Division in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, et seq.), and implementing regulations at 50 CFR § 402. This document is NMFS's final biological opinion (Opinion) on the anticipated effects of these actions on endangered and threatened species and critical habitat that has been designated for those species, and updates and supplements the 2012 Biological Opinion described in more detail below, which is incorporated by reference.

1.1 Consultation History

- On June 15, 2010, the Endangered Species Division issued a Programmatic Biological Opinion addressing four activities: (1) the U.S. Navy's proposal to continue in-water Research, Development, Test, and Evaluation activities at Naval Undersea Warfare Center Keyport Range Complex over a five-year period beginning

in June 2010 and ending in June 2015; (2) the U.S. Navy's proposal to continue training in the NWTRC over a five-year period beginning in June 2010 and ending in June 2015; (3) NMFS's Permits and Conservation Division's Permits and Conservation Division proposal to promulgate regulations governing the "take" of marine mammals (50 CFR Part 216) incidental to in-water Research, Development, Test and Evaluation activities at the U.S. Naval Undersea Warfare Center, Keyport Range Complex; and (4) the Permits and Conservation Division proposal to promulgate regulations governing the "take" of marine mammals (50 CFR Part 216) to allow the U.S. Navy to "take" marine mammals incidental to military readiness activities on the NWTRC.[1]

- On November 10, 2010, NMFS's Permits and Conservation Division published final regulations to allow the U.S. Navy to "take" of marine mammals incidental to military readiness activities on the NWTRC from November 2010 through November 2015, 75 FR 69296.

- On November 12, 2010, NMFS's Endangered Species Division issued a biological opinion on the U.S. Navy's military readiness activities and the NMFS's Permits and Conservation Division's proposed issuance of a one-year LOA to be valid from November 2010 through November 2011.

- On November 9, 2011, NMFS's Endangered Species Division issued a biological opinion on the U.S. Navy's military readiness activities and the NMFS's Permits and Conservation Division's proposed issuance of a one-year LOA to be valid from November 2011 through November 2012.

- On February 1, 2012, the five-year MMPA "take" regulations for the U.S. Navy's military readiness activities on the NWTRC (and similar MMPA take regulations) were amended to allow for the issuance of LOAs with longer periods of validity, 77 FR 4917.

- On October 16, 2012, NMFS's Endangered Species Division issued a biological opinion on the U.S. Navy's military readiness activities and the NMFS's Permits and

[1] The Programmatic Biological Opinion anticipated that the five-year MMPA regulations would take effect in June 2010 and run through June 2015. However, the regulations were promulgated in November 2010 and are effective from November 9, 2010, through November 9, 2015. See 75 Fed. Reg. 69,296 (Nov. 20, 2010). The change in the effective dates of the regulations has no effect on the substantive analyses and conclusions contained in the Programmatic Biological Opinion.

Conservation Division's proposed issuance of a three-year LOA to be valid from November 2012 through November 2015, covering the remaining effective period of the five-year "take" regulations for the NWTRC.

- On September 25, 2013 the United States District Court, Northern District of California,made a ruling (*Intertribal Sinkyone Wilderness Council v. NMFS*, 970 F. Supp. 2d 988 2013) that the October 2012 biological opinion (referred to by the Court as the 2012 LOA Biological Opinion), which the Court subsequently summarized as follows: "First, the court held that it was an abuse of discretion in regard to its duty to use the best scientific data available for the NMFS to fail to consider the 2010 and 2011 dolphin studies [James J. Finneran, et al., *Frequency-dependent and Longitudinal Changes in Noise-induced Hearing Loss in a Bottlenose Dolphin*, 128 J. Acoust. Soc. Am. (2) 567-570 at 657, 568 (2010); James J. Finneran, et al., *Subjective Loudness Measurements and Equal Loudness Contours in a Bottlenose Dolphin*, 130 J. Acoust. Soc. Am. (5) at 3124-3136 (2011)] in the 2012 LOA, Biological Opinion. (Doc. 66, 15:28 - 16- 1.). Second the court held because the NMFS abused its discretion in failing to consider the best scientific information available in its 2012 LOA, Biological Opinion, its estimates of the amount of take in the Incidental Take Statement, like its jeopardy analysis, was not based on the best scientific and commercial data available. The court found, therefore, that the NMFS abused its discretion in the issuance of the Incidental Take Statement. *Id*. at 17:17-20. Finally, the court held that it was an abuse of discretion for the NMFS to define the 'agency action' to be reviewed under ESA as the five-year period permitted under the MMPA. *Id*. at 23:17-19. These rulings impose on the NMFS a duty to correct its abuses of discretion. To the extent that the corrections require issuance, re-issuance or amendment of documents under ESA, such issuance, re-issuance or amendment shall be completed no later than August 1, 2014." Nov. 26, 2013 Remand Order at 3-4.

- On November 4, 2013, NMFS published its Final Rule to remove the Eastern distinct population segment (DPS) of Steller sea lion from the List of Endangered and Threatened Wildlife. The Final Rule became effective on December 4, 2013, 30 days after its publicaiton in the Federal Register.

- On March 5, 2014, NMFS's ESA Interagency Cooperation Division reinitiated consultation with the U.S. Navy and NMFS's Permits and Conservation Division to amend the 2012 biological opinion to address the Court's ruling and to assess any new scientific information that has become available since issuance of the 2012 opinion. This amended biological opinion, supercedes the 2010 programmatic pertaining to the NWTRC and 2012 biological opinions and constitutes the

controlling biological opinion for the remainder of the five-year MMPA Rule, the 2012 LOA, and the specified U.S. Navy training activities on the NWTRC, until this Opinion is superseded or amended.

- On 7 May 2014, NMFS and Navy subject matter experts met to discuss new science relative to this reinitiated biological opinion that has become available since the 2012 biological opinion and MMPA letter of authorization were issued.

- During the timeframe the NWTRC consultation was reinitiated, the U.S. Navy separately submitted a request for two LOAs for the incidental taking of marine mammals during the conduct of Phase II training activities within the Northwest Training and Testing (NWTT) Study Area, which includes the NWTRC, for the period of August 2015 through August 2020, and requested initiation of section 7 formal consultation on the NWTT action. The Navy also prepared a draft Environmental Impact Statement (EIS)/Overseas EIS (OEIS) for the NWTT Study Area, evaluating alternatives for all components of the proposed training activities. The No Action Alternative within the NWTT DEIS/OEIS, January 2014, is consistent with the preferred Alternative that was evaluated and selected in the 2010-2015 NWTRC Final EIS/OEIS. New information contained within the NWTT DEIS/OEIS for the No Action Alternative included the modeling of effects based on new criteria and thresholds which incorporated the 2010 and 2011 Finneran dolphin studies and other new science. These results were considered in this reinitiated biological opinion.

- Formal consultation has not yet commenced on the proposed NWTT action which includes additional testing activities not included in the current NWTRC training program. If approved, the resulting biological opinion for NWTT and any associated MMPA take authorization covering the period beyond November 2015, when the current MMPA rule expires, will supercede this opinion upon issuance.

- On 26 June 2014, the Navy provided a summary of monitoring accomplishments for the NWTRC through May 2014. *Comprehensive Marine Species Monitoring Report for The U.S. Navy's Northwest Training Range Complex 2011-2014*. U.S. Pacific Fleet, Pearl Harbor, Hawaii. Final July 1, 2014 as well as final post-calculations of estimated take for the period of November 2010 through May 2014.

- On 21 July 2014, the Navy provided a revision to its exposure analysis regarding the Guadalupe fur seal to support consultation on the Navy's current activities on the NWTRC. This revision accounts for best available science and more accurately

assesses impacts of NWTRC activities to Guadalupe fur seals based on review of how exposures to acoustic sources were initially derived, and how Guadalupe fur seal distribution in the offshore waters of the Pacific Northwest affect potential exposure estimates.

2 DESCRIPTION OF THE ACTIONS

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration. This opinion addresses three interdependent actions: (1) the U.S. Navy's military readiness activities conducted on the NWTRC; (2) the regulations promulgated by NMFS's Permits and Conservation Division pursuant to the MMPA governing the U.S. Navy's "take" of marine mammals incidental to the Navy's military readiness activities from November 2010 through November 2015; and (3) NMFS's Permits and Conservation Division's LOA issued pursuant to the regulations that authorizes the U.S. Navy to "take" marine mammals incidental to military readiness activities on the NWTRC (authorized by 50 CFR § 218.110) through November 2015. This Opinion supercedes the June 15, 2010 Programmatic Biological Opinion on the MMPA rulemaking for the NWTRC and the Final Biological Opinion issued on October 16, 2012.

The purpose of the activities the U.S. Navy conducts on the NWTRC is to meet the requirements of the U.S. Navy's Fleet Response Training Plan and allow Navy personnel to remain proficient in anti-submarine warfare and mine warfare skills (i.e., military readiness activities). The purpose of the MMPA regulations and the Permits and Conservation Division's LOA is to allow the U.S. Navy to "take" marine mammals incidental to military readiness activities on the NWTRC conducted through November 2015 in a manner that is consistent with the requirements of the MMPA and implementing regulations.

NMFS recognizes that while Navy training requirements change over time in response to global or geopolitical events and other factors, the general types of activities addressed by this consultation are expected to continue into the reasonably foreseeable future, along with the associated impacts. Therefore, as part of our effects analysis, we assumed that the activities proposed for the remainder of the five year period of the MMPA Rule would continue into the reasonably foreseeable future at levels similar to that assessed in this Opinion and described in the 2010 NWTRC EIS/OEIS and MMPA rule and the No Action Alternative of the NWTT Draft EIS/OEIS, January 2014. We considered the direct and indirect effects of those assumed future activities, together with the effects of

all interrelated and interdependent actions. This approach addresses the Court's decision summarized above. It is our understanding that the Court's ruling regarding the temporal scope of the "action" applies only to the jeopardy analysis in the 2012 BiOp and not to the Incidental Take Statement, which, as the Court recognized, is limited by law to the five-year take authorized under the MMPA. See 16 USC 1536(b)(4)(C) and (b)(4)(iii); 50 CFR 402.14(i)(1)(iii); and Order at 16. We consider this an interim approach and may consider different approaches in future actions.

Notwithstanding this analysis, however, NMFS would fully take into account all of the best available science and any change in the status of the species of the level of Navy activitity in the action area as part of the Navy's request for consultation on the proposed NWTT action and associated MMPA incidental take authorization for the period August 2015 - August 2020.

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

- Anti-air Warfare
- Strike Warfare
- Anti-submarine Warfare
- Mine Warfare
- Amphibious Warfare
- Anti-surface Warfare
- Electronic Warfare
- Naval Special Warfare

The following narratives summarize the information the U.S. Navy provided on the various military readiness activities to be conducted through November 2015 pursuant to the five-year (2010-2015) MMPA regulations and the current LOA. The Navy no longer proposes to conduct any sinking exercises (SINKEX) in NWTRC, which is a change from the original proposed action and a reduction in the scope of activities. The Navy originally anticipated performing two sinking exercises per year. The tempo of training within the NWTRC is subject to variation within the scope of the activities described in the Navy's NWTRC Environmental Impact Statement/Overseas Environmental Impact Statement and this Opinion. Annual variation in the number of training events and quantities of authorized sonar systems and explosive training could occur based on:

- Frequency of out-of-area training deployments to other Navy range complexes;
- Overseas deployments of ships and aircraft to the western Pacific and Middle East;
- Within-area maintenance and repair work that precludes completing some training within the NWTRC; and
- Certification and training needs for a given ship, submarine, or aircraft crew (e.g., some units could require a certain amount of one kind of training vice another).

While the tempo of training can vary annually, Navy training in the NWTRC is not expected to exceed the training levels identified in Table 1 through November 2015. Given the inherent uncertainty and potential variation within the training spectrum due to unforeseen world events, the Navy stated that it cannot predict exact annual system use for the period. Although the preferred alternative in the draft EIS/OEIS, January 2014, would change the level of Navy activity in the action area, the Navy has not yet adopted the preferred alternative. As stated above, any proposed change in the level of Navy activity occurring in the action area will be evaluated as part of the separate consultation on the NWTT action and request for associated incidental take authorization.

2.1 Activities Not Likely to Affect ESA-listed Resources

NMFS previously concluded that several of the activities the U.S. Navy plans to conduct on the NWTRC are not likely to adversely affect listed species or designated critical habitat because (1) the activities are not likely to produce stimuli that would represent potential stressors for endangered or threatened species or designated critical habitat under NMFS's jurisdiction; (2) the activities are likely to produce stimuli that would represent potential stressors for endangered or threatened species or designated critical habitat under NMFS's jurisdiction, but those species or critical habitat are not likely to be exposed to stressors; or (3) endangered or threatened species or designated critical habitat under NMFS's jurisdiction are likely to be exposed to potential stressors associated with the activities, but they are not likely to respond given that exposure.

Because these activities are (1) not likely to produce stimuli that would represent potential stressors for endangered or threatened species or designated critical habitat under NMFS's jurisdiction; or (2) the activities are likely to produce stimuli that would represent potential stressors for endangered or threatened species or designated critical habitat under NMFS's jurisdiction, but those species or critical habitat are not likely to be exposed to stressors; or (3) endangered or threatened species or designated critical habitat under NMFS's jurisdiction are likely to be exposed to potential stressors associated with the activities, but they are not likely to respond given that exposure, these activities are not likely to adversely affect endangered or threatened species under NMFS's jurisdiction. We will not consider these activities further in this document.

Specifically, the following activities are not likely to produce stressors that are relevant for endangered or threatened species and designated critical habitat under NMFS's jurisdiction or those species and designated critical habitat are not likely to be exposed to physical, chemical, or biotic stressors that might be associated with those activities:

2.1.1 Electronic Operations

As part of electronic combat operations training, Navy personnel are trained to prevent or reduce the effectiveness of enemy electronic equipment. Typical Electronic Combat activities include signals analysis and use of airborne and surface electronic jamming devices to defeat tracking radar systems. During these activities, aircraft, surface ships, and submarines attempt to control critical portions of the electromagnetic spectrum used by threat radars, communications equipment, and electronic detection equipment. Electronic combat training activities typically last one to two hours. Endangered and threatened species are not likely to be exposed to the electronic technologies associated with these electronic combat training activities and therefore are not discussed further. Vessel movements associated with this activity are discussed further.

2.1.2 Intelligence, Surveillance, and Reconnaissance

The U.S. Navy conducts intelligence, surveillance, and reconnaissance training with maritime patrol aircraft in W-237 (

Figure 2) and the Pacific Northwest Operating Area. Activities typically last six hours and involve a crew of 11 personnel. Aircrews on P-3 aircraft use a variety of intelligence gathering and surveillance methods, including visual, infrared, electronic, radar, and acoustic. Crews on EP-3 and EA-6B aircraft conduct intelligence, surveillance, and reconnaissance training as well, but to a lesser extent than P-3C crews. We concur with the Navy's determination that endangered and threatened species are not likely to be exposed to the technologies associated with these training activities.

2.1.3 Unmanned Aerial System Training

The U.S. Navy employs unmanned aerial systems to gather information about the activities of enemies, potential enemies, or tactical areas of operations using visual, aural, electronic, photographic and other on-board surveillance systems. The U.S. Navy currently employs several kinds of unmanned aerial systems that are typically flown at altitudes well above 3,000 feet. These training missions typically occur three times a year for three to four days each; during each of the three to four day testing, the unmanned aerial systems activities last about six hours. These activities typically occur in the offshore portions of the action areas. We concur with the Navy's determination that endangered and threatened species are not likely to be exposed to the technologies associated with these training activities.

2.1.4 Development of Air Target Services

Navy training requires air targets for Basic and Intermediate anti-air warfare, air-to-air, and surface-to-air gunnery exercises and missile exercises. Live rotary or fixed wing aircraft representing an opposition force are required for Basic and Intermediate anti-air warfare, anti-surface warfare, and Intermediate level anti-submarine warfare, strike

warfare, and electronic combat operations. Air target services can be used to generate electronic combat operations 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 electronic combat operations. We concur with the Navy's determination that endangered and threatened species are not likely to be exposed to the technologies associated with these training activities.

2.1.5 Development of Surface Target Services

The U.S. Navy proposes to develop surface target services which would be used to generate electronic combat threats as well as the visual and spectral signatures of real threats. The NWTRC currently does not have anti-surface warfare targets or target services in the complex. Surface ships have the ability to launch a Floating At-Sea Target 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 Floating At-Sea Target, although aircraft can launch a marine floating marker (flare), which also does not replicate the visual or spectral signature of real threats. We concur with the Navy's determination that endangered and threatened species are not likely to be exposed to the technologies associated with these training activities.

2.2 U.S. Navy Actions that are Likely to Adversely Affect Listed Resources

Below we summarize the remaining training operations the U.S. Navy plans to conduct on the NWTRC through the remainder of the current five-year MMPA rule. Table 1 identifies the specific training activities, number of events for each activity, and the locations of the different events; our 15 June 2010 Programmatic Biological Opinion provides more detailed narratives of these training operations and specific ordnance that might be involved in particular training operations.

2.2.1 Air Combat Maneuvers

Air Combat Maneuvers include basic flight maneuvers in which aircraft engage in offensive and defensive maneuvering against each other. Air Combat Maneuvers activities within the NWTRC are primarily conducted by EA-6B Prowlers (and EA-18G Growlers) within military operating areas and warning areas. Typically, Air Combat Maneuvers events last between 1.0 to 1.5 hours and do not occur at altitudes below 5,000 ft. No ordnance would be released during events. The U.S. Navy plans to conduct about 2,000 of these events annually through November 2015 in the NWTRC.

2.2.2 Air-To-Air Missile Exercise

In these training events, missiles are fired from aircraft against unmanned aerial target drones such as BQM-34s and BQM-74s. Typically, these training events last about one hour, and are conducted in a warning area at sea outside of 12 nm and well above 3,000 ft

altitude. The U.S. Navy plans to conduct about 24 of these training events annually, involving 30 missiles, in the NWTRC.

2.2.3 Surface-To-Air Gunnery Exercise

During these exercises, the gun crews of surface ships engage target aircraft or missile targets with their guns to disable or destroy the targets posing as "threats." Ships involved in these exercises maneuver as necessary but would typically operate at speeds of 10 to 12 knots (kts) or less during the exercise.

These exercises last about two hours which normally includes several non-firing tracking runs followed by one or more firing runs. Targets must maintain altitudes greater than 500 ft above sea level for safety reasons and are not destroyed during exercises. The U.S. Navy plans to conduct about 160 of these training events annually, in the NWTRC.

2.2.4 Surface-To-Air Missile Exercise

During these exercises, surface ships engage "threat" missiles and aircraft with surface-to-air missiles with the goal of disabling or destroying them. These exercises last about two hours. A parachute deploys at the end of target flight to enable recovery at sea. All of these exercises occur in the offshore portions of the action area of the NWTRC. The U.S. Navy plans to conduct about 4 of these training events annually, in the NWTRC.

2.2.5 Anti-Submarine Warfare Tracking Exercise, Maritime Patrol Aircraft

During these training activities, a typical scenario would involve a single maritime patrol aircraft (usually P-3s Orion or P-8 Poseidon aircraft; the U.S. Navy refers to the latters as multi-mission maritime aircraft) dropping sonobuoys, from an altitude below 3,000 ft (sometimes as low as 400 ft), into specific patterns designed to respond to the movement of a target submarine and specific water conditions. Typically, maritime patrol aircraft will use passive sonobuoys first to avoid alerting the target submarine.

These training events usually last for two to four hours and do not involve firing torpedoes. The U.S. Navy conducts about 210 events per year. All of these events would occur in the offshore area of the NWTRC.

2.2.6 Anti-Submarine Warfare Tracking - Extended Echo Ranging (EER)

These training events are at-sea flying events, typically conducted at altitudes below 3,000 ft. that are designed to train maritime patrol aircraft crews in deploying and using Extended Echo Ranging and Improved Extended Echo Ranging sonobuoy systems. The active component of these sonobuoy systems is the AN/SSQ-110A sonobuoy, which generates an explosive sound impulse, and a passive component that "listens" for the return echo that is reflected from the surface of a submarine. The AN/SSQ-110 Sonobuoy Series is an expendable and commandable sonobuoy: upon command from an aircraft,

the bottom payload is released to sink to a designated operating depth. A second command is required from the aircraft to cause the second payload to release and detonate generating a "ping." There is only one detonation in the pattern of buoys at a time.

The U.S. Navy plans to phase out the existing EER/IEER systems and replace them with the Advanced Extended Echo Ranging (AEER) system or recently renamed Multi-static Coherent Source (MAC) sonobuoy. The MAC is similar to the EER/IEER but instead of using an explosive as an impulsive source for the active acoustic wave, the MAC system uses a battery powered (electronic) source. The MAC system was initially scheduled to enter the fleet in 2011, but was delayed until mid-2013. Deployment began with east coast squadrons. Deployment in the NWTRC is currently expected to occur in 2014-2015.

These training events usually last for six hours, with one hour for sonobuoy pattern deployment and five hours for active search. The U.S. Navy conducts about 12 events per year. All of these events would occur in the offshore area of the NWTRC.

2.2.7 Anti-Submarine Warfare Tracking Exercise, Surface Ship

The U.S. Navy conducts about 26 training events annually involving guided-missile destroyers and 39 training events annually involving guided-missile frigates on the NWTRC. As proposed, the 26 training events involving guided missile destroyers could produce up to 43 hours of mid-frequency active sonar (from the AN/SQS-53 system hull-mounted sonar system) each year while the 39 training events involving guided-missile frigates would produce up to 65 hours of mid-frequency active sonar (from the AN/SQS-56 system hull-mounted sonar system) each year.

2.2.8 Anti-Submarine Warfare Tracking Exercise, Submarine

These tracking exercises are a primary training exercise for submarines based in Bangor. Training activities involve P-3 aircraft about 30 percent of the time. During these training events, submarines rely on passive sonar sensors almost exclusively to search, detect, classify, localize and track target submarines with the goal of developing a firing solution that could be used to launch a torpedo and destroy the threat submarine (active sonar use is tactically proscribed because it would reveal the tracking submarine's presence to the target submarine). No torpedoes are fired during this training activity.

No ordnance is expended during these training events, which usually last two to four hours. Training events in which P-3s and P-8s are used typically last 8 to 12 hours. The U.S. Navy conducts about 100 of these training events annually through November 2015 on the NWTRC.

2.2.9 Air-To-Surface Bombing Exercise

During Air-to-Surface Bombing Exercises, Maritime Patrol Aircraft and other fixed-wing aircraft deliver bombs against simulated surface maritime targets, typically a smoke float. Historically, ordnance has been released throughout W-237, just south of W-237, and in international waters in accordance with international laws, rules, and regulations. Each of these bombing exercises can take up to 4 hours to complete. The U.S. Navy conducts about 30 events annually in the NWTRC.

2.2.10 High-Speed Anti-Radiation Exercise (Air-to-Surface)

High-Speed Anti-Radiation (HARM) missile exercises (air-to-surface) train air-crews to conduct electronic attack using HARM missiles. Only non-firing HARMs are used during these training events on the Range Complex. These training events are non-firing events that typically last one to two hours. The U.S. Navy conducts a total of about 3,000 events annually in the NWTRC, including those events that occur as part of Strike Warfare Training exercises.

2.2.11 Sinking Exercise

Sinking exercises (SINKEX) are designed to train ship and aircraft crews in delivering live and inert ordnance on a real target. Each SINKEX uses an excess vessel hulk as a target that is eventually sunk during the course of the exercise. The hulk ship is towed to a designated location where various platforms would use multiple types of weapons to fire shots at the hulk. Platforms can consist of air, surface, and subsurface elements. Weapons can include missiles, precision and non-precision bombs, gunfire and torpedoes. If none of the shots result in the hulk sinking, either a submarine shot or placed explosive charges would be used to sink the ship. Charges ranging from 45 to 90 kilograms (100 to 200 pounds), depending on the size of the ship, would be placed on or in the hulk.

The U.S. Navy does not plan to conduct sinking exercises in the NWTRC during the remaining period of the MMPA rule through November 2015.

2.2.12 Land Demolitions

Land demolitions would continue to occur at two Detonation Training Ranges: Seaplane Base and Bangor. A typical land demolition training exercise lasts about eight hours and involves disrupting non-explosive Improvised Explosive Devices using different explosively actuated tools. Typical explosives used are C-4 demolition blocks, detonating cord, and electric blasting caps. The net explosive weight training limit is five pounds per charge at Detonation Training Range Bangor and one-pound per charge at Detonation Training Range Seaplane Base. Other Explosive Ordnance Disposal training activity occurs outside Detonation Training Range Seaplane Base within the Seaplane Base Survival Area to include locating and defusing (non-explosive) Mark 80 series General

Purpose bombs and simulated improvised explosive devices. The U.S. Navy conducts about 110 detonations annually on the Explosive Ordnance Disposal ranges in the NWTRC.

2.2.13 Mine Countermeasures Exercise

Mine Countermeasures consist of mine avoidance training and mine neutralization training. Mine neutralization activities consist of underwater demolitions designed to train Navy personnel in the destruction of mines, unexploded ordnance, obstacles, or other structures in an area to prevent interference with friendly or neutral forces and non-combatants.

Two active EOD ranges are located in the Inland Waters at the following locations:

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

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

As discussed in the 2012 Biological Opinion, the Navy changed the training ordnance such that they have the option of dividing the authorized explosive charge into several smaller ($\leq$1 lb.) charges. As previously described, two underwater demolition events were authorized annually at each of the two training sites; Crescent Harbor and Hood Canal EOD Ranges. The Crescent harbor site is currently authorized for up to 2.5 pound explosive weight charges and the Hood Canal site is authorized for up to 1.5 pound charges. With this change, the unit conducting the training has the option of utilizing up to four, one ounce explosive charges in lieu of one 2.5 or 1.5 pound charge. The four small charges would be initiated individually with an approximately 15 minute interval between charge initiations. The overall quantity of explosive material utilized in four, one ounce events would be substantially less than quantities utilized in either the 2.5 or 1.5 pound charges. All underwater detonation training events in the NWTRC utilize positive control, remote detonation of charges and none are proposed to be initiated by time delayed firing devices.

Small boats such as MK-5 or 7- or 9- meter Hull Inflatable Boats are used to insert Navy personnel for underwater activities and either a helicopter (H-60) or Rigid Hull Inflatable Boat is used to insert personnel for surface activities.

Mine countermeasures exercises typically last four hours for an underwater detonation and one hour for a surface detonation. The U.S. Navy plans to conduct about four mine countermeasures training events annually on the NWTRC through November 2015.

2.2.14 Naval Special Warfare

Naval Special Warfare training events include: insertion/extraction operations using parachutes, rubber boats, or helicopters; boat-to-shore and boat-to-boat gunnery; demolition training on land or underwater; reconnaissance; and small arms training.

2.2.15 Insertion/Extraction

Naval Special Warfare and other personnel train to approach or depart an objective area using various transportation methods and tactics. These activities train forces to insert and extract personnel and equipment day or night. The U.S. Navy plans to conduct about 27 of these exercises annually on the NWTRC through November 2015.

2.2.16 Range Enhancements

The U.S. Navy is developing a small scale underwater training minefield, new electronic combat threat simulators and targets, a portable undersea tracking range, and range pingers. The addition of a small scale under-water 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. These mine-like shapes will be placed within an area approximately 2 nm by 2 nm. Although the location for this minefield has not yet been determined, it would not be installed within the boundaries of the Olympic Coast National Marine Sanctuary.

The U.S. Navy is installing a portable undersea tracking range to support anti-submarine warfare training in areas where the ocean depth is between 300 ft and 12,000 ft and at least 3 nm from land. This system will temporarily instrument 25-square-mile or smaller areas on the seafloor, and consists of temporarily installing seven electronics packages, each approximately 3 ft long by 2 ft in diameter, 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 are either concrete or sand bags, which are approximately 1.5 ft-by-1.5 ft and weigh approximately 300 pounds. When training is complete, the U.S. Navy plans to recover the undersea tracking range. No on-shore construction will take place.

Range tracking pingers used on ships, submarines, and anti-submarine warfare targets when anti-submarine warfare tracking exercises are conducted on the portable undersea

tracking range. A typical range pinger generates a 12.93 kHz sine wave in pulses with a maximum duty cycle of 30 milliseconds (3 percent 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 anti-submarine warfare training activity. On average, two pingers are used for 3 hours each during portable undersea tracking range operational days.

Table 1. Training Activities the U.S. Navy Conducts in the Northwest Training Range Each Year

Range Operation	Platform	System or Ordnance	Actions	Location
ANTI-AIR WARFARE (AAW)				
Air Combat Maneuvers	EA-6B, EA-18G, FA-18, F-16	Chaff	2,000 events	Offshore and Inshore Areas
Gunnery Exercise (Surface-to-Air)	Guided missile destroyer	5-inch/54 BLP, 20 mm Close-in Weapon System	160 events	Offshore Area
	Guided missile frigate	76 mm, 20 mm Close-in Weapon System		
	Fast combat support ship	20 mm Close-in Weapon System		
Missile Exercise (Air-to-Air)	EA-18G	AIM-7 Sparrow, AIM-9 Sidewinder AIM-120 Advanced Medium Range Air-to-Air Missile	24 events 30 missiles	Offshore Area
Missile Exercise (Surface-to-Air)	Multi-Purpose Aircraft Carrier (Nuclear Propulsion)	Sea sparrow Missile or RAM	4 events	Offshore Area
ANTI-SUBMARINE WARFARE (ASW)				
Anti-submarine Warfare Tracking Exercise	P-3C	Targets: SSN, MK-39 Expendable Mobile Anti-submarine Warfare Training Target. sonobuoys: SSQ-53 DIFAR (passive), SSQ-62 DICASS (active), SSQ-77 VLAD, SSQ-36 BT	210 events	Offshore Area
	P-8 MMA			
Anti-submarine Warfare Tracking Exercise - Extended Echo Ranging	P-3C	SSQ-110A source sonobuoy (which will be incrementally replaced by the Advanced Extended Echo Ranging (AEER) sonobuoy between 2012 and 2015), SSQ-77 VLAD	12 events	
	P-8 MMA			
Anti-submarine Warfare Tracking Exercise – Surface Ship	Guided missile destroyer	SQS-53 mid-frequency active sonar	26 events 43 sonar hours	
	Guided missile frigate	SQS-56 mid-frequency active sonar	39 events 65 sonar hours	
Anti-submarine Warfare Tracking Exercise – Submarine	Ballistic missile submarine	BQQ-5 sonar (passive only)	100 events	
	Cruise missile submarine	BQQ-5 sonar (passive only)		
ANTI-SURFACE WARFARE (ASUW)				

Range Operation	Platform	System or Ordnance	Actions	Location
Gunnery Exercise (Surface-to-Surface)	Multi-Purpose Aircraft Carrier (Nuclear Propulsion)	20 mm Close-in Weapon System, .7.62-mm, 50 cal	8 events	Offshore Area
	Guided missile destroyer	5-inch/54 BLP, 20 mm, 7.62 mm, .50 cal.	42 events	
	Guided missile frigate	76 mm, 20 mm, 7.62 mm, .50 cal.	126 events	
	Fast combat support ship	20 mm, 7.62 mm, .50 cal.	4 events	
Bombing Exercise (Air-to-Surface)	P-3C aircraft	MK-82 (live), BDU-45 (inert)	30 events	Offshore Area
	P-8 aircraft	MK-82 (live), BDU-45 (inert)		
HARM Exercise	EA-6B	CATM-88C (not released)	See Strike Warfare	Offshore and Inshore Area
	EA-18G	CATM-88C (not released)		
Sink Exercise (SINKEX)	E-2	None	0 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 missile		
	EA-18G	AGM-88C HARM missile		
	SH-60	AGM-114 HELLFIRE missile		
	Guided missile destroyer	5-inch/54 ordnance		
	Guided missile frigate	76 mm ordnance		
	Fast-attack submarine (Nuclear propulsion)	MK-48 ADCAP torpedo		
ELECTRONIC COMBAT				
Electronic Combat Exercises	EA-6B/EA-18G	None	4,580 events	Offshore Area
	P-3		28 events	
	EP-3		390 events	
	Multi-Purpose Aircraft Carrier (Nuclear Propulsion)		50 events	
	Guided missile destroyer		50 events	
	Guided missile frigate		100 events	
	Fast combat support ship		25 events	

Range Operation	Platform	System or Ordnance	Actions	Location
	Cruise missile submarine		25 events	
	Ballistic missile submarine		25 events	
MINE WARFARE				
Land Demolitions	Explosive Ordnance Disposal personnel		110 detonations	Inshore Explosive Ordnance Disposal Ranges
Mine Avoidance	Cruise missile submarine (I per event)	AN/BQS-15 high-frequency active sonar	4 events, 24 sonar hours	Offshore Area
	Ballistic missile submarine (I per event)	AN/BQS-15 high-frequency active sonar	3 events, 18 sonar hours	
Mine Countermeasures	Explosive Ordnance Disposal personnel, H-60, Rigid-Hull Inflatable Boat	2.5 lb C-4, 1.5 lb C-4, or 4 x 1 oz	4 events, 4 detonations	Inshore Explosive Ordnance Disposal Ranges
NAVAL SPECIAL WARFARE				
Insertion/Extraction	C-130 (1 sortie per event)	None	27 events	Inshore Area, Explosive Ordnance Disposal Ranges
	H-60 (1 sortie per event)		93 events	
Naval Special Warfare Training	SDV (1 per event)		35 events	Indian Island
	Rigid-Hull Inflatable Boat (2 per event)		35 events	
STRIKE WARFARE				
HARM Missile exercise (non-firing)	EA-6B EA-18G	CATM-88C (not released)	3,000 events	Offshore and Inshore Areas
OTHER TRAINING ACTIVITIES				
Intelligence, Surveillance, and Reconnaissance	P-3, EP-3, EA-6B, EA-18G	None	100 events	Offshore Area
Unmanned Aerial System Research, Development, Test, and Evaluation and Training	Scan Eagle, Global Hawk, BAMS	None	112 events	Offshore and Inshore Areas

2.2.17 Summary of Proposed Training Activities as Analyzed with Phase II Criteria and the Navy Acoustic Effects Model (NAEMO)

To support this Opinion, the Navy completed a comparison of the 2010 NWTRC EIS/OEIS preferred action[2] and the no action alternative of the 2014 NWTT Draft EIS/OEIS, January 2014, for proposed training from November 2015 through 2020, Phase II, marine mammal model results[3]. The activity levels modeled are summarized in Table 2 and indicate that the activity levels analysis in the 2014 no action alternative which was assessed in this Opinion.

Table 2. Proposed Training Activities as Analyzed Using Phase II Criteria and NAEMO

Range Activity	Location		
		No. of events (per year)	Ordnance (Number per year)
Anti-Air Warfare			
Air Combat Maneuver (ACM)	Offshore Area (W-237)	160	None
Missile Exercise (Air-to-Air) (MISSILEX [A-A])	Offshore Area (W-237)	24	30 (AIM-7/9/120) 15 HE warheads
Gunnery Exercise (Surface- to-Air) (GUNEX [S-A])	Offshore Area (W-237)	160	310 large-caliber rounds (230 HE) 16,000 medium- caliber rounds (6,320 HE)
Missile Exercise (Surface- to-Air) (MISSILEX [S-A])	Offshore Area (W-237)	4	8 HE warheads
Anti-Surface Warfare (ASUW)			

[2] DoN. 2011. Northwest Training Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement- Final. Department of the Navy, US Pacific Fleet. September 2010.

[3] DoN. 2014b. Determination of Acoustic Effects on Marine Mammals and Sea Turtles for the Northwest Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement. Department of the Navy, Naval Undersea Warfare Center, Newport, RI. NUWC-Npt Technical Report xx,xxx. 75 p. http://nwtteis.com/Portals/NWTT/DraftEIS2014/SupportingDocs/TR_NWTT_PRE-FINAL_2014.01.17.pdf

Gunnery Exercise (Surface- to-Surface) – Ship (GUNEX [S-S] – Ship)	Offshore Area	180	117,000 small-caliber rounds 32,760 medium- caliber rounds (48 HE) 2,880 large-caliber rounds (160 HE)
Gunnery Exercise (Surface- to-Surface) – Boat (GUNEX [S-S] – Boat)	Inland Waters (Crescent Harbor)	0	None
Missile Exercise (Air-to- Surface) (MISSILEX [A-S])	Offshore Area (W-237)	2	All non-firing Captive Air Training Missiles
Bombing Exercise (Air-to- Surface) (BOMBEX [A-S])	Offshore Area (W-237)	30	10 HE Bombs 110 NEPM Bombs
Anti-Surface Warfare (ASUW) (continued)			
Sinking Exercise (SINKEX)	Offshore Area	2	24 HE Bombs 22 HE Missiles 80 HE large-caliber rounds 2 MK-48 HE
Anti-Submarine Warfare (ASW)			
Tracking Exercise – Submarine (TRACKEX – Sub)	Offshore Area	100	None
Tracking Exercise – Surface (TRACKEX – Surface)	Offshore Area	65	None
Tracking Exercise – Helicopter (TRACKEX – Helo)	Offshore Area	0	None
Tracking Exercise – Maritime Patrol Aircraft (TRACKEX – MPA)	Offshore Area	210	None
Tracking Exercise – Maritime Patrol (Extended Echo Ranging Sonobuoys)	Offshore Area	54	150 IEER or SSQ- 125 sonobuoys
Electronic Warfare (EW)			

Electronic Warfare Operations (EW OPS)	Offshore Area	2,900 (aircraft) 275 (ship)	None
Mine Warfare (MIW)			
Mine Neutralization – Explosive Ordnance Disposal (EOD)	Crescent Harbor EOD Training Range	2	two 2.5 lb. charges (or up to four 1.0lb charges)
	Hood Canal EOD Training Range	2	two 1.5 lb. charges (or up to four 1.0lb charges)
Submarine Mine Exercise	Offshore Area	0	None
Civilian Port Defense	Inland Waters	0	n/a
Naval Special Warfare (NSW)			
Personnel Insertion/Extraction – Submersible	Inland Waters	35	None
Personnel Insertion/Extraction – Non-Submersible	Inland Waters (Crescent Harbor)	120	None
Other			
Precision Anchoring	Inland Waters (Naval Station Everett, Indian Island)	Not Previously Analyzed	None
Small Boat Attack	Naval Station Everett NAVBASE Kitsap Bangor NAVBASE Kitsap Bremerton	0	None
Other (continued)			
Intelligence, Surveillance, Reconnaissance (ISR)	Offshore Area	100	None
Search and Rescue	Crescent Harbor, Navy 7 Olympic MOA	180	None

Surface Ship Sonar Maintenance	NAVBASE Kitsap Bremerton, Naval Station Everett, and Offshore Area	0	None
Submarine Sonar Maintenance	NAVBASE Kitsap Bangor, NAVBASE Kitsap Bremerton, and Offshore Area	0	None

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

2.3 U.S. Navy Mitigation Measures

As required to satisfy the requirements of the MMPA, the U.S. Navy is implementing measures that would allow their training activities to have the least practicable adverse impact on marine mammal species or stocks (which includes considerations of personnel safety, practicality of implementation, and impact on the effectiveness of the "military readiness activity"). Those measures are summarized in this section; for a complete description of all of the measures applicable to the exercises, readers should refer to the 2012 LOA to "take" marine mammals incidental to military readiness activities on the NWTRC and the Permit Division's MMPA regulations for those activities.

The U.S. Navy continues to implement the following procedures to maximize the ability of Navy personnel to recognize instances when marine mammals are in the vicinity as a measure to reduce risk to ESA-listed species. Some of these measures would also identify, and hence be protective of, sea turtles if they are in the area.

2.3.1 General Maritime

The following mitigation measures would apply during general maritime activities.

2.3.1.1 **Personnel Training – for all Training Types**

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.

(A) All commanding officers (COs), executive officers (XOs), lookouts, Officers of the Deck (OODs), junior OODs (JOODs), maritime patrol aircraft aircrews, and Anti-submarine Warfare (ASW)/Mine Warfare (MIW) helicopter crews shall complete the NMFS-approved Marine Species Awareness Training (MSAT) by viewing the U.S. Navy MSAT digital versatile disk (DVD). All bridge lookouts shall complete both parts one and two of the MSAT; part two is optional for other personnel.

(B) Navy lookouts shall undertake extensive training in order to qualify as a watchstander in accordance with the Lookout Training Handbook (Naval Education and Training Command [NAVEDTRA] 12968-D).

(C) Lookout training shall include on-the-job instruction under the supervision of a qualified, experienced lookout. Following successful completion of this supervised training period,

lookouts shall 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.

(D) Lookouts shall 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.

2.3.1.2 **Operating Procedures and Collision Avoidance**

(A) Prior to major exercises, a Letter of Instruction, Mitigation Measures Message or Environmental Annex to the Operational Order shall be issued to further disseminate the personnel training requirement and general marine species mitigation measures.

(B) COs shall 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.

(C) While underway, surface vessels shall have at least two lookouts with binoculars; surfaced submarines shall 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 OOD the presence of marine mammals.

(D) On surface vessels equipped with a multi-function active sensor, pedestal mounted "Big Eye" (20x110) binoculars shall be properly installed and in good working order to assist in the detection of marine mammals in the vicinity of the vessel.

(E) Personnel on lookout shall employ visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D).

(F) After sunset and prior to sunrise, lookouts shall employ Night Lookout Techniques in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D).

(G) While in transit, naval vessels shall 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.

(H) When marine mammals have been sighted in the area, Navy vessels shall 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).

(I) Naval vessels shall maneuver to keep at least 1,500 ft (500 yds) away from any observed whale in the vessel's path and avoid approaching whales head-on. These requirements do 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 activities, launching and recovering aircraft or landing craft, minesweeping activities, replenishment while underway and towing activities that severely restrict a vessel's ability to deviate course. Vessels shall take reasonable steps to alert other vessels in the vicinity of the whale. Given rapid swimming speeds and maneuverability of many dolphin species, naval vessels would maintain normal course and speed on sighting dolphins unless some condition indicated a need for the vessel to maneuver.

(J) Navy aircraft participating in exercises at sea shall conduct and maintain, when operationally feasible and safe, surveillance for marine mammals as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties. Marine mammal detections shall 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.

(K) All vessels shall maintain logs and records documenting training operations 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.

2.3.2 Measures for Specific Training Events

These mitigation measures would apply during training events as specified below.

2.3.2.1 **Mid-Frequency Active Sonar Training Activities**

2.3.2.1.1 Personnel Training

(A) 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.

(B) 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.

(C) Navy lookouts will undertake extensive training in order to qualify as a watchstander in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D).

(D) 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.

(E) 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.

2.3.2.1.2 Lookout and Watchstander Responsibilities

(A) 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.

(B) 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.

(C) 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.

(D) 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.

(E) Personnel on lookout will employ visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D).

(F) After sunset and prior to sunrise, lookouts will employ Night Lookouts Techniques in accordance with the Lookout Training Handbook.

(G) 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.

2.3.2.1.3 Operating Procedures

(A) Navy will distribute final mitigation measures contained in the LOA and the Incidental take statement of NMFS's biological opinion to the Fleet.

(B) COs shall 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.

(C) All personnel engaged in passive acoustic sonar operation (including aircraft, surface ships, or submarines) shall monitor for marine mammal vocalizations and report the detection of any marine mammal to the appropriate watch station for dissemination and appropriate action.

(D) During mid-frequency active sonar operations, personnel shall utilize all available sensor and optical systems (such as night vision goggles) to aid in the detection of marine mammals.

(E) Navy aircraft participating in exercises at sea shall 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.

(F) Aircraft with deployed sonobuoys shall use only the passive capability of sonobuoys when marine mammals are detected within 200 yds (183 m) of the sonobuoy.

(G) Marine mammal detections shall be reported immediately 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.

(H) Safety Zones – When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) the Navy shall ensure that sonar transmission levels are limited to at least 6 dB below normal operating levels if any detected marine mammals are within 1,000 yards (914 m) of the sonar dome (the bow).

> (1) Ships and submarines shall continue to limit maximum transmission levels by this 6-dB factor until the animal has been seen to leave the 1,000-yd safety zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yds (1,829 m) beyond the location of the last detection.
>
> (2) When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) the Navy shall ensure that sonar transmission levels are limited to at least 10 dB below normal operating levels if any detected marine

mammals are within 500 yds (457 m) of the sonar dome (the bow). Ships and submarines shall continue to limit maximum ping levels by this 10-dB factor until the animal has been seen to leave the 500-yd safety zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yds (1,829 m) beyond the location of the last detection.

(3) When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) the Navy shall ensure that sonar transmission ceases if any detected marine mammals are within 200 yds (183 m) of the sonar dome (the bow). Sonar shall not resume until the animal has been seen to leave the 200-yd safety zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yds (1,829 m) beyond the location of the last detection.

(4) Special conditions applicable for dolphins and porpoises only: If, after conducting an initial maneuver to avoid close quarters with dolphins or porpoises, the OOD 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.

(5) 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 what level above 235 dB active sonar was being operated).

(I) 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.

(J) Active sonar levels (generally) – Navy shall operate active sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet tactical training objectives.

(K) Helicopters shall observe/survey the vicinity of an ASW training event for 10 minutes before the first deployment of active (dipping) sonar in the water.

(L) Helicopters shall not dip their active sonar within 200 yds (183 m) of a marine mammal and shall cease pinging if a marine mammal closes within 200 yds of the sound source (183 m) after pinging has begun.

(M) Submarine sonar operators shall review detection indicators of close-aboard marine mammals prior to the commencement of ASW training events involving active mid-frequency sonar.

(N) Night vision goggles shall be available to all ships and air crews, for use as appropriate.

2.3.2.2 **Underwater Detonations**

2.3.2.3 **Surface-to-Surface Gunnery (non-explosive rounds)**

(A) A 200 yd (183 m) radius buffer zone shall be established around the intended target.

(B) From the intended firing position, trained lookouts shall survey the buffer zone for marine mammals prior to commencement and during the exercise as long as practicable.

(C) If applicable, target towing vessels shall maintain a lookout. If a marine mammal is sighted in the vicinity of the exercise, the tow vessel shall immediately notify the firing vessel in order to secure gunnery firing until the area is clear.

(D) The exercise shall be conducted only when the buffer zone is visible and marine mammals are not detected within the target area and the buffer zone.

2.3.2.4 **Surface-to-Air Gunnery (explosive and non-explosive rounds)**

(A) Vessels shall orient the geometry of gunnery exercises in order to prevent debris from falling in the area of sighted marine mammals.

(B) Vessels will attempt to recover any parachute deploying aerial targets to the extent practicable (and their parachutes if feasible) to reduce the potential for entanglement of marine mammals.

(C) For exercises using targets towed by a vessel or aircraft, target towing vessel/aircraft shall maintain a lookout. If a marine mammal is sighted in the vicinity of the exercise, the tow aircraft shall immediately notify the firing vessel in order to secure gunnery firing until the area is clear.

2.3.2.5 **Air-to-Surface At-sea Bombing Exercises (explosive and non-explosive)**

(A) If surface vessels are involved, trained lookouts shall survey for floating kelp and marine mammals. Ordnance shall not be targeted to impact within 1,000 yd (914 m) of known or observed floating kelp or marine mammals.

(B) A 1,000 yd (914 m) radius buffer zone shall be established around the intended target.

(C) Aircraft shall visually survey the target and buffer zone for marine mammals prior to and during the exercise. The survey of the impact area shall 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.

(D) The exercise will be conducted only if marine mammals are not visible within the buffer zone.

2.3.2.6 **Air-to-Surface Missile Exercises (explosive and non-explosive)**

(A) Ordnance shall not be targeted to impact within 1,800 yd (1,646 m) of known or observed floating kelp.

(B) Aircraft shall visually survey the target area for marine mammals. Visual inspection of the target area shall be made by flying at 1,500 ft (457 m) 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 (1646 m) of sighted marine mammals.

2.3.2.7 **Demolitions, Mine Warfare, and Mine Countermeasures (up to a 2.5-lb charge)**

(A) Exclusion Zones—All Mine Warfare and Mine Countermeasures Operations involving the use of explosive charges must include exclusion zones for marine mammals to prevent physical and/or acoustic effects to those species. These exclusion zones shall extend in a 700-yard (640 m) arc radius around the detonation site.

(B) Pre-Exercise Surveys—For Demolition and Ship Mine Countermeasures Operations, pre-exercise surveys shall 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 shall be alert to the presence of any marine mammal. Should such an animal be present within the survey area, the explosive event shall not be started until the animal voluntarily leaves the area. The Navy will ensure the area is clear of marine mammals for a full 30 minutes prior to initiating the explosive event. Personnel will record any marine mammal observations during the exercise as well as measures taken if species are detected within the exclusion zone.

(C) Post-Exercise Surveys—Surveys within the same radius shall also be conducted within 30 minutes after the completion of the explosive event.

(D) Reporting—If there is evidence that a marine mammal may have been stranded, injured or killed by the action, Navy training activities shall 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 Northwest, Environmental Director, and the chain-of-command. The situation shall also be reported to NMFS (see Stranding Plan for details).

2.3.2.8 **Extended Echo Ranging/ Improved Extended Echo Ranging (EER/ IEER)**

(A) Crews shall conduct visual reconnaissance of the drop area prior to laying their intended sonobuoy pattern. This search shall be conducted at an altitude below 1500 ft (457 m) at a slow speed, if operationally feasible and weather conditions permit. In dual aircraft operations, crews are allowed to conduct area clearances utilizing more than one aircraft.

(B) For IEER (AN/SSQ–110A), crews shall conduct a minimum of 30 minutes of visual and aural monitoring of the search area prior to commanding the first post detonation. This 30-minute observation period may include pattern deployment time.

(C) For any part of the intended sonobuoy pattern where a post (source/ receiver sonobuoy pair) will be deployed within 1,000 yd (914 m) of observed marine mammal activity, the Navy shall deploy the receiver only (*i.e.*, not the source) and monitor while conducting a visual search. When marine mammals are no longer detected within 1,000 yd (914 m) of the intended post position, the source sonobuoy (AN/ SSQ–110A/SSQ–125) will be co-located with the receiver.

(D) When operationally feasible, Navy crews shall conduct continuous visual and aural monitoring of marine mammal activity. This shall include monitoring of aircraft sensors from the time of the first sensor placement until the aircraft have left the area and are out of RF range of these sensors.

(E) Aural Detection—If the presence of marine mammals is detected aurally, then that shall cue the Navy aircrew to increase the vigilance of their visual surveillance. Subsequently, if no marine mammals are visually detected, then the crew may continue multi-static active search.

(F) Visual Detection—If marine mammals are visually detected within 1,000 yd (914 m) of the explosive source sonobuoy (AN/SSQ–110A) intended for use, then that payload shall 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.

(G) For IEER (AN/SSQ–110A), aircrews shall 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 shall refrain from using the ''Scuttle'' command when two payloads remain at a given post. Aircrews will ensure that 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.

(H) Aircrews shall 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, or in-flight emergencies. In these cases, the sonobuoy will self-scuttle using the secondary or tertiary controls.

(I) The Navy shall 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, then upon landing via naval message.

(J) Mammal monitoring shall continue until out of own-aircraft sensor range.

2.4 NMFS's Permits and Conservation Division Actions Pursuant to the MMPA That Are Likely to Affect ESA-listed Resources

Under the Marine Mammal Protection Act (MMPA) of 1972 as amended (16 United States Code [U.S.C.] § 1371(a)(5)), the Secretary of Commerce shall allow, upon request, the incidental, but not intentional, taking of marine mammals by U.S. citizens who engage in a specified activity during periods of not more than 5 years, if certain findings are made and regulations are issued after notice and opportunity for public comment. The Secretary must find that the taking will have a negligible impact on the species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses. The regulations must set forth the permissible methods of taking, other means of affecting the least practicable adverse impact on the species or stock(s), and requirements pertaining to the monitoring and reporting of such taking.

2.4.1 Promulgation of the Five-Year MMPA Regulations (2010-2015)

NMFS's Permits and Conservation Division finalized regulations (50 CFR § 218.110 et seq.) authorizing issuance of incidental take authorizations for the U.S. Navy's "take" of marine mammals (a) within the U.S. Navy's NWTRC, which is bounded by 48°30° N. latitude (lat.), 130°00° W. longitude (long.); 40°00° N. lat. and on the east by 124°00° W. long.; or by the shorelines where the shoreline extends west of 124°00°W. long. (excluding the Strait of Juan de Fuca; east of 124°40° W. long.) which is not included in the offshore area and (b) incidental to the following activities within the following designated amounts of use:

1 The use of the following mid-frequency active sonar (MFAS) and high frequency active sonar (HFAS) sources for U.S. Navy anti-submarine warfare (ASW) training:

- i AN/SQS-53 (hull-mounted active sonar) – up to 43 hours per year;
- ii AN/SQS-56 (hull-mounted active sonar) – up to 65 hours per year;
- iii AN/BQS-15 (submarine navigational sonar) – up to 42 hours per year;
- iv AN/SSQ-62 (Directional Command Activated Sonobuoy System (DICASS) sonobuoys) –up to 886 sonobuoys per year;

v AN/SSQ-125 (AEER sonobuoys) –up to 149 sonobuoys per year (total combined with EER/IEER);
vii Range Pingers – up to 180 hours per year; and
viii PUTR uplink – up to 150 hours per year.

2 The detonation of the underwater explosives conducted as part of the training events indicated in this paragraph:
i Underwater Explosives (Net Explosive Weight):

(A) 5" Naval Gunfire (9.5 lbs);
(B) 76 mm rounds (1.6 lbs);
(C) MK-82 (238 lbs);
(D) Demolition Charges (2.5 lbs, 1.5 lbs or 1 oz);
(E) AN/SSQ-110A (IEER explosive sonobuoy - 5 lbs);
(F) GBU 10, 12, AND 16

ii Training Events:
(A) Surface-to-surface gunnery exercises – up to 340 exercises per year;
(B) Bombing Exercises – up to 30 exercises per year;
(C) Extended Echo Ranging and Improved Extended Echo Ranging (EER/IEER) Systems – up to 149 sonobuoy deployments per year.

(b) The authorization is also valid for the activities and sources listed above should the amounts (i.e., hours, dips, number of exercises) vary from those estimated, provided that the variation does not result in exceeding the amount of take indicated in 50 C.F.R. § 218.112.

2.4.2 Mitigation Required by NMFS's Permits and Conservation Division

NMFS's Permits and Conservation Division requires that the U.S. Navy, as the holder of the LOA, implement the mitigation measures, *see* 50 CFR § 218.114, as well as any additional measures contained in the LOA, when conducting activities identified in 50 CFR § 218.110(c) and those described above in Sections 2.1 and 2.2 on the NWTRC.

2.4.3 Monitoring and Reporting

When conducting operations under the LOA, the U.S. Navy must implement the following monitoring and reporting measures:

(a) General Notification of Injured or Dead Marine Mammals – Navy personnel shall ensure that NMFS is notified immediately (see Communication Plan) or as soon as clearance procedures allow) if an injured, stranded, or dead marine mammal is found during or shortly after, and in the vicinity of, any Navy training exercise utilizing MFAS, HFAS, or underwater explosive detonations. The Navy will provide NMFS with the name of species or description of the animal

(s), the condition of the animal(s) (including carcass condition if the animal is dead), location, time of first discovery, observed behaviors (if alive), and photo or video (if available). In the event that an injured, stranded, or dead marine mammal is found by the Navy that is not in the vicinity of, or during or shortly after, MFAS, HFAS, or underwater explosive detonations, the Navy will report the same information as listed above as soon as operationally feasible and clearance procedures allow.

(b) General Notification of Ship Strike – In the event of a ship strike by any Navy vessel, at any time or place, the Navy shall do the following:

(1) Immediately report to NMFS the species identification (if known), location (lat./long.) of the animal (or the strike if the animal has disappeared), and whether the animal is alive or dead (or unknown).

(2) Report to NMFS as soon as operationally feasible the size and length of animal, an estimate of the injury status (ex., dead, injured but alive, injured and moving, unknown, etc.), vessel class/type and operational status.

(3) Report to NMFS the vessel length, speed, and heading as soon as feasible.

(4) Provide NMFS a photo or video, if equipment is available.

(c) Event Communication Plan – The Navy shall develop a communication plan that will include all of the communication protocols (phone trees, etc.) and associated contact information required for NMFS and the Navy to carry out the necessary expeditious communication required in the event of a stranding or ship strike, including as described in the notification measures above.

(d) The Navy must conduct all monitoring and required reporting under the LOA, including abiding by NWTRC Monitoring Plan.

(e) The Navy shall comply with the Integrated Comprehensive Monitoring Program (ICMP) Plan and continue to improve the program in consultation with NMFS.

(f) Annual NWTRC Monitoring Plan Report – The Navy shall submit a report on July 1st of each year describing the implementation and results through May 1st of the same year) of the NWTRC Monitoring Plan. Data collection methods will be standardized across range complexes to allow for comparison in different geographic locations. Although additional information will also be gathered, the marine mammal observers (MMOs) collecting marine mammal data pursuant to the NWTRC Monitoring Plan shall, at a minimum, provide the same marine mammal observation data required in 50 CFR § 218.115(g)(1). The NWTRC Monitoring Plan Report may

be provided to NMFS within a larger report that includes the required Monitoring Plan Reports from multiple Range Complexes.

(g) Annual NWTRC Exercise Report – The Navy shall submit an Annual NWTRC Exercise Report on July 1st (covering data gathered through May 1st). This report shall contain information identified in 50 CFR § 218.115(g)(1) through (5).

(1) ASW Summary – This section shall include the following information as summarized from non-major training exercises (unit-level exercises, such as TRACKEXs):

(i) Total annual hours of each type of sonar source (along with explanation of how hours are calculated for sources typically quantified in alternate way (buoys, torpedoes, etc.))

(ii) Cumulative Impact Report – To the extent practicable, the Navy, in coordination with NMFS, shall develop and implement a method of annually reporting non-major (i.e., other than MTEs) training exercises utilizing hull-mounted sonar. The report shall present an annual (and seasonal, where practicable) depiction of non-major training exercises geographically across the NWTRC. The Navy shall include (in the NWTRC annual report) a brief annual progress update on the status of the development of an effective and unclassified method to report this information until an agreed-upon (with NMFS) method has been developed and implemented.

(3) IEER Summary – This section shall include an annual summary of the following IEER information:

(i) Total number of IEER events conducted in the NWTRC

(ii) Total expended/detonated rounds (buoys)

(iii) Total number of self-scuttled IEER rounds

(4) Explosives Summary – To the extent practicable, the Navy will provide the information described below for all of their explosive exercises. Until the Navy is able to report in full the information below, they will provide an annual update on the Navy's explosive tracking methods, including improvements from the previous year.

(i) Total annual number of each type of explosive exercises (of those identified as part of the "specified activity" in this final rule) conducted in the NWTRC Range.

(ii) Total annual expended/detonated rounds (missiles, bombs, etc.) for each explosive type.

(h) NWTRC 5-yr Comprehensive Report – The Navy shall submit to NMFS a draft report that analyzes and summarizes all of the multi-year marine mammal information gathered during ASW and explosive exercises for which annual reports are required (Annual NWTRC Exercise Reports and NWTRC Monitoring Plan Reports). This report will be submitted at the end of the fourth year of the rule (July 2014), covering activities that have occurred through February1, 2014.

(i) Comprehensive National ASW Report – The Navy submitted a draft National Report that analyzes, compares, and summarizes the active sonar data gathered (through January 1, 2014) from the watchstanders and pursuant to the implementation of the Monitoring Plans for the Southern California Range Complex, the Atlantic Fleet Active Sonar Training, the Hawaii Range Complex, the Mariana Islands Range Complex, the NWTRC, and the Gulf of Alaska.

(j) The Navy has responded to NMFS comments and/or requests for additional information or clarification on the NWTRC Comprehensive Report, the Comprehensive National ASW report, the Annual NWTRC Exercise Report, or the Annual NWTRC Monitoring Plan Report (or the multi-Range Complex Annual Monitoring Plan Report. These reports will be considered final after the Navy has addressed NMFS' comments or provided the requested information, or three months after the submittal of the draft if NMFS does not comment by then.

2.5 Action Area

The action area for this Opinion encompasses waters within and adjacent to the U.S. Navy's NWTRC. This consists of two primary components: the Offshore Area and the Inshore Area (see Figure 1,

Figure 2, and Figure 3). The Northwest Range Complex includes ranges, operating areas, and airspace that extend west to 250 nautical miles (nm) (463 kilometers [km]) beyond the coast of Washington, Oregon, and Northern California; and east to the Washington/Idaho border. These components of the NWTRC encompass 122,440 square nautical miles (420,163 square kilometers [km2]) of surface and subsurface ocean operating areas, 46,048 nm2 (157,928 km2) of special use airspace, 367 nm2 (1,258 km2) of Restricted Airspace and 875 acres (354 hectares) of land.

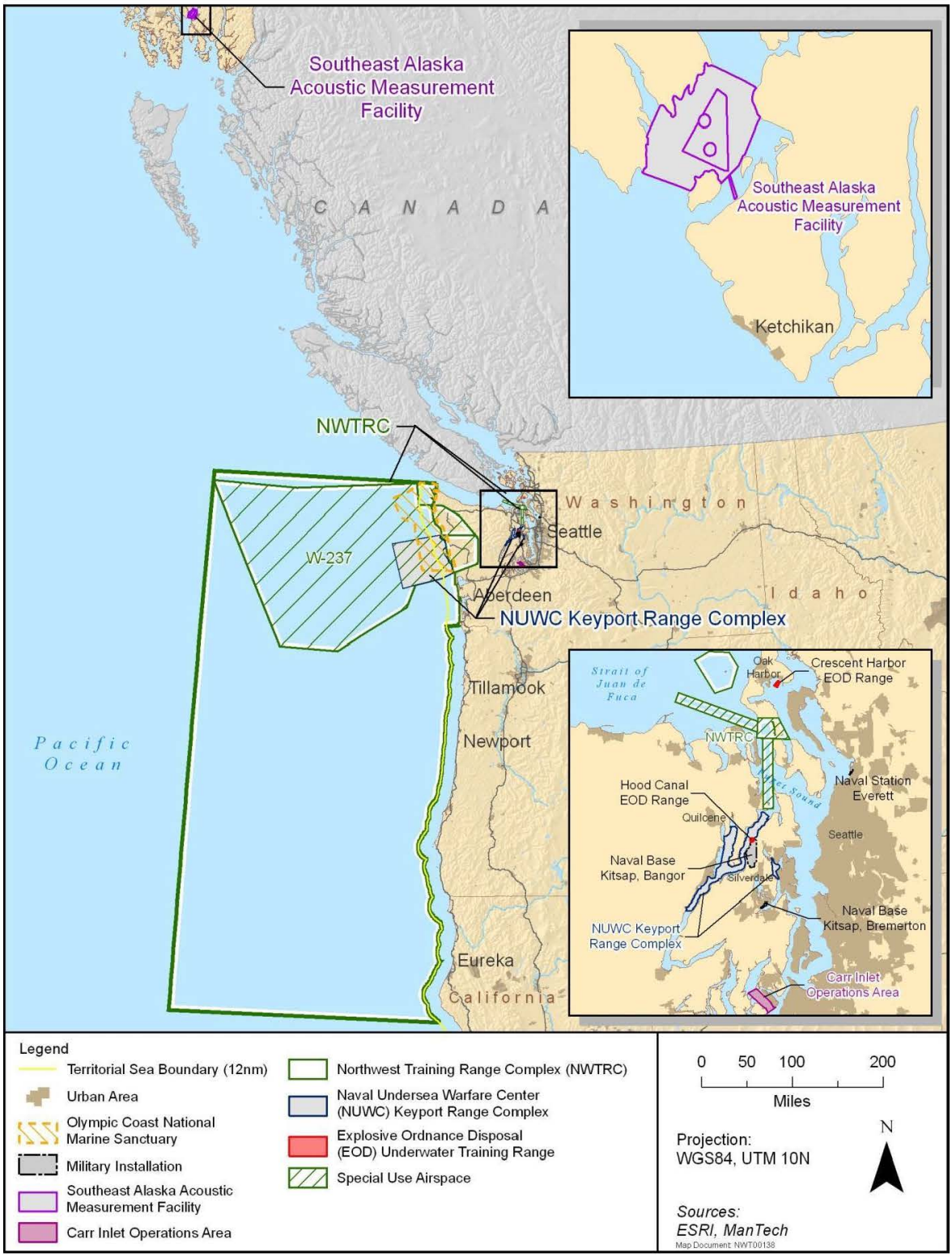

Figure 1. The Action Area (Northwest Training Range Complex)

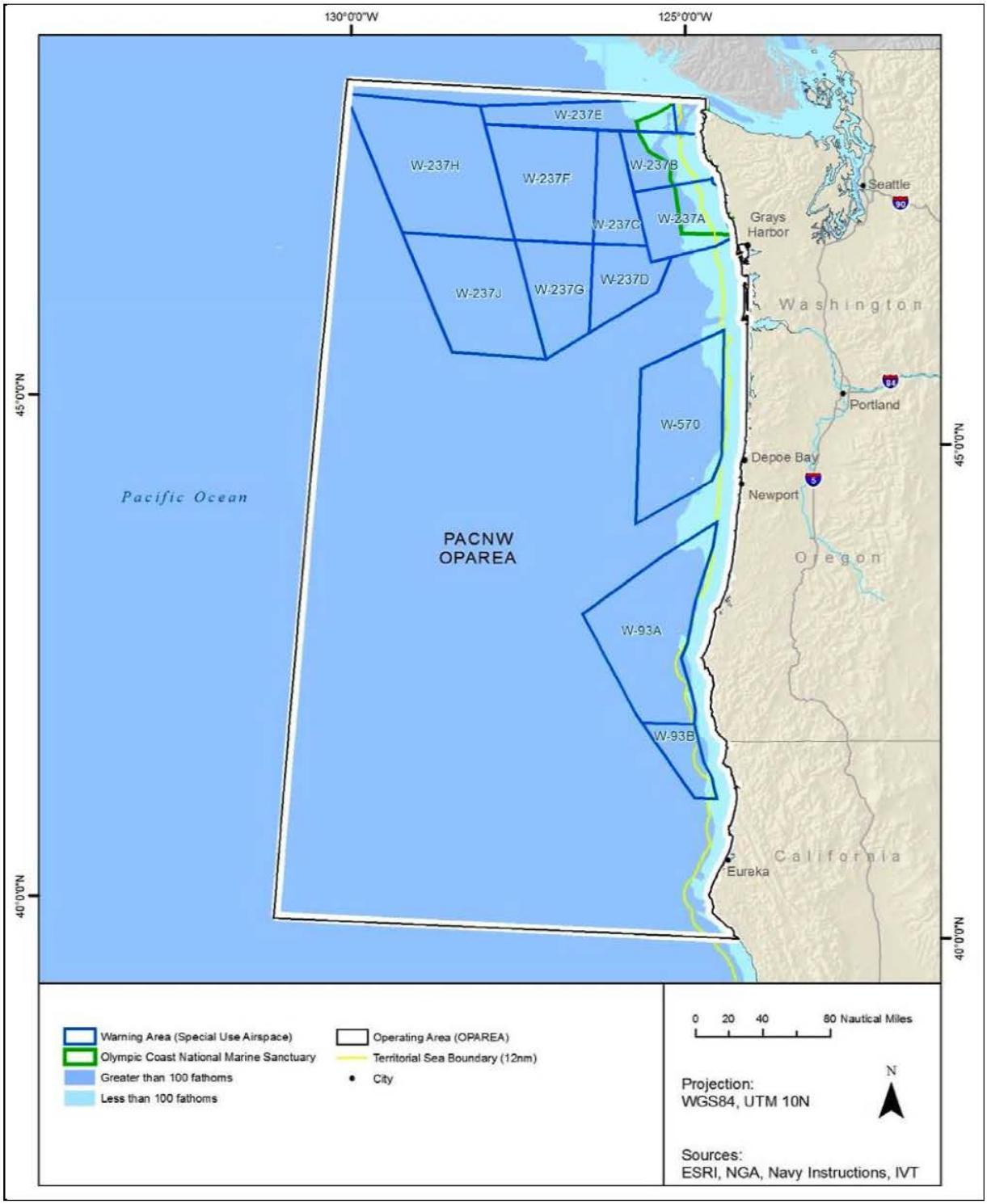

Figure 2. The Offshore Areas of the Northwest Training Range Complex.

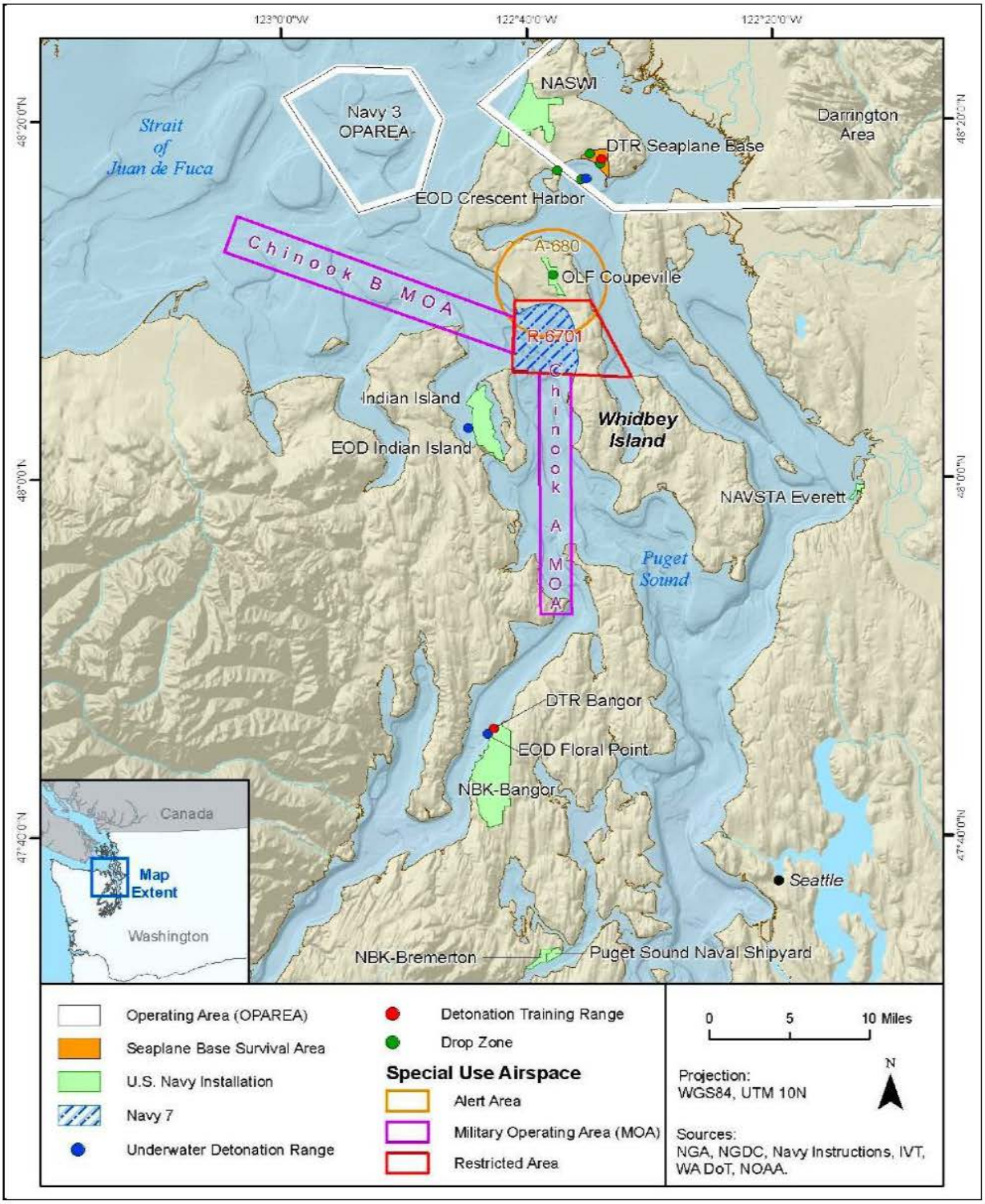

Figure 3. The Puget Sound Training Areas of the Northwest Training Range Complex.

We assume that any activities that are likely to occur landward of the mean higher high water line that may affect threatened or endangered species under the jurisdiction of the U.S. Fish and Wildlife Service, including activities that may affect sea turtles landward of the mean higher high water line are addressed in separate section 7 consultations with the U.S. Fish and Wildlife Service[4].

3 APPROACH TO THE ASSESSMENT

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. The jeopardy analysis considers both survival and recovery of the species. The adverse modification analysis considers the impacts on the conservation value of designated critical habitat.

"To jeopardize the continued existence of a listed species" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02).

This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 C.F.R. 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.[5]

3.1 Overview of NMFS' Assessment Framework

We will use the following approach to determine whether the action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the action.
- Describe the environmental baseline in the action area. The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities *in the action area*. It includes the anticipated impacts of Federal projects that

[4] Since 1977, NOAA Fisheries and U.S. Fish and Wildlife Service (USFWS) have shared shared jurisdiction for recovery and conservation of sea turtles listed under the ESA. A Memorandum of Understanding [pdf] outlines our specific roles: we lead the conservation and recovery of sea turtles in the marine environment, and USFWS has the lead for the conservation and recovery of sea turtles on nesting beaches.

[5] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the "Destruction or Adverse Modification" Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process.

- Analyze the effects of the action on both species and their habitat. In this step, we consider how the action would affect the species' reproduction, numbers, and distribution or, in the case of salmon and steelhead, their viable salmonid population (VSP) parameters. We also evaluate the action's effects on critical habitat features.
- Describe any cumulative effects in the action area. Cumulative effects, as defined in our implementing regulations (50 CFR §402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the action are not considered because they require separate section 7 consultation.

We integrate and synthesize the above factors to assess the risk that the action poses to species and critical habitat. In this step (*Integration and Synthesis*), we add the effects of the action (Section 6) to the *Environmental Baseline* (Section 5) and the *Cumulative Effects* (Section 6.10) to assess whether the action could reasonably be expected to: (1) reduce appreciably the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the conservation value of designated or proposed critical habitat. These assessments are made in full consideration of the *Status of the Species* and critical habitat (Section 4).

Reach jeopardy and adverse modification C*onclusion*. In this step (Section 8) we state our conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 8. These conclusions flow from the logic and rationale presented in Section 7 (*Integration and Synthesis*).

If necessary, **define a reasonable and prudent alternative to the action**. If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative to the action. The action as conducted in accordance with the reasonable and prudent alternative must not be likely to jeopardize the continued existence of listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

3.2 Risk Analysis for Endangered and Threatened Species

Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of listed species depends on the fate of the populations that comprise them, the viability (that is, the probability of extinction or probability of persistence) of listed species

depends on the viability of the populations that comprise the species. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species and the populations that comprise them, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individuals risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the individual's "fitness," which are changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable response to an Action's effects on the environment (which we identify in our *response analyses*) are likely to have consequences for the individual's fitness.

When individual, listed plants or animals are expected to experience reductions in fitness, we would expect those reductions to also reduce the abundance, reproduction rates, or growth rates (or increase variance in one or more of these rates) of the populations those individuals represent (Stearns 1992a). Reductions in one or more of these variables (or one of the variables we derive from them) is a *necessary* condition for reductions in a population's viability, which is itself a *necessary* condition for reductions in a species' viability. Therefore, when listed plants or animals exposed to an Action's effects are *not* expected to experience reductions in fitness, we would not expect that Action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (Anderson 2000a; Mills and Beatty 1979; Stearns 1992a). As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment because an Action that is not likely to affect the fitness of individuals is not likely to jeopardize the continued existence of listed species.

If, however, we conclude that individual listed plants or animals are likely to experience reductions in their fitness, our assessment tries to determine if those fitness reductions are likely to be sufficient to reduce the viability of the populations those individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about the population's extinction risks). In this step of our analyses, we use the population's base condition (established in the *Environmental Baseline* and *Status of Listed Resources* sections of this Opinion) as our point of reference. Finally, our assessment tries to determine if changes in population viability are likely

to be sufficient to reduce the viability of the species those populations comprise. In this step of our analyses, we use the species' status (established in the *Environmental Baseline* and *Status of Listed Resources* sections of this Opinion) as our point of reference and we use our understanding of the general patterns and processes by which species become extinct to help inform our decision about whether changes in the performance of one or more populations are likely to affect the viability of the species those populations comprise.

3.3 Risk Analysis for Designated Critical Habitat

Our "destruction or adverse modification" determinations must be based on an action's effects on the conservation value of habitat that has been designated as critical to threatened or endangered species[6]. If an area encompassed in a critical habitat designation is likely to be exposed to the *direct or indirect consequences of the action on the natural environment*, we ask if primary or secondary constituent elements included in the designation (if there are any) or physical or biotic phenomena that give the designated area value for the conservation are likely to respond to that exposure.

In this step of our assessment, we identify (a) the spatial distribution of stressors produced by an action; (b) the temporal distribution of stressors and subsidies produced by an action; (c) changes in the spatial distribution of the stressors with time; (d) the intensity of stressors in space and time; (e) the spatial distribution of physical and biological features of designated critical habitat; and (f) the temporal distribution of constituent elements of designated critical habitat.

If primary constituent elements of designated critical habitat (or physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species) are likely to respond given exposure to the *direct or indirect consequences of the proposed action on the natural environment*, we ask if those responses are likely to be sufficient to reduce the quantity, quality, or availability of those constituent elements or physical, chemical, or biotic phenomena.

In this step of our assessment, we must identify or make assumptions about (a) the habitat's probable condition before any exposure as our point of reference (that is part of the impact of the *Environmental Baseline* on the conservation value of the designated critical habitat); (b) the ecology of the habitat at the time of exposure; (c) where the exposure is likely to occur; and (d) when the exposure is likely to occur; (e) the intensity of exposure; (f) the duration of exposure; and (g) the frequency of exposure.

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[6] We are aware that several courts have ruled that the definition of destruction or adverse modification that appears in the section 7 regulations at 50 CFR §402.02 is invalid and do not rely on that definition for the determinations we make in this Opinion. Instead, as we explain in the text, we use the "conservation value" of critical habitat for our determinations which focuses on the designated area's ability to contribute to the conservation or the species for which the area was designated.

In this step of our assessment, we recognize that the conservation value of critical habitat, like the base condition of individuals and populations, is a dynamic property that changes over time in response to changes in land use patterns, climate (at several spatial scales), ecological processes, changes in the dynamics of biotic components of the habitat, etc. For these reasons, some areas of critical habitat might respond to an exposure when others do not. We also consider how designated critical habitat is likely to respond to any interactions and synergisms between or cumulative effects of pre-existing stressors and proposed stressors.

If the quantity, quality, or availability of the primary constituent elements of the area of designated critical habitat (or physical, chemical, or biotic phenomena) are reduced, we ask if those reductions are likely to be sufficient to reduce the conservation value of the designated critical habitat for listed species in the action area. In this step of our assessment, we combine information about the contribution of constituent elements of critical habitat (or of the physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species, particularly for older critical habitat designations that have no constituent elements) to the conservation value of those areas of critical habitat that occur in the action area, given the physical, chemical, biotic, and ecological processes that produce and maintain those constituent elements in the action area. We use the conservation value of those areas of designated critical habitat that occur in the action area as our point of reference for this comparison. For example, if the critical habitat in the action area has limited current value or potential value for the conservation of listed species that limited value is our point of reference for our assessment.

If the conservation value of designated critical habitat in an action area is reduced, the final step of our analyses asks if those reductions are likely to be sufficient to reduce the conservation value of the entire critical habitat designation. In this step of our assessment, we combine information about the constituent elements of critical habitat (or of the physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species, particularly for older critical habitat designations that have no constituent elements) that are likely to experience changes in quantity, quality, and availability given exposure to an action with information on the physical, chemical, biotic, and ecological processes that produce and maintain those constituent elements in the action area. We use the conservation value of the entire designated critical habitat as our point of reference for this comparison. For example, if the entire designated critical habitat has limited current value or potential value for the conservation of listed species that limited value is our point of reference for our assessment.

3.4 Defining "Significance"

In biological opinions, we focus on potential physical, chemical, or biotic stressors that are "significant" in the sense of being distinct from ambient or background. We then ask if

a. exposing individuals to those potential stressors is likely to represent a "significant" negative experience in the life history of individuals that have been exposed; and if

b. exposing individuals to those potential stressors is likely to cause the individuals to experience "significant" physical, chemical, or biotic responses; and if

c. any "significant" physical, chemical, or biotic response are likely to have "significant" consequence for the fitness of the individual animal; and if

d. exposing the physical, chemical, or biotic phenomena that we identified as constituent elements in a critical habitat designation or, in the case of critical habitat designations that do not identify constituent elements, those physical, chemical or biotic phenomena that give designated critical habitat value for the conservation of endangered or threatened species is likely to represent a "significant" change in the quantity, quality, or availability of the physical, chemical, or biotic resource; and if

e. any "significant" change in the quantity, quality, or availability of a physical, chemical, or biotic resource is likely to "significantly" reduce the conservation value of the designated critical habitat.

In all of these cases, the term "significant" means "clinically or biotically significant" rather than statistically significant because the presence or absence of statistical significance do not imply the presence or absence of clinical significance (Achinstein 2001; Royall 2004) (Johnson 1999).

For populations (or sub-populations, demes, etc.), we are concerned about whether the number of individuals that are likely to experience "significant" reductions in fitness and the nature of any fitness reductions are likely to have a "significant" consequence for the viability (= probability of demographic, ecological, or genetic extinction) of the population(s) those individuals represent. Here "significant" also means "clinically or biotically significant" rather than statistically significant.

For "species" (the entity that has been listed as endangered or threatened, not the biological species concept), we are concerned about whether the number of populations that are likely to experience "significant" reductions in viability (= increases in their extinction probabilities) and the nature of any reductions in viability are likely to have "significant" consequence for the viability (= probability of demographic, ecological, or genetic extinction) of the "species" those populations comprise. Here, again, "significant" also means "clinically or biotically significant" rather than statistically significant.

For designated critical habitat, we are concerned about whether the area that has been designated is likely to experience "significant" reductions in the quantity, quality, or availability of physical,

chemical, or biotic resources that are likely to result in "significant" reductions in the conservation value (usually measured using the concept of "carrying capacity[7]") of the entire are contained in the designation.

3.5 Treatment of "Cumulative Impacts" (in the sense of NEPA)

Several organizations have argued that previous biological opinions on the U.S. Navy's use of active sonar failed to consider the "cumulative impact" (in the NEPA sense of the term) of active sonar on the ocean environment and its organisms, particularly endangered and threatened species and critical habitat that has been designated for them. The U.S. Council on Environmental Quality defined "cumulative effects" (which we refer to as "cumulative impacts" to distinguish between NEPA and ESA uses of the same term) as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions" (40 CFR §1508.7). The effects analyses of biological opinions evaluate the same information contained in the "cumulative impacts" sections of NEPA documents. We consider the "impacts" on listed species and designated critical habitat that result from the additional impact of an action by identifying natural and anthropogenic stressors that affect endangered and threatened species throughout their range (the *Status of Listed Resources*) and within an Action Area (the *Environmental Baseline*, which articulate the pre-existing *impacts* of Federal, state and private activities that occur in an Action Area, including the past, contemporaneous, and future *impacts* of those activities). We assess the effects of a proposed action by adding their direct and indirect effects to the *impacts* of the activities we identify in an *Environmental Baseline* (50 CFR §402.02), in light of the impacts of the status of the listed species and designated critical habitat throughout their range. We also add and analyze the effects of those future State or private activities that are reasonably certain to occur and that do not require Federal funding or authorization. We do not include those activities requiring Federal approval or funding because those will undergo an independent section 7 consultation that will treat the activity under consultation as part of the environmental baseline.

We considered potential cumulative impacts as part of our consultation. Specifically, we considered (1) impacts or effects that accumulate in the environment in the form of stressors or reservoirs of stressors and (2) impacts or effects that represent either the response of individuals, populations, or species to that accumulation of stressors in the environment or the accumulated responses of individuals, populations, and species to sequences of exposure to stressors. Further, we considered the potential impacts of these accumulative phenomena on an annual basis, over the duration of the five-year MMPA regulations, and under the assumption that these activities

[7] largest number of individuals of a particular species that can survive over long periods of time in a given enviroment, this level depends on the effect of the limiting factors

would continue into the reasonably foreseeable future. Given the ongoing nature of the activities, we assume that the type, amount, and extent of training in the NWTRC does not exceed maximum levels assessed in the action.

In the sense of Item 1, which captures the normal usage of "cumulative impacts," we concluded that phenomena like sound do not accumulate (sound energy rapidly transforms into other forms of energy), although phenomena like the acreage of habitat destroyed and concentrations of toxic chemicals, sediment, and other pollutants accumulate. If there is sufficient time between exposures of individuals to sound stressors below levels for permanent injury, individuals would have ability to recover. We conclude that the probability of vessel strikes accumulated, in the sense that the probabilities of collisions associated with multiple transits are higher than the probabilities associated with a single transit. We factored those considerations into our estimation of the probability of a collision associated with multiple transits.

In the sense of Item 2, we considered phenomena that accumulate in individuals and individually contribute or collectively determine the probable fitness of the individuals that comprise a population. These include, the passage of time and its corollary, the passage or loss of time (specifically, the loss of time to reproduce, to forage, and to migrate, etc.); reproductive success; longevity; energy debt, including allostatic loading; body burdens of toxic chemicals; the fitness costs of behavioral decisions (canonical costs); injuries and tissue damage; and overstimulation of sensory organs (which would include noise-induced losses of hearing sensitivity).

At the level of populations, phenomena that "accumulate" include population abundance; the number or percent of individuals in a population with lifetime reproductive success greater than 2.0; the number or percent of individuals in a population with lifetime reproductive success equal to 2.0; the number or percent of individuals in a population with lifetime reproductive success less than 2.0; the number or percent of individuals that emigrate from a population per unit time; the number or percent of individuals that immigrate into a population per unit time; mortality within a particular age or stage over generation time; and the reservoir of juveniles in a population that have a high probability of surviving to the age of reproduction (population momentum or its absence).

At the species level, we accumulate those phenomena that allow us to estimate the extinction risks facing a species. These include increases or decreases in the number of occurrences or populations; the extinction probability of particular occurrences; variance in the rates of population growth or decline; and demographic stochasticity.

Cumulative effects also include effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

3.6 Evidence Available for the Consultation

To conduct these analyses, we considered all lines of evidence available through published and unpublished sources that represent evidence of adverse consequences or the absence of such consequences. Over the past decade, a considerable body of scientific information on anthropogenic sounds and their effect on marine mammals and other marine life has become available. Many investigators have studied the potential responses of marine mammals and other marine organisms to human-generated sounds in marine environments or have integrated and synthesized the results of these studies. Additionally, recent NMFS status reviews for listed species also provide information on the status of the species including their resiliency, population trends and specific threats to recovery that contributes to our *Status of the Species*, *Environmental Baseline*, and Risk Analyses.

To supplement that body of knowledge, we conducted electronic literature searches. Our searches specifically focus on *Dissertation Abstracts, Conference Papers Index, and Proceedings* which index the major journals dealing with issues of biology and ecological risk. In addition to these sources, we searched NMFS Office of Protected Resources' electronic library (using *EndNote* ® software) consisting of information from these and many other sources that collectively provide a comprehensive collection of citations and documents on listed species as well as the anthropogenic and natural stressors they experience. To supplement our searches, we examined the literature that was cited in the submittal documents and any articles we collected through our electronic searches. We did not conduct hand searches of published journals for this consultation. We organized the results of these searches using commercial bibliographic software.

To comply with our obligation to use the best scientific and commercial data available, we conducted additional searches throughout the consultation and during drafting of the biological opinion to identify information that has become available since we issued the previous biological opinions on the training by the U.S. Navy's Pacific Fleet in the NWTRC. The U.S. Navy provided NMFS with a final EIS/OEIS, in September 2010, on training that in the NWTRC. In addition to the 2010 Final EIS/OEIS, we evaluated new modeling analysis based on the latest criteria for injury and mortality and species density information, described in the No Action Alternative of the January 2014 Draft EIS/OEIS for NWTT. We also evaluated the Navy's annual and comprehensive major training exercise and monitoring reports to assess effectiveness of mitigation and actual take incidental to actual training activity levels where feasible.

NMFS is currently in the process of re-evaluating the acoustic criteria as they apply to all activity types (not just the Navy). Although our current use of acoustic criteria and acoustic thresholds represents the best available science at the time of this action, our continued evaluation of all available science and that science's application in the context of an acoustic threshold could potentially result in changes to the acoustic criteria to the extent they are relevant to Navy

activities. However, it is important to note that while changes in acoustic criteria may affect the enumeration of "takes," they do not necessarily significantly change the evaluation of population level effects or the outcome of a jeopardy analysis. Further, while acoustic criteria may also inform mitigation and monitoring activities, the Navy has a robust adaptive management program that actively and regularly addresses new information and allows for modification of mitigation and/or monitoring measures as appropriate. When new information is identified that would potentially change our conclusions on population-level effects or our jeopardy analysis, reinitiation of consultation may be required.

Considering the information that was available, this consultation and our Opinion involved a large amount of uncertainty about the basic hearing capabilities of marine mammals, sea turtles, and fishes; how these taxa use sounds as environmental cues, how they perceive acoustic features of their environment; the importance of sound to the normal behavioral and social ecology of species; the mechanisms by which human-generated sounds affect the behavior and physiology (including the non-auditory physiology) of exposed individuals, and the circumstances that are likely to produce outcomes that have adverse consequences for individuals and populations of exposed species.

3.6.1 **The U.S. Navy's Exposure Estimates**

The 2010 Final EIS/OEIS used an acoustic modeling methodology and marine mammal density information developed by the Navy in cooperation with NMFS that was the best available information at the time. A subsequent review on behalf of NMFS by the Center for Independent Experts analyzed the various approaches the Navy used for acoustic effects analyses, leading to the refinement of the previous methodologies for determining acoustic effects. The result was the development of a standard Navy model for acoustic effects, the Navy Acoustic Effects Model (NAEMO). By using this more comprehensive modeling software, the inclusion of sources not previously analyzed, updated marine mammal densities, and revised acoustic criteria (based in part on the 2010 and 2011 Finneran dolphin studies referenced in the Court's order summarized above), the predicted number of effects are expected to change from those quantified in the 2010 EIS/OEIS. To comply with the Court's order that NMFS consider the best available scientific data (including the 2010 and 2011 Finneran dolphin studies),this Opinion analyzes the environmental consequences based on new marine mammal density data, a new acoustic modeling method that employs revised acoustic criteria, and new scientific information as prepared for the Phase II, NWTT action, as described in the January 2014 draft EIS/OEIS covering training and testing activities from 2015 to 2020. The U.S. Navy will consult with NMFS on the activities in the NWTT action.

3.6.1.1 **The U.S. Navy Acoustic Effects Model (NAEMO)**

Since 1997, the U.S. Navy has modeled the potential acoustic effects on marine mammals and sea turtles from specific Navy training and test activities. Various models used "area density"

approaches in which acoustic footprints were computed and then multiplied by animal densities to calculate effects. As a result of a review conducted by the Center for Independent Experts, as required by the National Marine Fisheries Service, the Navy refined its process. The new model, NAEMO, is the standard model now used by the Navy to estimate the potential acoustic effects of Navy training activities on marine mammals and sea turtles.

NAEMO is comprised of seven modules: Scenario Builder, Environment Builder, Acoustic Builder, Marine Species Distribution Builder, Scenario Simulator, Post Processor, and Report Generator. Scenario Builder is a graphical user interface (GUI)-based tool that defines where an activity would occur, the duration of the activity, a description of the activity, and what platforms would be participating. Once a platform is identified, all the sound sources typically associated with that platform are displayed, thus providing standardization and repeatability when different analysts are entering data. Individual sources can be turned on or off according to the requirements of the scenario. Platforms are either stationary or can be moved through the action area in either a defined track or random straight-line movement.

Environment Builder is a GUI that extracts all of the oceanographic and environmental data required for a scenario simulation. When an area is selected, information on bathymetry, sound speed profiles, wind speeds, and bottom properties are extracted from an array of points across the region, using Oceanographic and Atmospheric Master Library databases. Seasonal averages are created for the sound speed profiles and wind speeds from historical average values.

Acoustic Builder is a GUI that generates acoustic propagation data. It reads the Scenario Builder file, allows the user to define analysis points for propagation software, and creates the propagation model inputs. Depending on the source characteristics, the propagation models utilized are Comprehensive Acoustic Simulation System/Gaussian Ray Bundle, Range-Dependent Acoustic Model, or Reflection and Refraction Multilayered Ocean/Ocean Bottoms with Shear Wave Effects.

Marine Species Distribution Builder is a module that allows the user to distribute marine species within the modeling environment in accordance with the bathymetry and relevant descriptive data. Marine species density data, which include seasonal information when available, are obtained from the Navy Marine Species Density Database; the sizes of cells and density of marine species within each cell vary by species and location.

Scenario Simulator executes the simulation and records the sound received by each marine mammal and sea turtle in the area for every time step that sound is emitted; it incorporates the scenario definition, sound propagation data, and marine species distribution data, ultimately providing raw data output for each simulation. Most scenarios are run in small, 4- to 12-hour segments based on representative training activities. Some scenarios are evaluated by platform

and single locations, while others are evaluated in multiple locations within a single range complex or testing range. Within each scenario, multiple ship track iterations are run to provide a statistical set of raw data results.

Post Processor provides the computation of estimated effects that exceed defined threshold criteria from each of the raw data files produced by Scenario Simulator which are designed for determining harassment and mortality as defined by the MMPA for military readiness activities. It also affords the option to review the output data through a series of tables and graphs.

Report Generator enables the user to assemble a series of simulation results created by multiple post-processing runs and produce a combined result. Multipliers can be applied to each scenario to compute the effects of conducting them multiple times. Results can also be exported via Microsoft Excel files for further analysis and reporting.

Modeled effects from NAEMO were used to support the U.S. Navy's analyses in the January 2014 NWTT Draft EIS/OEIS, mitigation strategies, and documentation associated with ESA Biological Evaluations and MMPA permit applications. We have verified methodology and data used in NAEMO for these analyses and thus accept the modeling conclusions on exposure of marine species. We have verified the methodology and data used in NAEMO for these analyses, accept the modeling conclusions on exposure of marine species, and have considered those exposures in our analysis. A full description of NAEMO can be accessed in the NUWC-NPT Technical Report 12,071a, 23 August 2013 (updated from 12 March 2012) at: www.nwtteis.com.

3.6.1.2 **Marine Mammal Density Estimate Use in U.S. Navy Exposure Estimates**

There is no single source of density data for every area, species, and season because of the fiscal costs, resources, and effort involved to provide enough survey coverage to sufficiently estimate density. Therefore, to characterize marine mammal density for areas of concern such as the Action Area, the Navy compiled data from multiple sources. Each data source may use different methods to estimate density, of which, uncertainty in the estimate can be directly related to the method applied.

The Navy thus developed a protocol to select the best available data sources based on species, area, and time (season). The Navy then used this protocol to identify the best available density data from available sources, including habitat-based density models, line-transect analyses, and peer-reviewed published studies. These data were incorporated into a Geographic Information System database that includes seasonal (summer/fall and winter/spring) density values for every marine mammal species present within the Action Area. Detailed information on the Navy's selection protocol, datasets, and specific density values are provided in a Pacific Navy Marine Species Density Database Technical Report (U.S. Department of the Navy 2014).

A quantitative impact analysis requires an estimate of the number of animals that might be affected. A key element of this estimation is knowledge of the abundance and concentration of the species in specific areas where those activities will occur. The most appropriate unit of metric for this type of analysis is density or the number of animals present per unit area. Marine species density estimation requires a significant amount of effort to both collect and analyze data to produce a reasonable estimate. Unlike surveys for terrestrial wildlife, many marine species spend much of their time submerged, and are not easily observed. In order to collect enough sighting data to make reasonable density estimates, multiple observations are required, often in areas that are not easily accessible (e.g., far offshore). Ideally, marine species sighting data would be collected for the specific area and time period of interest and density estimates derived accordingly. However, in many places poor weather conditions and high sea states prohibit the completion of comprehensive surveys.

For most cetacean species, abundance is estimated using line-transect surveys or mark-recapture studies.(Barlow 2010; Barlow and Forney 2007; Calambokidis et al. 2008b). The result provides one single density estimate value, for each species, across broad geographic areas, such as waters within the U.S. Exclusive Economic Zone off California, Oregon, and Washington. This is the general approach applied in estimating cetacean abundance in the NMFS stock assessment reports. Though the single value provides a good average estimate of abundance (total number of individuals) for a specified area, it does not provide information on the species distribution or concentrations within that area, and does not estimate density for other timeframes/seasons that were not surveyed. More recently, habitat modeling has been used to estimate cetacean densities (Barlow et al. 2009; Becker et al. 2012a; Becker et al. 2012b; Becker et al. 2010; Becker et al. 2012c; Ferguson et al. 2006; Forney et al. 2012; Redfern et al. 2006). These models estimate cetacean density as a continuous function of habitat variables (e.g., sea surface temperature, seafloor depth, etc.) and thus allow predictions of cetacean densities on finer spatial scales than traditional line-transect or mark-recapture analyses. Within the Action Area that was modeled, densities can be predicted wherever these habitat variables can be measured or estimated.

Currently-published density estimates rely on low numbers of sightings available for their derivation. This can lead to uncertainty which is typically expressed by the coefficient of variation of the estimate, which is derived using standard statistical methods and describes the amount of variation with respect to the population mean. It is expressed as a fraction or sometimes a percentage and can range upward from zero, indicating no uncertainty, to high values. For example, a coefficient of variation of 0.85 would indicate high uncertainty in the population estimate. When the coefficient of variation exceeds 1.0, the estimate is very uncertain. The uncertainty associated with movements of animals into or out of an area (due to factors such as availability of prey or changing oceanographic conditions) is much larger than is indicated by the coefficient of variation.

The methods used to estimate pinniped at-sea densities are typically different than those used for cetaceans. Pinniped abundance is generally estimated via shore counts of animals at known rookeries and haul-out sites. Translating these numbers to in-water densities is difficult given the variability in foraging ranges, migration, and haul-out behavior between species and within each species, and is driven by factors such as age class, sex class, seasonal variation, etc. Details of the density derivation for each species of pinniped in the Action Area are provided in the Pacific Navy Marine Species Density Database Technical Report (U.S. Department of the Navy 2014). In summary, the methods used to derive pinniped densities involved a series of species-specific data reviews to compile the most accurate and up-to-date information available. This review was undertaken by a panel of subject matter experts, including marine mammal scientists from the Washington State Department of Fish and Wildlife, Navy, and ManTech International. Once all available information, including known haul-out sites and local abundance, had been reviewed and updated as necessary, the resulting numbers of animals were assigned to inland water areas divided into regions consistent with Jeffries et al. (Jeffries et al. 2003). The total abundance divided by the area of the region was the resultant density for each species in a given location.

3.6.1.3 **Differences Between Navy Modeling Considered in Previous Biological Opinions and this Reinitiated Biological Opinion**

Phase I (roughly 2008 through 2015) of the Navy's at-sea environmental planning and permitting effort including NWTRC addressed U.S. Navy training and testing activities in a number of separate documents. Different modeling processes were used to estimate the effects of sound on marine species incidental to military readiness activities. Phase II (roughly 2014 through 2020) methodology eliminates the varying modeling processes by utilizing a standard model, NAEMO, for all acoustic effects analyses. The Phase II approach is used in this reinitiated Phase I consultation due to timing and overlap in the Phase II planning for the comprehensive NWTT activities described in the Navy's draft EIS/OEIS, January 2014, and pending section 7 consultation.

The first step earlier in the Phase I modeling process involved propagation modeling. For sonars, the Comprehensive Acoustic System Simulation (CASS)/Gaussian Ray Bundle (GRAB) model was used. Explosive sources were analyzed using either Reflection and Refraction in Multilayered Ocean/Ocean Bottoms with Shear Wave Effects (REFMS) or a modified version of CASS/GRAB. Phase II modeling retains some of the Phase I features, such as use of the same propagation model (i.e., CASS/GRAB), for developing tonal source footprints. Phase II uses REFMS exclusively for explosive propagation and includes the addition of the Range-Dependent Acoustic Model (RAM) to model non-explosive impulsive sources (i.e., airguns).

For Phase I, footprints were created for each active source used in an activity, and the movements of the source were modeled over the operating area. Only one source type was modeled at a time. Unlike Phase I, NAEMO has the capability to simultaneously run multiple

sources during a scenario, affording a more realistic depiction of the potential effects of an activity. For example, transmissions emitted by a surface combatant with its hull-mounted sonar, a helicopter with its dipping sonar, a torpedo's homing sonar, and the countermeasures discharged by the targeted submarine can be modeled simultaneously.

Although the acoustic propagation was modeled in three dimensions during Phase I analyses, in some cases, the three-dimensional (3-D) footprint was collapsed into a two-dimensional (2-D) acoustic footprint by utilizing the maximum received level, irrespective of the depth, at each range step. In other areas, a volumetric, 3-D footprint was developed to allow for variations in animal depth. For Phase II analyses, the 3-D acoustic propagation field was maintained throughout the analysis process.

Phase I distributed marine species uniformly in the respective density cells over the area being modeled. The animals were distributed in two dimensions, except in locations where data for species-specific dive profiles were available. In those areas, the animals were distributed in 3-D. In the 2-D distribution, all animals within the range of the maximum energy field would be affected, while in the volumetric approach, effects depended on where the animals were in the water column in relation to the propagation pattern. In Phase II, data on species-specific habitat preference, podding behavior, and dive profiles were taken into account and used to distribute individual animals in the model. An animat, or virtual representation of a marine animal, serves as a dosimeter, recording the energy received from all active sources during a scenario, resulting in the cumulative effects of all sources being accounted for when the impacts are analyzed.

Another difference between Phase I and Phase II modeling involves the environmental data used during propagation modeling. Phase II incorporates bathymetry into the propagation modeling process for non-impulsive sources and non-explosive impulsive (i.e., airgun) sources; Phase I used flat-bottomed bathymetry. Flat-bottom bathymetry will continue to be used in Phase II for all impulsive sources, as it was in Phase I. Futhermore, Phase II uses range-dependent sound speeds, wind speed, and bottom properties.

3.6.2 Discussion of Finneran and Schlundt 2010 and 2011 Dolphin Studies in the Context of Phase II Modeling

In accordance with the Court's order, Navy and NMFS reconsidered the two Finneran studies (2010 and 2011) in this reinitiation of consultation for NWTRC. The Navy incorporated the data within these studies, in coordination with other scientific literature, to develop auditory weighting functions and "weighted" thresholds for auditory criteria. A summary of the findings from the two papers is provided below as well as an explanation of how the Navy incorporated the results of these papers into the weighting functions and thresholds used to support the Atlantic Fleet Training and Testing (AFTT) and Hawaii-Southern California Training and Testing (HSTT) EIS/OEIS, and the January 2014 NWTT DEIS/OEIS adopted by NMFS in the

AFTT and HSTT biological and in this Opinion. We address the likely reasons that takes for ESA species declined when comparing the take estimates for NWTRC to the NWTT no action alternative (NAA), despite the fact that one might have anticipated the application of the two recent Finneran papers (Finneran 2010) (Finneran 2011) would have resulted in increased estimated takes overall. The Navy and NMFS determined it was appropriate to use a new Navy model – NAEMO - that is considered the best available information and incorporates the new weighting functions and thresholds. NAEMO also incorporates a number of other significant changes and enhancements compared with the SAIC model used in NWTRC. This paper surmises that the changes in density data and distributions incorporated in NAEMO was likely the main factor that influenced an overall reduction of take estimates for ESA species between NWTRC and the NWTT NAA used in this Biological Opinion.

3.6.2.1 **Finneran and Schlundt (2010)**

Finneran and Schlundt (Finneran and Schlundt 2010) measured temporary threshold shift (TTS) in a single female bottlenose dolphin (*Tursiops truncatus*) after exposure to tones at 3 and 20 kHz in order to examine the effects of exposure frequency on the onset and growth of TTS. The preliminary data provide evidence of frequency specific differences in TTS onset and growth between the 3 kHz and 20 kHz exposures. At 20 kHz, where bottlenose dolphin hearing sensitivity is better, TTS not only began at a lower exposure level compared to the 3 kHz exposures, but also grew at a faster rate. This demonstrated that damage risk criteria for dolphins exposed to underwater sound should account for the exposure frequency and that criteria developed for lower frequencies (e.g. 3 kHz) may underestimate the amount of TTS if applied to higher frequencies (e.g. 20 kHz), where hearing sensitivity is better. This research suggests the need for analogous data across the entire audible range so that potential effects of various frequency tones can be properly assessed.

3.6.2.2 **Finneran and Schlundt (2011)**

For humans, acoustic damage-risk criteria rely on numeric thresholds based on "weighted" noise levels. Weighted noise levels are calculated by applying a frequency-dependent filter, or "weighting function" to the measured sound pressure before calculation of the overall sound pressure level (SPL). The weighting functions are designed to emphasize frequencies where sensitivity to sound is high and to de-emphasize frequencies where sensitivity is low. This technique allows for a single, weighted damage-risk criterion, regardless of the sound frequency. Weighting functions for humans are derived from equal loudness contours – graphs representing the SPLs that led to a sensation of equal loudness magnitude in the listener as a function of sound frequency (Suzuki and Takshima 2004). Equal loudness contours are derived from loudness experiments where the listener is asked to judge the relative loudness of two tones with different frequencies. Prior to (Finneran and Schlundt 2011) there were no direct measurements of subjective loudness in non-human animals from which to develop equal loudness contours. Finneran and Schlundt (2011) trained a bottlenose dolphin to perform a loudness comparison

test, where the listener indicated which of two sequential tones was louder. This study demonstrated that a non-human animal could be conditioned for subjective loudness testing and therefore, it was possible to directly measure loudness levels in some species. Additional data is required to more accurately predict the relationship below 2.5 kHz. The weighting function derived here is substantially different than the "M-weighting function" proposed for mid-frequency cetaceans in Southall et al. (2007), which is nearly flat over the range of ~1-30 kHz and thus does not mirror the change in equal loudness contours observed over that frequency range. Nor does the M-weighting function capture the difference in TTS onset and growth reported for a single bottlenose dolphin tested at 3 and 20 kHz in Finneran and Schlundt (2010).

3.6.2.3 **Application to the Navy's Criteria and Thresholds**

The following section focuses on the application of the Finneran and Schlundt (2010) and (2011) studies to modification in the criteria and thresholds since the NWTRC EIS/OEIS. The Navy's *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis Technical Report* (Finneran and Jenkins 2012) details the criteria, thresholds, and auditory weighting functions used to support the AFTT and HSTT EIS/OEIS, adopted by NMFS in the AFT and HSTT biological opinions, and utilized in the NWTT DEIS/OEIS. The Navy used the data reported in Finneran and Schlundt (2010) and (2011) to modify existing auditory weighting functions developed by Southall et al. (2007) and to derive frequency weighted thresholds for mid frequency cetaceans. The Navy actually uses two auditory weighting functions - Type I and Type II - to estimate the effects of acoustic exposures depending on the species and acoustic source. Type I weighting functions for cetaceans and for phocids (in air and underwater) are identical to the Southall et al. (2007) M-weighting functions. The Type I weighting function for ottariids, odobenids, mustelids, ursid, and sirenians are based on estimated functional hearing limits for those functional groups, but retain the flat shape over most of the hearing range like the M-weighting functions. The Type II weighting functions modify the Type I weighting functions (or M-weighting functions) by including a region of increased amplitude (increased susceptibility) based on the equal loudness countours developed in Finneran and Schlundt (2011). The Type II weighting functions were only derived for cetaceans, because the underlying data necessary for the functions were only available for bottlenose dolphins, a mid-frequency cetacean. While TTS data exist for three pinniped species, most exposure consisted of octave band noise centered at 2.5 kHz, thus the data are insufficient to derive weighting functions in a manner analogous to that used for MF cetaceans. The idea behind the Type II function is to enhance the Type I functions by accounting for the increased susceptibility to sound seen in bottlenose TTS data above 3 kHz (Finnernan and Schlundt 2010). The equal loudness functions are not used by themselves due to the uncertainty regarding the weighting function amplitude at low frequencies, resulting from the lack of TTS or equal loudness data below 2.5-3 kHz.

Instead of altering the SAIC model used for NWTRC BiOp to incorporate the new thresholds, Navy and NMFS determined that it was appropriate to consider the results of the NWTT

DEIS/OEIS for the No Action Alternative which were developed using the NAEMO model. The NAA results already apply the new thresholds, and the Navy considers the NAEMO modeling processs to incorporate the best available information, as discussed in section 3.6.1. Because the activities modeled under the NWTT NAA represent the same activities proposed by the Navy in the NWTRC reinitiation consultation, the NWTT NAA results constitute the best available estimate of impacts from the Navy's proposed action that takes into account Finneran and Schlundt (2010, 2011). While the Finneran and Schlundt (2010, 2011) resulted in a lowering of some of the thresholds for cetaceans and therefore one might have expected an overall increase in the estimated takes, this did not prove true for the ESA species assessed in this Opinion because the thresholds are just one element among the updated best available science utilized in the NAEMO modeling process. Many of the changes in the modeling process between NWTRC and NWTT were detailed in Section 3.6.1.3 of this Biological Opinion. These changes included: 1) updates to the density data and density distribution within the model; 2) increases in the environmental and system parameters considered by the model; and 3) 2-D vs 3-D modeling. These three changes are summarized below, but the changes in density data and density distribution are likely the most significant driver for the overall reduction in takes from NWTRC to NWTT's NAA.

1. Density data and Density Distribution

In NWTRC, marine species were uniformly distributed in the respective density cells over the area being modeled. There was often a single value used to represent each species throughout the offshore study area and for all seasons. These values were based off of line transect surveys conducted by the NMFS SWFSC in the years 1991, 1993, 1996, 2001, and 2005. Descriptions of the survey methods are described by Barlow and Forney (2007). For species which had a sufficient number of sightings (> 40 sightings) predictive species-specific habitat models were built to interpolate the predicted density across the study area. The methods used for predictive species-habitat modeling in that analysis were consistent with those used by Becker (2007). The following ESA species had sufficient sightings and adequate model performance for the results to be used: sperm whale (*Physeter macrocephalus*), fin whale (*Balaenoptera physalu*s), blue whale (*Balaenoptera musculus*), and humpback whale (*Megaptera novaeangliae*) (see Table 1 of the *Marine Mammal and Sea Turtle Density Estimates for the Pacific Northwest Study Area* (DoN 2007)). For species with an insufficient numbers of sightings, or for which the models exhibited poor performance, the representative density estimates for the study area were obtained directly from Barlow and Forney (2007). This included the ESA listed sei whale (*Balaenoptera borealis*).

For the Draft NWTT EIS/OIES, the Navy completed a thorough review of all recent marine mammal survey information that could be used to estimate densities of marine species. Marine mammal densities were improved for NWTT using NMFS' spatial habitat modeling based on

West Coast survey data collected by NMFS from 1991 through 2008 as well as incorporating spatial model code improvements. From the habitat model, NMFS was able to provide unique 25 km by 25 km density estimates for blue whales, fin whales, humpback whale, and sperm whales. Given insufficient NMFS sightings for sei whale to spatially model their density, the Navy, with NMFS concurrence, used a newer derivation of static density for sei whale in NWTT. The Navy's Marine Species Density Database technical report (DoN 2014) documents the densities used in the NWTT DEIS for all species. Density values in NWTT were also developed for more than one season. While information did not support the development of densities for each of the four seasons (summer, fall, winter, and spring) they did allow for the development of two seasons – "warm" (summer and fall), and "cold" (winter and spring). This more realistically represented the density and temporal distribution of the species because many species undertake seasonal migrations, or are temporally and spatially distributed based on environmental factors which affect prey, such as sea surface temperature. For instance, most of the ESA listed species considered in this Biological Opinion have disparate seasonal distributions. Humpback whale densities in the NWTT study area for the "cold" season are significantly lower than the warm since during these time periods the species migrate to warmer, tropical or sub-tropical waters (e.g. Hawaii) in winter months where they calve. Similarly, fin whales in the eastern Pacific winter from California southward (Gambell 1985a) and are therefore only present at extremely low densities in the "cold" season within the NWTT study area. Lastly, unlike NWTRC where densities were spatially distributed uniformly using the SAIC model, NWTT densities were distributed based on where the habitat models indicated an increased likelihood of occurrence for the species. Animats were also distributed taking into account species specific behaviors such as diving, podding, etc.

The overall improvements in the density data in the model resulted in variations which contributed to the differences in exposures outputs between the NWTRC and NWTT modeling results. In particular, the increased temporal and spatial specificity of the density data and how it was used in the modeling process likely contributed substantially to the reduction in exposures. Instead of using a single static value, the spatial variation in the density data present in the NWTT would result in more variable exposures depending on the co-occurrence of activities and high density areas. Since the majority of the Navy's training activities occur far offshore (> 50 nm) where densities are generally lowest for the ESA species, this resulted in a reduction in exposures. Additionally, the increased temporal specificity in the densities also results in a reduction in exposures. NWTT modeling more accurately reflected reduced occurrence of these species in the study area during the "cold" season, therefore, the proportion of activities occurring in the "cold" season would result in fewer exposures in the NWTT modeling when compared to those same activities modeled in NWTRC using the single higher density value.

2. Increases in the environmental parameters considered by the model

The NAEMO model incorporated more environmental and system parameters than the previous SAIC model which reduced the conservativeness of assumptions employed in the NWTRC modeling. For instance, NAEMO models multiple sources at a time and accumulates sound energy across multiple systems to determine the effects. Previously, these systems were each individually modeled and then summed, which could have increased exposures. Additionally, the oceanographic and environmental data utilized in NAEMO modeling were much more detailed than in NWTRC. For each modeling area within the NAEMO model, parameters such as bathymetry, sound speed profile, wind speed, and bottom properties are extracted from an array of points across the region, using Oceanographic and Atmospheric Master Library (OAML) databases. Seasonal averages are created for the sound speed profiles and wind speeds from historical average values. SAIC used a flat bottom bathymetry for all modeling locations and did not use range-dependent sound speeds, wind speed, and bottom properties. As a result of the incorporation of these parameters, there is increased variability in how sounds propagate between locations. The Navy conducted a comprehensive effort with Fleet operators to improve the accuracy of selected modeling locations in NWTT based on historical usage of the Study Area, resulting in slight changes to the modeling locations of certain activities in NWTRC vs NWTT. These changes in the locations of certain activities, coupled with the improved use of environmental parameters to more accurately affect how sound propagates in these locations, could result in variations in the modeling results between NWTRC and NWTT for the same activity.

3. 2-D vs 3-D modeling

In NWTRC the animals were distributed in two dimensions, except in locations where data for species-specific dive profiles were available. In the 2-D distribution, all animals within the range of the maximum energy field would be affected, while in the volumetric approach (3-D) utilized in NAEMO, effects depended on where the animals were in the water column in relation to the propagation pattern. In Phase II, data on species-specific dive profiles were taken into account and used to distribute individual animals in the model. The animats were also moved vertically within the sound field simulating a dive profile in NWTT, but were static in NWTRC modeling. A sound field is highly variable throughout the water column as transmission loss occurs on the vertical as well as horizontal axis from the source. Additionally, sound transmission within the water column is affected by reflections, refractions, and ducting events. Because the animats are moving in this complex sound field, their location during the proportion of the simulation in which active sonar is in use may not always align with where the highest probability of effects are expected to occur. In contrast, with a static animal and a 2-D sound field, an animal will receive the highest exposure at that location for the entirety of the simulation. Thus the use of 2-D modeling and static animats results in an increased co-occurrence of the sound source and the animals and therefore overestimates exposures.

3.6.3 Background and Framework of U.S. Navy Analyses for Marine Mammals

The following is a brief summary of the Navy's current approach. The methods used to predict acoustic effects to marine mammals build on the *Conceptual Framework for Assessing Effects from Sound Producing Activities*.

3.6.3.1 **Direct Injury of Marine Mammals**

The potential for direct injury in marine mammals has been inferred from terrestrial mammal experiments and from post-mortem examination of marine mammals believed to have been exposed to underwater explosions (Ketten et al. 1993; Richmond et al. 1973; Yelverton et al. 1973). Additionally, non-injurious effects on marine mammals (e.g., Temporary Threshold Shift [TTS]) are extrapolated to injurious effects (e.g., Permanent Threshold Shift [PTS]) based on data from terrestrial mammals to derive the criteria serving as the potential for injury (Southall et al. 2007). Actual effects on marine mammals may differ from terrestrial animals due to anatomical and physiological adaptations to the marine environment, e.g., some characteristics such as a reinforced trachea and flexible thoracic cavity (Ridgway and Dailey 1972) may or may not decrease the risk of lung injury.

Potential non-auditory direct injury from non-impulsive sound sources, such as sonar, is unlikely due to relatively lower peak pressures and slower rise times than potentially injurious impulsive sources such as explosives. Non-impulsive sources also lack the strong shock wave such as that associated with an explosion. Therefore, primary blast injury and barotrauma (i.e., injuries caused by large pressure changes; discussed below) would not occur due to exposure to non-impulsive sources such as sonar. Even for the most sensitive auditory tissues and although there have been strandings associated with use of sonar (see Department of the Navy 2013), as Ketten (2012) has recently summarized, "to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result [of] anthropogenic noise exposures, including sonar." The theories of sonar induced acoustic resonance and sonar induced bubble formation are discussed below. These phenomena, if they were to occur, would require the co-occurrence of a precise set of circumstances that in the natural environment under real-world conditions are unlikely to occur.

3.6.3.1.1 Primary Blast Injury and Barotrauma

The greatest potential for direct, non-auditory tissue effects is primary blast injury and barotrauma after exposure to high amplitude impulsive sources, such as explosions. Primary blast injury refers to those injuries that result from the initial compression of a body exposed to a blast wave. Primary blast injury is usually limited to gas-containing structures (e.g., lung and gut) and the auditory system (Office of the Surgeon General 1991; (Craig Jr. 2001; Craig Jr. and Hearn 1998). Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system, as measured in terrestrial mammals, may consist of pulmonary

contusions, pneumothorax, pneumomediastinum, traumatic lung cysts, or interstitial or subcutaneous emphysema (Office of the Surgeon General 1991). These injuries may be fatal depending upon the severity of the trauma. Rupture of the lung may introduce air into the vascular system, possibly producing air emboli that can cause a cerebral infarct or heart attack by restricting oxygen delivery to these organs. Though often secondary in life-threatening severity to pulmonary blast trauma, the gastrointestinal tract can also suffer contusions and lacerations from blast exposure, particularly in air-containing regions of the tract. Potential traumas include hematoma, bowel perforation, mesenteric tears, and ruptures of the hollow abdominal viscera. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered.

The only known occurrence of mortality or injury to a marine mammal due to a U.S. Navy training or testing event involving impulsive sources occurred in March 2011 in nearshore waters off San Diego, California, at the Silver Strand Training Complex. This area has been used for underwater demolitions training for at least three decades without incident. On this occasion, however, a group of long-beaked common dolphins entered the mitigation zone surrounding an area where a time-delayed firing device had been initiated on an explosive with a net explosive weight of 8.76 pounds (lb.) (3.97 kilograms [kg]) placed at a depth of 48 ft. (14.6 m). Approximately 1 minute after detonation, three animals were observed dead at the surface; a fourth animal was discovered 3 days later stranded dead 42 nm to the north of the detonation. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil and St. Leger 2011). See Section 3.4.3.1.8 (Stranding) and U.S. Department of the Navy (2013) for more information on the topic of stranding.

3.6.3.1.2 Auditory Trauma

Relatively little is known about auditory system trauma in marine mammals resulting from a known sound exposure. A single study spatially and temporally correlated the occurrence of auditory system trauma in humpback whales with the detonation of a 5,000 kg (11,023 lb.) explosive (Ketten et al. 1993). The exact magnitude of the exposure in this study cannot be determined, but it is likely the trauma was caused by the shock wave produced by the explosion. There are no known occurrences of direct auditory trauma in marine mammals exposed to tactical sonar or other non-impulsive sound sources (Ketten 2012). The potential for auditory trauma in marine mammals exposed to impulsive sources (e.g., explosions) is inferred from tests of submerged terrestrial mammals exposed to underwater explosions (Ketten et al. 1993; Richmond et al. 1973; Yelverton et al. 1973).

3.6.3.1.3 Acoustic Resonance

Acoustic resonance has been proposed as a hypothesis suggesting that acoustically-induced vibrations (sound) from sonar or sources with similar operating characteristics could be damaging tissues of marine mammals. In 2002, NMFS convened a panel of government and

private scientists to investigate the issue (NMFS 2002). They modeled and evaluated the likelihood that Navy mid-frequency sonar caused resonance effects in beaked whales that eventually led to their stranding (U.S. Department of the Navy 2013d). The conclusions of that group were that resonance in air-filled structures was not likely to have caused the Bahamas stranding (NMFS 2002). The frequencies at which resonance was predicted to occur were below the frequencies utilized by the mid-frequency sonar systems associated with the Bahamas event. Furthermore, air cavity vibrations, even at resonant frequencies, were not considered to be of sufficient amplitude to cause tissue damage, even under the worst-case scenario in which air volumes would be undamped by surrounding tissues and the amplitude of the resonant response would be maximal. These same conclusions would apply to other training activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance is not likely under realistic conditions during training activities and this type of impact is not considered further in this analysis.

3.6.3.1.4 Bubble Formation (Acoustically Induced)

A suggested cause of injury to marine mammals is rectified diffusion (Crum and Mao 1996), the process of increasing the size of a bubble by exposing it to a sound field (see Section 3.4.3.1.8, Stranding, regarding strandings that gave rise to the debate about bubble formation). The process is dependent upon a number of factors including the sound pressure level and duration. Under this hypothesis, one of three things could happen: (1) bubbles grow to the extent that tissue hemorrhage (injury) occurs, (2) bubbles develop to the extent that a complement immune response is triggered or the nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury), or (3) the bubbles are cleared by the lung without negative consequence to the animal. The probability of rectified diffusion, or any other indirect tissue effect, will necessarily be based upon what is known about the specific process involved. Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. Repetitive diving by marine mammals can cause the blood and some tissues to accumulate gas to a greater degree than is supported by the surrounding environmental pressure (Ridgway and Howard 1979). The dive patterns of some marine mammals (e.g., beaked whales) are theoretically predicted to induce greater supersaturation (Houser 2010; 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 or explosion sounds would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis has also been suggested: stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of the tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state

for a long enough period of time for bubbles to become a problematic size. Recent research with *ex vivo* supersaturated bovine tissues suggested that for a 37 kHz signal, a sound exposure of approximately 215 dB re 1 μPa would be required before microbubbles became destabilized and grew (Crum et al. 2005). Assuming spherical spreading loss and a nominal sonar source level of 235 dB re 1 μPa at 1 m, a whale would need to be within 10 m (33 ft.) of the sonar dome to be exposed to such sound levels. Furthermore, tissues in the study were supersaturated by exposing them to pressures of 400–700 kilopascals for periods of hours and then releasing them to ambient pressures. Assuming the equilibration of gases with the tissues occurred when the tissues were exposed to the high pressures, levels of supersaturation in the tissues could have been as high as 400–700 percent. These levels of tissue supersaturation are substantially higher than model predictions for marine mammals (Houser et al. 2001) (Saunders et al. 2008). It is improbable that this mechanism is responsible for stranding events or traumas associated with beaked whale strandings. Both the degree of supersaturation and exposure levels observed to cause microbubble destabilization are unlikely to occur, either alone or in concert.

There is considerable disagreement among scientists as to the likelihood of this phenomenon (Evans and Miller 2004; Piantadosi and Thalmann 2004). Although it has been argued that traumas from recent beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Fernandez et al. 2005; Jepson et al. 2003), nitrogen bubble formation as the cause of the traumas has not been verified. The presence of bubbles postmortem, particularly after decompression, is not necessarily indicative of bubble pathology (Bernaldo de Quiros et al. 2012; Dennison et al. 2011; Moore et al. 2009). Prior experimental work has also demonstrated the post-mortem presence of bubbles following decompression in laboratory animals can occur as a result of invasive investigative procedures (Stock et al. 1980).

3.6.3.1.5 Nitrogen Decompression

Although not a direct injury, variations in marine mammal diving behavior or avoidance responses could possibly result in nitrogen tissue supersaturation and nitrogen off-gassing, possibly to the point of deleterious vascular and tissue bubble formation (Jepson et al. 2003) (Hooker et al. 2012) (Saunders et al. 2008); nitrogen off-gassing occurring in human divers is called decompression sickness. The mechanism for bubble formation from saturated tissues would be indirect and also different from rectified diffusion, but the effects would be similar. Although hypothetical, the potential process is under debate in the scientific community (Saunders et al. 2008) (Hooker et al. 2012). The hypothesis speculates that if exposure to a startling sound elicits a rapid ascent to the surface, tissue gas saturation sufficient for the evolution of nitrogen bubbles might result (Fernandez et al. 2005; Hooker et al. 2012; Jepson et al. 2003). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation.

Previous modeling suggested that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales (Zimmer and Tyack 2007). Tyack et al. (2006) suggested that emboli observed in animals exposed to mid-frequency active (MFA) sonar (Fernandez et al. 2005; Jepson et al. 2003) could stem instead from a behavioral response that involves repeated dives, shallower than the depth of lung collapse. A bottlenose dolphin was trained to repetitively dive to specific depths to elevate nitrogen saturation to the point that asymptomatic nitrogen bubble formation was predicted to occur. However, inspection of the vascular system of the dolphin via ultrasound did not demonstrate the formation of any nitrogen gas bubbles (Houser 2010).

More recently, modeling has suggested that the long, deep dives performed regularly by beaked whales over a lifetime could result in the saturation of long-halftime tissues (e.g., fat, bone lipid) to the point that they are supersaturated when the animals are at the surface (Hooker et al. 2009)(Saunders et al. 2008). Proposed adaptations for prevention of bubble formation under conditions of persistent tissue saturation have been suggested (Fahlman et al. 2006; Hooker et al. 2009), while the condition of supersaturation required for bubble formation has been demonstrated in by-catch animals drowned at depth and brought to the surface (Moore et al. 2009). Since bubble formation is facilitated by compromised blood flow, it has been suggested that rapid stranding may lead to bubble formation in animals with supersaturated, long-halftime tissues because of the stress of stranding and the cardiovascular collapse that can accompany it (Houser 2010).

A fat embolic syndrome was identified by Fernández et al. (2005) coincident with the identification of bubble emboli in stranded beaked whales. The fat embolic syndrome was the first pathology of this type identified in marine mammals, and was thought to possibly arise from the formation of bubbles in fat bodies, which subsequently resulted in the release of fat emboli into the blood stream. Recently, Dennison et al. (2011) reported on investigations of dolphins stranded in 2009–2010 and, using ultrasound, identified gas bubbles in kidneys of 21 of 22 live-stranded dolphins and in the liver of two of 22. The authors postulated that stranded animals are unable to recompress by diving, and thus may retain bubbles that are otherwise re-absorbed in animals that can continue to dive. The researchers concluded that the minor bubble formation observed can be tolerated since the majority of stranded dolphins released did not re-strand (Dennison et al. 2011). Recent modeling by Kvadsheim et al. (2012) determined that while behavioral and physiological responses to sonar have the potential to result in bubble formation, the actual observed behavioral responses of cetaceans to sonar did not imply any significantly increased risk over what may otherwise occur normally in individual marine mammals. As a result, no marine mammals addressed in this analysis are given differential treatment due to the possibility for acoustically mediated bubble growth.

3.6.3.1.6 Hearing Loss

The most familiar effect of exposure to high intensity sound is hearing loss, meaning an increase in the hearing threshold. The meaning of the term "hearing loss" does not equate to "deafness." This phenomenon is called a noise-induced threshold shift, or simply a threshold shift (Miller 1994). If high-intensity sound over stimulates tissues in the ear, causing a threshold shift, the impacted area of the ear (associated with and limited by the sound's frequency band) no longer provides the same auditory impulses to the brain as before the exposure (Ketten 2012). The distinction between PTS and TTS is based on whether there is a complete recovery of a threshold shift following a sound exposure. If the threshold shift eventually returns to zero (the threshold returns to the pre-exposure value), the threshold shift is a TTS.

For TTS, full recovery of the hearing loss (to the pre-exposure threshold) has been determined from studies of marine mammals, and this recovery occurs within minutes to hours for the small amounts of TTS that have been experimentally induced (Finneran et al. 2005; Finneran and Schlundt 2010; Nachtigall et al. 2004). The recovery time is related to the exposure duration, sound exposure level, and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran et al. 2005; Finneran and Schlundt 2010; Mooney et al. 2009a; Mooney et al. 2009b). In some cases, threshold shifts as large as 50 dB (loss in sensitivity) have been temporary, although recovery sometimes required as much as 30 days (Ketten 2012). If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Again for clarity, PTS, as discussed in this document, is not the loss of hearing, but instead is the loss of hearing sensitivity over a particular range of frequency. Figure 4 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS. The actual amount of threshold shift depends on the amplitude, duration, frequency, temporal pattern of the sound exposure, and on the susceptibility of the individual animal.

Both auditory trauma and auditory fatigue may result in hearing loss. Many are familiar with hearing protection devices (i.e., ear plugs) required in many occupational settings where pervasive noise could otherwise cause auditory fatigue and possibly result in hearing loss. The mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic fatigue and exhaustion of the hair cells and cochlear tissues. Note that the term "auditory fatigue" is often used to mean "temporary threshold shift"; however, the Navy uses a more general meaning is used to differentiate fatigue mechanisms (e.g., metabolic exhaustion and distortion of tissues) from trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure). The actual amount of threshold shift depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure.

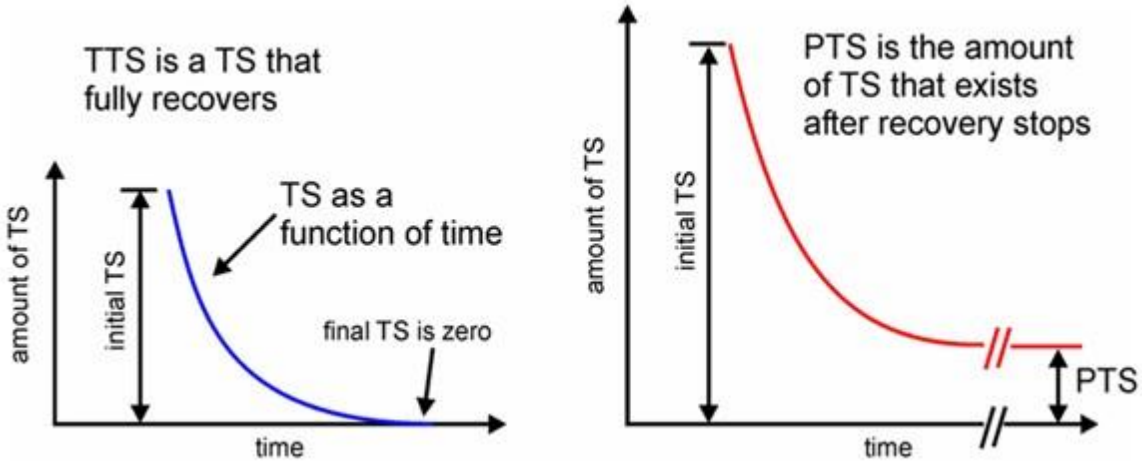

Figure 4. Two Hypothetical Threshold Shifts, Temporary and Permanent

Hearing loss, or auditory fatigue, in marine mammals has been studied by a number of investigators. (Finneran et al. 2005; Finneran and Schlundt 2010; Finneran et al. 2007; Finneran et al. 2000b; Finneran et al. 2002; Lucke et al. 2009; Mooney et al. 2009a; Mooney et al. 2009b; Nachtigall et al. 2003; Schlundt et al. 2000a). The studies of marine mammal auditory fatigue were all designed to determine relationships between TTS and exposure parameters such as level, duration, and frequency.

In these studies, hearing thresholds were measured in trained marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds indicated the amount of TTS. Species studied include the bottlenose dolphin (total of 9 individuals), beluga (2), harbor porpoise (1), finless porpoise (2), California sea lion (3), harbor seal (1), and Northern elephant seal (1). Some of the more important data obtained from these studies are onset-TTS levels— exposure levels sufficient to cause a just-measurable amount of TTS, often defined as 6 dB of TTS (Schlundt et al. 2000a). These criteria for onset-TTS are very conservative, and it is not clear that this level of threshold shift would have a functional effect on the hearing of a marine mammal in the ocean.

The primary findings of the marine mammal TTS studies are:

- The growth and recovery of TTS shift are analogous to those in terrestrial mammals. This means that, as in terrestrial mammals, threshold shifts primarily depend on the amplitude, duration, frequency content, and temporal pattern of the sound exposure.
- The amount of TTS increases with exposure sound pressure level and the exposure duration.

- For continuous sounds, exposures of equal energy lead to approximately equal effects (Ward 1997). For intermittent sounds, less hearing loss occurs than from a continuous exposure with the same energy (some recovery will occur during the quiet `period between exposures) (Kryter et al. 1965; Ward 1997).

- Sound exposure level is correlated with the amount of TTS and is a good predictor for onset-TTS from single, continuous exposures with similar durations. This agrees with human TTS data presented by Ward et al. (1958; 1959a, b). However, for longer duration sounds—beyond 16–32 seconds, the relationship between TTS and sound exposure level breaks down and duration becomes a more important contributor to TTS (Finneran and Schlundt 2010).

- The maximum TTS after tonal exposures occurs one-half to one octave above the exposure frequency (Finneran et al. 2007; Schlundt et al. 2000a). TTS from tonal exposures can thus extend over a large (greater than one octave) frequency range.

- For bottlenose dolphins, sounds with frequencies above 10 kHz are more hazardous than those at lower frequencies (i.e., lower sound exposure levels required to affect hearing) (Finneran and Schlundt 2010).

- The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic. The amount of time required for complete recovery of hearing depends on the magnitude of the initial shift; for relatively small shifts recovery may be complete in a few minutes, while large shifts (e.g., 40 dB) require several days for recovery.

- TTS can accumulate across multiple intermittent exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same sound exposure level. This means that predictions based on total, cumulative sound exposure level will overestimate the amount of TTS from intermittent exposures.

Although there have been no marine mammal studies designed to measure PTS, the potential for PTS in marine mammals can be estimated based on known similarities between the inner ears of marine and terrestrial mammals. Experiments with marine mammals have revealed their similarities with terrestrial mammals with respect to features such as TTS, age-related hearing loss (called Presbycusis), ototoxic drug-induced hearing loss, masking, and frequency selectivity. Therefore, in the absence of marine mammal PTS data, onset-PTS shift exposure levels may be estimated by assuming some upper limit of TTS that equates the onset of PTS, then using TTS growth relationships from marine and terrestrial mammals to determine the exposure levels capable of producing this amount of TTS.

Hearing loss resulting from auditory fatigue could effectively reduce the distance over which animals can communicate, detect biologically relevant sounds such as predators, and echolocate (for odontocetes). The costs to marine mammals with TTS, or even some degree of PTS have not been studied; however, it is likely that a relationship between the duration, magnitude, and frequency range of hearing loss could have consequences to biologically important activities (e.g., intraspecific communication, foraging, and predator detection) that affect survivability and reproduction.

3.6.3.1.7 Auditory Masking

Auditory masking occurs when a sound, or noise in general, limits the perception of another sound. As with hearing loss, auditory masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Unlike auditory fatigue, which always results in a localized stress response, behavioral changes resulting from auditory masking may not be coupled with a stress response. Another important distinction between masking and hearing loss is that masking only occurs in the presence of the sound stimulus, whereas hearing loss can persist after the stimulus is gone.

Critical ratios have been determined for pinnipeds (Southall et al. 2000; Southall et al. 2003) and bottlenose dolphins (Johnson 1967) and detections of signals under varying masking conditions have been determined for active echolocation and passive listening tasks in odontocetes (Au and Pawloski 1989; Erbe 2000; Johnson 1971). These studies provide baseline information from which the probability of masking can be estimated.

Clark et al. (2009) developed a methodology for estimating masking effects on communication signals for low frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, their technique calculates that in Stellwagen Bank National Marine Sanctuary, when two commercial vessels pass through a North Atlantic right whale's optimal communication space (estimated as a sphere of water with a diameter of 20 km), that space is decreased by 84 percent. This methodology relies on empirical data on source levels of calls (which is unknown for many species), and requires many assumptions about ancient ambient noise conditions and simplifications of animal behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication. Subsequent research for the same species and location estimated that an average of 63–67 percent of North Atlantic right whale's communication space has been reduced by an increase in ambient noise levels, and that noise associated with transiting vessels is a major contributor to the increase in ambient noise (Hatch et al. 2012).

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Changes to vocal behavior and call structure may result from a need to

compensate for an increase in background noise. In cetaceans, vocalization changes have been reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying.

In the presence of low frequency active sonar, humpback whales have been observed to increase the length of their 'songs' (Fristrup et al. 2003; Miller et al. 2000), possibly due to the overlap in frequencies between the whale song and the low frequency active sonar. North Atlantic right whales have been observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007) as well as increasing the amplitude (intensity) of their calls (Parks 2009). In contrast, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test (Bowles et al. 1994a), although it cannot be absolutely determined whether the inability to acoustically detect the animals was due to the cessation of sound production or the displacement of animals from the area.

Differential vocal responding in marine mammals has been documented in the presence of seismic survey noise. An overall decrease in vocalization during active surveying has been noted in large marine mammal groups (Potter et al. 2007), while blue whale feeding/social calls increased when seismic exploration was underway (Di Lorio and Clark 2010), indicative of a potentially compensatory response to the increased noise level. Melcón et al. (2012) recently documented that blue whales decreased the proportion of time spent producing certain types of calls when simulated mid-frequency sonar was present. Castellote et al. (2012) found that vocalizing fin whales in the Mediterranean left the area where a seismic survey was being conducted and that their displacement persisted beyond the completion of the survey. At present it is not known if these changes in vocal behavior corresponded to changes in foraging or any other behaviors. Controlled exposure experiments (CEEs) in 2007 and 2008 in the Bahamas recorded responses of false killer whales, short-finned pilot whales, and melon-headed whales to simulated MFA sonar (Deruiter et al. 2013a). The responses to exposures between species were variable. After hearing each MFA signal, false killer whales were found to "increase their whistle production rate and made more-MFA-like whistles" (Deruiter et al. 2013a). In contrast, melon-headed whales had "minor transient silencing" after each MFA signal, while pilot whales had no apparent response. Consistent with the findings of other previous research (see, for example, Southall et al. 2007), DeRuiter et al. (2013) found the responses were variable by species and with the context of the sound exposure.

Evidence suggests that at least some marine mammals have the ability to acoustically identify potential predators. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales, but not others. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required for

attending to and responding to all killer whale calls. The occurrence of masking or hearing impairment provides a means by which marine mammals may be prevented from responding to the acoustic cues produced by their predators. Whether or not this is a possibility depends on the duration of the masking/hearing impairment and the likelihood of encountering a predator during the time that predator cues are impeded.

3.6.3.1.8 Physiological Stress

Marine mammals may exhibit a behavioral response or combinations of behavioral responses upon exposure to anthropogenic sounds. If a sound is detected by a marine mammal, a stress response (e.g., startle or annoyance) or a cueing response (based on a past stressful experience) can occur. Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, and interactions with predators all contribute to the stress a marine mammal experiences. In some cases, naturally occurring stressors can have profound impacts on marine mammals; for example, chronic stress, as observed in stranded animals with long-term debilitating conditions (e.g., disease), has been demonstrated to result in an increased size of the adrenal glands and an increase in the number of epinephrine-producing cells (Clark et al. 2006).

Anthropogenic activities have the potential to provide additional stressors above and beyond those that occur naturally. Various efforts have been undertaken to investigate the impact from vessels (both whale-watching and general vessel traffic noise) and demonstrated impacts do occur (Bain 2002; Erbe 2002b; Noren et al. 2009; Williams and Ashe 2006; Williams and Noren 2009). For example, in an analysis of energy costs to killer whales, Williams et al. (2009) suggested that whale-watching in the Johnstone Strait resulted in lost feeding opportunities due to vessel disturbance, which could carry higher costs than other measures of behavioral change might suggest. Ayres et al. (2012) recently reported on research in the Salish Sea involving the measurement of southern resident killer whale fecal hormones to assess two potential of threats to the species recovery: lack of prey (salmon) and impacts to behavior from vessel traffic. Ayres et al. (2012) suggested that the lack of prey overshadowed any population-level physiological impacts on southern resident killer whales from vessel traffic.

Although preliminary because of the small numbers of samples collected, different types of sounds have been shown to produce variable stress responses in marine mammals. Belugas demonstrated no catecholamine (hormones released in situations of stress) response to the playback of oil drilling sounds (Thomas et al. 1990) but showed an increase in catecholamines following exposure to impulsive sounds produced from a seismic water gun (Romano et al. 2004). A bottlenose dolphin exposed to the same seismic water gun signals did not demonstrate a catecholamine response, but did demonstrate an elevation in aldosterone, a hormone that has been suggested as being a significant indicator of stress in odontocetes (St. Aubin et al. 2001; St.

Aubin and Geraci 1989). Increases in heart rate were observed in bottlenose dolphins to which conspecific calls were played, although no increase in heart rate was observed when tank noise was played back (Miksis et al. 2001). Collectively, these results suggest a variable response that depends on the characteristics of the received signal and prior experience with the received signal.

Other types of stressors include the presence of vessels, fishery interactions, acts of pursuit and capture, the act of stranding, and pollution. In contrast to the limited amount of work performed on stress responses resulting from sound exposure, a considerably larger body of work exists on stress responses associated with pursuit, capture, handling and stranding. Many cetaceans exhibit an apparent vulnerability in the face of these particular situations when taken to the extreme. A recent study compared pathological changes in organs/tissues of odontocetes stranded on beaches or captured in nets over a 40-year period (Cowan and Curry 2008). The type of changes observed indicate multisystemic harm caused in part by an overload of catecholamines into the system, as well as a restriction in blood supply capable of causing tissue damage or tissue death. This extreme response to a major stressor/s is thought be mediated by the over activation of the animal's normal physiological adaptations to diving or escape. Pursuit, capture and short-term holding of belugas have been observed to result in a decrease in thyroid hormones (St. Aubin and Geraci 1988) and increases in epinephrine (St. Aubin and Dierauf 2001). In dolphins, the trend is more complicated with the duration of the handling time potentially contributing to the magnitude of the stress response (Ortiz and Worthy 2000; St. Aubin 2002; St. Aubin et al. 1996). Male grey seals subjected to capture and short-term restraint showed an increase in cortisol levels accompanied by an increase in testosterone (Lidgard et al. 2008). This result may be indicative of a compensatory response that enables the seal to maintain reproduction capability in spite of stress. Elephant seals demonstrate an acute cortisol response to handling, but do not demonstrate a chronic response; on the contrary, adult females demonstrate a reduction in the adrenocortical response following repetitive chemical immobilization (Engelhard et al. 2002). Similarly, no correlation between cortisol levels and heart/respiration rate changes were seen in harbor porpoises during handling for satellite tagging (Eskesen et al. 2009). Taken together, these studies illustrate the wide variations in the level of response that can occur when faced with these stressors.

Factors to consider when trying to predict a stress or cueing response include the mammal's life history stage and whether they are naïve or experienced with the sound. Prior experience with a stressor may be of particular importance as repeated experience with a stressor may dull the stress response via acclimation (St. Aubin and Dierauf 2001).

The sound characteristics that correlate with specific stress responses in marine mammals are poorly understood. Therefore, in practice, a stress response is assumed if a physiological reaction such as a hearing loss or trauma is predicted; or if a significant behavioral response is predicted.

3.6.3.1.9 Behavioral Reactions

The response of a marine mammal to an anthropogenic sound will depend on the frequency, duration, temporal pattern and amplitude of the sound as well as the animal's prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure). The distance from the sound source and whether it is perceived as approaching or moving away can affect the way an animal responds to a sound (Wartzok et al. 2003). For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson and others (Richardson et al. 1995). More recent reviews (Ellison et al. 2012; Nowacek et al. 2007; Southall et al. 2009; Southall et al. 2007) address studies conducted since 1995 and focus on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated.

Except for some vocalization changes that may be compensating for auditory masking, all behavioral reactions are assumed to occur due to a preceding stress or cueing response, however stress responses cannot be predicted directly due to a lack of scientific data (see preceding section). Responses can overlap; for example, an increased respiration rate is likely to be coupled to a flight response. Differential responses between and within species are expected since hearing ranges vary across species and the behavioral ecology of individual species is unlikely to completely overlap.

Southall et al. (2007) synthesized data from many past behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels. While in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al. 2007). After examining all of the available data, the authors felt that the derivation of thresholds for behavioral response based solely on exposure level was not supported because context of the animal at the time of sound exposure was an important factor in estimating response. Nonetheless, in some conditions consistent avoidance reactions were noted at higher sound levels dependent on the marine mammal species or group allowing conclusions to be drawn. Most low-frequency cetaceans (mysticetes) observed in studies usually avoided sound sources at levels of less than or equal to 160 dB re 1 µPa. Published studies of mid-frequency cetaceans analyzed include sperm whales, belugas, bottlenose dolphins, and river dolphins. These groups showed no clear tendency, but for non-impulsive sounds, captive animals tolerated levels in excess of 170 dB re 1 µPa before showing behavioral reactions, such as avoidance, erratic swimming, and attacking the test apparatus. High-frequency cetaceans (observed from studies with harbor porpoises) exhibited changes in respiration and avoidance behavior at levels between 90 and 140 dB re 1 µPa, with profound avoidance behavior noted for levels exceeding this. Phocid seals showed avoidance reactions at or below 190 dB re 1 µPa, thus seals may actually receive levels adequate to produce TTS before avoiding the source. Recent studies with beaked whales have shown them to be particularly

sensitive to noise, with animals during 3 playbacks of sound breaking off foraging dives at levels below 142 dB re 1 µPa, although acoustic monitoring during actual sonar exercises revealed some beaked whales continuing to forage at levels up to 157 dB re 1 µPa (Tyack et al. 2011a).

3.6.3.2 **Behavioral Reactions of Marine Mammals to Impulsive Sound Sources**

3.6.3.2.1 Mysticetes

Baleen whales have shown a variety of responses to impulsive sound sources, including avoidance, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Richardson et al. 1995a; Southall et al. 2007) (Gordon et al. 2003). While most bowhead whales did not show active avoidance until within 8 km of seismic vessels (Richardson et al. 1995), some whales avoided vessels by more than 20 km at received levels as low as 120 dB re 1 µPa root mean square. Additionally, Malme et al. (1988) observed clear changes in diving and respiration patterns in bowheads at ranges up to 73 km from seismic vessels, with received levels as low as 125 dB re 1 µPa.

Gray whales migrating along the U.S. west coast showed avoidance responses to seismic vessels by 10 percent of animals at 164 dB re 1 µPa, and by 90 percent of animals at 190 dB re 1 µPa, with similar results for whales in the Bering Sea (Malme et al. 1986) (Malme 1988). In contrast, noise from seismic surveys was not found to impact feeding behavior or exhalation rates while resting or diving in western gray whales off the coast of Russia (Gailey et al. 2007; Yazvenko et al. 2007).

Humpback whales showed avoidance behavior at ranges of 5–8 km from a seismic array during observational studies and CEEs in western Australia (McCauley et al. 1998; Todd et al. 1996a) found no clear short-term behavioral responses by foraging humpbacks to explosions associated with construction operations in Newfoundland, but did see a trend of increased rates of net entanglement and a shift to a higher incidence of net entanglement closer to the noise source.

Seismic pulses at average received levels of 131 dB re 1 µPa^2-s caused blue whales to increase call production (Di Lorio and Clark 2010). In contrast, McDonald et al. (1995) tracked a blue whale with seafloor seismometers and reported that it stopped vocalizing and changed its travel direction at a range of 10 km from the seismic vessel (estimated received level 143 dB re 1 µPa peak-to-peak). Castellote et al. (2012) found that vocalizing fin whales in the Mediterranean left the area where a seismic survey was being conducted and that their displacement persisted beyond the completion of the survey. These studies demonstrate that even low levels of noise received far from the noise source can induce behavioral responses.

3.6.3.2.2 Odontocetes

Madsen et al. (2006) and Miller et al. (2009) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic airgun surveys. Sound sources were from approximately 2–7 nm away from the whales and based on multipath propagation received levels were as high as 162 dB SPL re 1 µPa with energy content greatest between 0.3 to 3.0 kHz (Madsen et al. 2006). The whales showed no horizontal avoidance, although the whale that was approached most closely had an extended resting period and did not resume foraging until the airguns had ceased firing (Miller et al. 2009). The remaining whales continued to execute foraging dives throughout exposure, however swimming movements during foraging dives were 6 percent lower during exposure than control periods, suggesting subtle effects of noise on foraging behavior (Miller et al. 2009). Captive bottlenose dolphins sometimes vocalized after an exposure to impulsive sound from a seismic watergun (Finneran and Schlundt 2010).

3.6.3.2.3 Pinnipeds

A review of behavioral reactions by pinnipeds to impulsive noise can be found in Richardson et al. (1995) and Southall et al. (2007). Blackwell et al. (2004) observed that ringed seals exhibited little or no reaction to pipe-driving noise with mean underwater levels of 157 dB re 1 µPa root mean square and in air levels of 112 dB re 20 µPa, suggesting that the seals had habituated to the noise. In contrast, captive California sea lions avoided sounds from an impulsive source at levels of 165–170 dB re 1 µPa (Finneran et al. 2003b).

Experimentally, Götz and Janik (2011) tested underwater startle responses to a startling sound (sound with a rapid rise time and a 93 dB sensation level [the level above the animal's threshold at that frequency]) and a non-startling sound (sound with the same level, but with a slower rise time) in wild-captured gray seals. The animals exposed to the startling treatment avoided a known food source, whereas animals exposed to the non-startling treatment did not react or habituated during the exposure period. The results of this study highlight the importance of the characteristics of the acoustic signal in an animal's response of habituation.

3.6.3.3 Behavioral Reactions of Marine Mammals to Sonar and Other Active Acoustic Sources

3.6.3.3.1 Mysticetes

Specific to U.S. Navy systems using low frequency sound, studies were undertaken pursuant to the Navy's Low Frequency Sound Scientific Research Program. These studies found only short-term responses to low frequency sound by mysticetes (fin, blue, and humpback) including changes in vocal activity and avoidance of the source vessel (Clark and Fristrup 2001a; Croll et al. 2001b; Fristrup et al. 2003; Miller et al. 2000; Nowacek et al. 2007). Recent work by (Risch et al. 2012) found that humpback whale vocalizations ("song") were reduced concurrent with pulses from the low frequency Ocean Acoustic Waveguide Remote Sensing source located

approximately 200 km away. Baleen whales exposed to moderate low- frequency signals demonstrated no variation in foraging activity (Croll et al. 2001). However, five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives, although the alarm signal was long in duration, lasting several minutes, and purposely designed to elicit a reaction from the animals as a prospective means to protect them from ship strikes (Nowacek et al. 2004). Although the animal's received sound pressure level was similar in the latter two studies (133–150 dB re1 µPa), the frequency, duration, and temporal pattern of signal presentation were different. Additionally, the right whales did not respond to playbacks of either right whale social sounds or vessel noise, highlighting the importance of the sound characteristics, species differences, and individual sensitivity in producing a behavioral reaction.

Low-frequency signals of the Acoustic Thermometry of Ocean Climate sound source were not found to affect dive times of humpback whales in Hawaiian waters (Frankel and Clark 2000) or to overtly affect elephant seal dives off California (Costa et al. 2003). However, they did produce subtle effects that varied in direction and degree among the individual seals, again illustrating the equivocal nature of behavioral effects and consequent difficulty in defining and predicting them.

Blue whales exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low frequency calls usually associated with feeding behavior (Melcon et al. 2012a). It is not known whether the lower rates of calling actually indicated a reduction in feeding behavior or social contact since the study used data from remotely deployed, passive acoustic monitoring buoys. In contrast, blue whales increased their likelihood of calling when ship noise was present, and decreased their likelihood of calling in the presence of explosive noise, although this result was not statistically significant (Melcon et al. 2012a). Additionally, the likelihood of an animal calling decreased with the increased received level of mid-frequency sonar, beginning at a sound pressure level of approximately 110–120 dB re 1 µPa (Melcon et al. 2012a). Preliminary results from the 2010–2011 field season of an ongoing behavioral response study in Southern California waters indicated that in some cases and at low received levels, tagged blue whales responded to mid-frequency sonar but that those responses were mild and there was a quick return to their baseline activity (Southall et al. 2011) Blue whales responded to a mid-frequency sound source, with a source level between 160 and 210 dB re 1 µPa at 1 m and a received sound level up to 160 dB re 1 µPa, by exhibiting generalized avoidance responses and changes to dive behavior during CEEs (Goldbogen et al. 2013). However, reactions were not consistent across individuals based on received sound levels alone, and likely were the result of a complex interaction between sound exposure factors such as proximity to sound source and sound type (mid-frequency sonar simulation vs. pseudo-random noise), environmental conditions, and behavioral state. Surface feeding whales did not show a change in behavior during CEEs, but deep feeding and non-feeding whales showed temporary reactions that quickly abated after sound exposure. Whales were sometimes less than a mile from the sound source during CEEs.

These preliminary findings from Melcón et al. (2012) and Goldbogen et al. (2013) are consistent with the Navy's criteria and thresholds for predicting behavioral effects to mysticetes (including blue whales) from sonar and other active acoustic sources used in the Navy's quantitative acoustic effects analysis. The behavioral response function predicts a probability of a substantive behavioral reaction for individuals exposed to a received sound pressure level of 120 dB re 1 µPa or greater, with an increasing probability of reaction with increased received level as demonstrated in Melcón et al. (2012).

3.6.3.3.2 Odontocetes

From 2007 to 2011, behavioral response studies were conducted through the collaboration of various research organizations in the Bahamas, Southern California, Mediterranean, Cape Hatteras, and Norwegian waters. These studies attempted to define and measure responses of beaked whales and other cetaceans to controlled exposures of sonar and other sounds to better understand their potential impacts. Results from the 2007–2008 study conducted near the Bahamas showed a change in diving behavior of an adult Blainville's beaked whale to playback of mid-frequency source and predator sounds (Boyd et al. 2008; Tyack et al. 2011b)(Southall et al. 2009b). Reaction to mid-frequency sounds included premature cessation of clicking and termination of a foraging dive, and a slower ascent rate to the surface. Preliminary results from a similar behavioral response study in Southern California waters have been presented for the 2010–2011 field season (Southall 2011). Deruiter et al. (2013b) presented results from two Cuvier's beaked whales that were tagged and exposed to simulated MFA sonar during the 2010 and 2011 field seasons of the southern California behavioral response study. The 2011 whale was also incidentally exposed to MFA sonar from a distant naval exercise. Received levels from the MFA sonar signals from the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa root mean square, respectively. Both whales showed responses to the controlled exposures, ranging from initial orientation changes to avoidance responses characterized by energetic fluking and swimming away from the source. However, the authors did not detect similar responses to incidental exposure to distant naval sonar exercises at comparable received levels, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor. Cuvier's beaked whale responses suggested particular sensitivity to sound exposure as consistent with results for Blainville's beaked whale. Similarly, beaked whales exposed to sonar during British training exercises stopped foraging (Defence Science and Technology Laboratory 2007) and preliminary results of controlled playback of sonar may indicate feeding/foraging disruption of killer whales and sperm whales (Miller et al. 2011).

NOTE: Miller et al. (2011, 2014) reported on behavioral responses of pilot whales and killer whales off Norway to a transducer with outputs including the mid-frequency 1-2 kHz and 6-7 kHz ranges (see also Kvadsheim et al. 2011). However, there were methodological issues with the exposure experiment which confound the usefulness of the data. Notably, the sound

sources had significant frequency output outside the intended 1-2 kHz and 6-7 kHz ranges, there were additional stressors that may have resulted in reactions including high frequency sources being used to track the whales and the close vessel approaches themselves, and each exposure was treated as independent even though the samples were often collected from the same animal(s) via multiple approaches within a 24-hr period.

Because the two primary sources had output frequencies much broader than characterized (see Fig 4.8 Kvadsheim et al 2011 and Figure 9 Miller et al. 2012), it calls into question the control of the exposures and the reported results. The authors note that "we cannot rule out that the higher source level itself or different patterns of reverberation and/or harmonics, were salient features of the source to which the subject whales were more likely to respond with higher severity levels". It is also unclear from the data if reactions could have been from the vessel itself, without sonar on, or from additional whale observing boats that were separate from the sonar source vessel. The sample size used to derive their results was very small (4 individual killer whales). The experiments also made use of prolonged, continued, and repeated approaches often to relatively close ranges to killer whale pods. The practice of continually heading towards the target whale (and course correcting to ensure that the source vessel was always heading towards the whale) also confounds the interpretation of the response. The methodology of this study makes implementation of the proposed risk function difficult. Navy vessels do not in training conditions continually adjust their heading to maintain an approach on individual whales. Therefore, the responses interpreted by the authors are a result of conditions that would not occur during Navy training exercises. Using the risk function proposed in Miller et al. (2014) to estimate exposure impacts would likely lead to an overestimate of avoidance responses. In reality, the Navy applies specific mitigations including powering down and turning sonar off upon sighting marine mammals at designated ranges. In addition, Navy ships try to avoid approaching within 500 yards of whales to the best extent practical in consideration of safe navigation.

In the 2007–2008 Bahamas study, playback sounds of a potential predator— a killer whale— resulted in a similar but more pronounced reaction, which included longer inter-dive intervals and a sustained straight-line departure of more than 20 km from the area. The authors noted, however, that the magnified reaction to the predator sounds could represent a cumulative effect of exposure to the two sound types since killer whale playback began approximately 2 hours after mid-frequency source playback. Pilot whales and killer whales off Norway also exhibited horizontal avoidance of a transducer with outputs in the mid-frequency range (signals in the 1–2 kHz and 6–7 kHz ranges) (Miller 2011). Additionally, separation of a calf from its group during exposure to mid-frequency sonar playback was observed on one occasion (Miller 2011) In contrast, preliminary analyses suggest that none of the pilot whales or false killer whales in the Bahamas showed an avoidance response to controlled exposure playbacks (Southall et al. 2009b).

Through analysis of the behavioral response studies, a preliminary overarching effect of greater sensitivity to all anthropogenic exposures was seen in beaked whales compared to the other

odontocetes studied (Southall et al. 2009b). Therefore, recent studies have focused specifically on beaked whale responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Defence Science and Technology Laboratory 2007; (Claridge and Durban 2009; McCarthy et al. 2011; Moretti 2009; Tyack et al. 2011b). In the Bahamas, Blainville's beaked whales located on the range will move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge and Durban 2009; McCarthy et al. 2011; Moretti 2009; Tyack et al. 2011b).

As presented in more detail in Section 3.4.3.1.8 (Stranding), in May 2003, killer whales in Haro Strait, Washington were observed exhibiting what were believed by some observers to be aberrant behaviors while the USS SHOUP was in the vicinity and using MFA sonar. Sound fields modeled for the USS SHOUP sonar transmissions (Fromme 2004)(National Marine Fisheries Service 2011b; U.S. Department of the Navy 2004) estimated a mean received sound pressure level of approximately 169.3 dB re 1 µPa at the location of the killer whales during the closest point of approach between the animals and the vessel (estimated sound pressure levels ranged from 150 to 180 dB re 1 µPa).

In the Caribbean, research on sperm whales near the Grenadines in 1983 coincided with the U.S. intervention in Grenada where sperm whales were observed to interrupt their activities by stopping echolocation and leaving the area in the presence of underwater sounds surmised to have originated from submarine sonar signals since the source was not visible (Watkins et al. 1985)(Watkins and Schevill 1975). The authors did not provide any sound levels associated with these observations although they did note getting a similar reaction from banging on their boat hull. It was unclear if the sperm whales were reacting to the "sonar" signal itself or to a potentially new unknown sound in general as had been demonstrated previously on another occasion in which sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins and Schevill 1975).

Researchers at the Navy's Marine Mammal Program facility in San Diego, California have conducted a series of controlled experiments on bottlenose dolphins and beluga whales to study TTS (Finneran et al. 2001; Finneran et al. 2003a; Finneran et al. 2010; Finneran and Schlundt 2004; Schlundt et al. 2000a); (Finneran 2010); (Finneran 2011) . Ancillary to the TTS studies, scientists evaluated whether the marine mammals performed their trained tasks when prompted, during and after exposure to mid-frequency tones. Altered behavior during experimental trials usually involved refusal of animals to return to the site of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al. 2002; Schlundt et al. 2000a). Bottlenose dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 Pa root mean square, and beluga whales did so at received levels of 180–196 dB re 1 Pa and above. In some instances, animals exhibited

aggressive behavior toward the test apparatus (Ridgway et al. 1997; Schlundt et al. 2000a). While these studies were generally not designed to test avoidance behavior and animals were commonly reinforced with food, the controlled environment and ability to measure received levels provide insight on received levels at which animals will behaviorally responds to noise sources.

Studies with captive harbor porpoises showed increased respiration rates upon introduction of acoustic alarms, such as those used on fishing nets to help deter marine mammals from becoming caught or entangled (Kastelein et al. 2001; Kastelein et al. 2006a) and emissions for underwater data transmission (Kastelein et al. 2005). However, exposure of the same acoustic alarm to a striped dolphin under the same conditions did not elicit a response (Kastelein et al. 2006b), again highlighting the importance in understanding species differences in the tolerance of underwater noise (Southall et al. 2007).

3.6.3.3.3 Pinnipeds

Different responses displayed by captive and wild phocid seals to sound judged to be 'unpleasant' have been reported; where captive seals habituated (did not avoid the sound), and wild seals showed avoidance behavior (Götz and Janik 2011). Captive seals received food (reinforcement) during sound playback, while wild seals were exposed opportunistically. These results indicate that motivational state (e.g., reinforcement via food acquisition) can be a factor in whether or not an animal habituates to novel or unpleasant sounds. Another study found that captive hooded seals reacted to 1–7 kHz sonar signals, in part with displacement to the areas of least sound pressure level, at levels between 160 and 170 dB re 1 µPa (Kvadsheim et al. 2010).

Captive studies with other pinnipeds have shown a reduction in dive times when presented with qualitatively 'unpleasant' sounds. These studies indicated that the subjective interpretation of the pleasantness of a sound, minus the more commonly studied factors of received sound level and sounds associated with biological significance, can affect diving behavior (Götz and Janik 2011).

3.6.3.4 **Behavioral Reactions of Marine Mammals to Vessels**

Sound emitted from large vessels, such as shipping and cruise ships, is the principal source of low-frequency noise in the ocean today, and marine mammals are known to react to or be affected by that noise (Foote et al. 2004; Hatch and Wright 2007; Hildebrand 2005; Holt et al. 2008b; Melcon et al. 2012a; Richardson et al. 1995a)(Kerosky et al. 2013). As noted previously, in the Inland Waters of Puget Sound, Erbe et al. (2012) estimated the maximum annual underwater sound exposure level from vessel traffic near Seattle was 215 dB re 1 µPa^2-s and Bassett et al. (2010) measured mean sound pressure levels at Admiralty Inlet from commercial shipping at 117 dB re 1 µPa with a maximum exceeded 135 dB re 1 µPa on some occasions.

In short-term studies, researchers have noted changes in resting and surface behavior states of cetaceans to whale watching vessels (Acevedo 1991b; Aguilar Soto et al. 2006; Arcangeli and Crosti 2009; Au and Green 2000b; Christiansen et al. 2010; Erbe 2002b; Noren et al. 2009; Stensland and Berggren 2007a; Stockin et al. 2008; Williams and Noren 2009). Noren et al. (2009) conducted research in the San Juan Islands in 2005 and 2006 and their findings suggested that close approaches by vessels impacted the whales' behavior and that the whale-watching guideline minimum approach distance of 100 m may be insufficient in preventing behavioral responses. Most studies of this type are opportunistic and have only examined the short-term response to vessel sound and vessel traffic ((Magalhaes et al. 2002; Noren et al. 2009; Richardson and Wursig 1995; Watkins 1981c). Long-term and cumulative implications of vessel sound on marine mammals remains largely unknown (National Marine Fisheries Service 2012a, b). Clark et al. (2009) provided a discussion on calculating the cumulative impacts of anthropogenic noise on baleen whales and estimated that in one Atlantic setting and with the noise from the passage of two vessels, the optimal communication space for North Atlantic right whale could be decreased by 84 percent (see also Hatch et al. 2013).

Bassett et al. (2012) recorded vessel traffic over a period of just under a year as large vessels passed within 20 km of a hydrophone site located at Admiralty Inlet in Puget Sound. During this period there were 1,363 unique Automatic Identification System transmitting vessels recorded. Navy vessels, given they are much fewer in number, are a small component of overall vessel traffic and vessel noise in most areas where they operate and this is especially the case in the Action Area (see Mintz and Filadelfo (2011) concerning a general summary for the U.S. Exclusive Economic Zone). In addition, Navy combatant vessels have been designed to generate minimal noise and use ship quieting technology to elude detection by enemy passive acoustic devices (Southall et al. 2005; Mintz and Filadelfo 2011).

3.6.3.4.1 Mysticetes

Fin whales may alter their swimming patterns by increasing speed and heading away from a vessel, as well as changing their breathing patterns in response to a vessel approach (Jahoda et al. 2003). Vessels that remained 328 ft. (100 m) or farther from fin and humpback whales were largely ignored in one study in an area where whale watching activities are common (Watkins 1981). Only when vessels approached more closely did the fin whales in this study alter their behavior by increasing time at the surface and exhibiting avoidance behaviors. Other studies have shown when vessels are near, some but not all fin whales change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Castellote et al. 2012) (Au and Green 2000; Richter et al. 2003; Williams et al. 2002).

Based on passive acoustic recordings and in the presence of sounds from passing vessels, Melcon et al. (2012a) reported that blue whales had an increased likelihood of producing certain types of

calls. Castellote et al. (2012) demonstrated that fin whales' songs had shortened duration and decreased bandwidth, center frequency, and peak frequency in the presence of high shipping noise levels such as those found in the Strait of Gibraltar. At present it is not known if these changes in vocal behavior corresponded to any other behaviors.

In the Watkins (1981) study, humpback whales did not exhibit any avoidance behavior but did react to vessel presence. In a study of regional vessel traffic, Baker et al. (1983) found that when vessels were in the area, the respiration patterns of the humpback whales changed. The whales also exhibited two forms of behavioral avoidance: horizontal avoidance (changing direction or speed) when vessels were between 1.24 and 2.48 mi. (2,000 and 4,000 m) away, and vertical avoidance (increased dive times and change in diving pattern) when vessels were within approximately 1.2 mi. (2,000 m; Baker and Herman 1983). Similar findings were documented for humpback whales when approached by whale watch vessels in Hawaii and having responses that including increased speed, changed direction to avoid, and staying submerged for longer periods of time (Au and Green 2000b).

Recently, Gende et al. (2011) reported on observations of humpback whale in inland waters of Southeast Alaska subjected to frequent cruise ship transits (i.e., in excess of 400 transits in a 4-month season in 2009). The study was focused on determining if close encounter distance was a function of vessel speed. The reported observations, however, seem in conflict with other reports of avoidance at much greater distance so it may be that humpback whales in those waters are more tolerant of vessels (given their frequency) or are engaged in behaviors, such as feeding, that they are less willing to abandon. This example again highlights that context is critical for predicting and understanding behavioral reactions as concluded by Southall et al. (2007a, b) and Ellison et al. (2012).

Sei whales have been observed ignoring the presence of vessels and passing close to the vessel (National Marine Fisheries Service 1993). In the presence of approaching vessels, blue whales perform shallower dives accompanied by more frequent surfacing, but otherwise do not exhibit strong reactions (Calambokidis et al. 2009a). Minke whales in the Antarctic did not show any apparent response to a survey vessel moving at normal cruising speeds (about 12 knots) at a distance of 5.5 nm; however, when the vessel drifted or moved at very slow speeds (about 1 knot), many whales approached it (Leatherwood et al. 1982a).

Although not expected to be in the Action Area, North Atlantic right whales tend not to respond to the sounds of oncoming vessels (Nowacek et al. 2004). North Atlantic right whales continue to use habitats in high vessel traffic areas (Nowacek et al. 2004). Studies show that North Atlantic right whales demonstrate little if any reaction to sounds of vessels approaching or the presence of the vessels themselves (Terhune and Verboom 1999, (Nowacek et al. 2004). Although this may minimize potential disturbance from passing ships, it does increase the whales' vulnerability to

potential ship strike. The regulated approach distance for North Atlantic right whales is 500 yards (yd.) (457 m) (National Oceanic and Atmospheric Administration 1997).

Using historical records, Watkins (1986) showed that the reactions of four species of mysticetes to vessel traffic and whale watching activities in Cape Cod had changed over the 25-year period examined (1957–1982). Reactions of minke whales changed from initially more positive reactions, such as coming towards the boat or research equipment to investigate, to more 'uninterested' reactions towards the end of the study. Finback [fin] whales, the most numerous species in the area, showed a trend from initially more negative reactions, such as swimming away from the boat with limited surfacing, to more uninterested (ignoring) reactions allowing boats to approach within 98.4 ft. (30 m). Right whales showed little change over the study period, with a roughly equal number of reactions judged to be negative and uninterested; no right whales were noted as having positive reactions to vessels. Humpback whales showed a trend from negative to positive reactions with vessels during the study period. The author concluded that the whales had habituated to the human activities over time (Watkins 1986).

Mysticetes have been shown to both increase and decrease calling behavior in the presence of vessel noise. An increase in feeding call rates and repetition by humpback whales in Alaskan waters was associated with vessel noise (Doyle et al. 2008); Melcón et al. (2012) also recently documented that blue whales increased the proportion of time spent producing certain types of calls when vessels were present. Conversely, decreases in singing activity by humpback whales have been noted near Brazil due to boat traffic (Sousa-Lima and Clark 2008). The Central North Pacific stock of humpback whales is the focus of whale-watching activities in both its feeding grounds (Alaska) and breeding grounds (Hawaii). Regulations addressing minimum approach distances and vessel operating procedures are in place in Hawaii, however, there is still concern that whales may abandon preferred habitats if the disturbance is too high (Allen and Angliss 2010).

3.6.3.4.2 Odontocetes

Sperm whales generally react only to vessels approaching within several hundred meters; however, some individuals may display avoidance behavior, such as quick diving (Magalhaes et al. 2002; Wursig et al. 1998). One study showed that after diving, sperm whales showed a reduced timeframe from when they emitted the first click than before vessel interaction (Richter et al. 2006). The smaller whale-watching and research vessels generate more noise in higher frequency bands and are more likely to approach odontocetes directly, and to spend more time near the individual whale. Reactions to Navy vessels are not well documented, but smaller whale-watching and research boats have been shown to cause these species to alter their breathing intervals and echolocation patterns.

Wursig et al. (1998) reported most *Kogia* species and beaked whales react negatively to vessels by quick diving and other avoidance maneuvers. Cox et al. (2006) noted very little information is available on the behavioral impacts of vessels or vessel noise on beaked whales. A single observation of vocal disruption of a foraging dive by a tagged Cuvier's beaked whale documented when a large noisy vessel was opportunistically present, suggests that vessel noise may disturb foraging beaked whales (Aguilar Soto et al. 2006). Tyack et al. (2011) noted the result of a controlled exposure to pseudorandom noise suggests that beaked whales would respond to vessel noise and at similar received levels to those noted previously and for mid-frequency sonar.

Most delphinids react neutrally to vessels, although both avoidance and attraction behavior is known (Hewitt 1985a; Wursig et al. 1998). Avoidance reactions include a decrease in resting behavior or change in travel direction (Bejder et al. 2006a). Incidence of attraction includes harbor porpoises approaching a vessel and common, rough-toothed, and bottlenose dolphins bow riding and jumping in the wake of a vessel (Norris and Prescott 1961; Shane et al. 1986) (Ritter 2002; Wursig et al. 1998). A study of vessel reactions by dolphin communities in the eastern tropical Pacific found that populations that were often the target of tuna purse-seine fisheries (spotted, spinner and common dolphins) show evasive behavior when approached; however populations that live closer to shore (within 100 nm; coastal spotted and bottlenose dolphins) that are not set on by purse-seine fisheries tend to be attracted to vessels (Archer et al. 2010a; Archer et al. 2010b).

Killer whales, the largest of the delphinids, are targeted by numerous small whale-watching vessels in the Pacific Northwest and, from 1998 to 2012 during the viewing season, have had an annual monthly average of nearly 20 vessels of various types within 0.5 mile of their location from between the hours of 9 a.m. and 6 p.m. (Eisenhardt 2012). For the 2012 season, it was reported that 1,590 vessel incidents were possible violations of the federal vessel approach regulations or MMPA and ESA laws as well (Eisenhardt 2012). Research suggests that whale-watching guideline distances may be insufficient to prevent behavioral disturbances due to vessel noise (Noren et al. 2009). In 2012, there were 79 U.S. and Canadian commercial whale watch vessels in the Haro Strait region (Eisenhardt 2012).These vessels have measured source levels that ranged from 145 to 169 dB re 1 µPa at 1 m and have the sound they produce underwater has the potential to result in behavioral disturbance, interfere with communication, and affect the killer whales' hearing (Erbe 2002). Killer whales foraged significantly less and traveled significantly more when boats were within 328 ft. (100 m) of the whales (Kruse 1991a; Trites and Bain 2000; Williams and Noren 2009; Williams et al. 2002b);Lusseau et al. 2009). These short-term feeding activity disruptions may have important long-term population-level effects (Lusseau et al. 2009; (Noren et al. 2009). The reaction of the killer whales to whale-watching

vessels may be in response to the vessel pursuing them, rather than to the noise of the vessel itself, or to the number of vessels in their proximity.

Similar behavioral changes (increases in traveling and other stress-related behaviors) have been documented in Indo-Pacific bottlenose dolphins in Zanzibar (Christiansen et al. 2010; Englund and Berggren 2002; Stensland and Berggren 2007a). Short-term displacement of dolphins due to tourist boat presence has been documented (Carrera et al. 2008), while longer term or repetitive/sustained displacement for some dolphin groups due to chronic vessel noise has been noted (Haviland-Howell et al. 2007; Miksis-Olds et al. 2007). Most studies of the behavioral reactions to vessel traffic of bottlenose dolphins have documented at least short-term changes in behavior, activities, or vocalization patterns when vessels are near, although the distinction between vessel noise and vessel movement has not been made clear (Acevedo 1991b; Arcangeli and Crosti 2009; Berrow and Holmes 1999; Gregory and Rowden 2001; Janik and Thompson 1996; Lusseau 2004; Mattson et al. 2005; Scarpaci et al. 2000).

Both finless porpoises (Li et al. 2008) and harbor porpoises (Polacheck and Thorpe 1990) routinely avoid and swim away from large motorized vessels. The vaquita, which is closely related to the harbor porpoise in the Action Area, appears to avoid large vessels at about 2,995 ft. (913 m) Jaramillo-Legorreta, 1999 #67695}. The assumption is that the harbor porpoise would respond similarly to large Navy vessels.

Odontocetes have been shown to make short-term changes to vocal parameters such as intensity (Holt et al. 2008a) as an immediate response to vessel noise, as well as increase the pitch, frequency modulation, and length of whistling (May-Collado and Wartzok 2008). Likewise, modification of multiple vocalization parameters has been shown in belugas residing in an area known for high levels of commercial traffic. These animals decreased their call rate, increased certain types of calls, and shifted upward in frequency content in the presence of small vessel noise (Lesage et al. 1999). Another study detected a measurable increase in the amplitude of their vocalizations when ships were present (Scheifele et al. 2005). Killer whales off the northwestern coast of the United States have been observed to increase the duration of primary calls once a threshold in observed vessel density (e.g., whale watching) was reached, which has been suggested as a response to increased masking noise produced by the vessels (Foote et al. 2004). On the other hand, long-term modifications to vocalizations may be indicative of a learned response to chronic noise, or of a genetic or physiological shift in the populations. For example, the source level of killer whale vocalizations has been shown to increase with higher background noise levels associated with vessel traffic (the Lombard effect) (Hotchkin and Parks 2013). In addition, calls with a high-frequency component have higher source levels than other calls, which may be related to behavioral state, or may reflect a sustained increase in background noise levels (Holt et al. 2008).

3.6.3.4.3 Pinnipeds

Little is known about pinniped reactions to underwater non-impulsive sounds (Southall et al. 2007a,) including vessel noise. In a review of reports on reactions of pinnipeds to small craft and ships, Richardson et al. (1995) note that information is on pinniped reactions is limited and most reports are based on anecdotal observations. Specific case reports in Richardson et al. (1995) vary based on factors such as routine anthropogenic activity, distance from the vessel, engine type, wind direction, and ongoing subsistence hunting. As with reactions to sound reviewed by Southall et al. (2007a) pinniped responses to vessels are affected by the context of the situation and by the animal's experience. In summary, pinniped's reactions to vessels are variable and reports include a wide entire spectrum of possibilities from avoidance and alert to cases where animals in the water are attracted and cases on land where there is lack of significant reaction suggesting "habituation" or "tolerance" of vessels (Richardson et al. 1995).

A study of reactions of harbor seals hauled out on ice to cruise ship approaches in Disenchantment Bay, Alaska revealed that animals are more likely to flush and enter the water when cruise ships approach within 1,640 ft. (500 m) and four times more likely when the cruise ship approaches within 328 ft. (100 m) (Jansen et al. 2010). Navy vessels would generally not operate in vicinity of nearshore natural areas that are pinniped haul-out or rookery locations.

3.6.3.5 **Behavioral Reactions of Marine Mammals to Aircraft and Missile Overflights**

Thorough reviews of the subject and available information are presented in Richardson et al. (1995a), Efroymson et al. (2000), Luksenburg and Parsons (2009), and Holst et al. (2011). The most common responses of cetaceans to overflights were short surfacing durations, abrupt dives, and percussive behavior (breaching and tail slapping) (Nowacek et al. 2007). Other behavioral responses such as flushing and fleeing the area of the source of the noise have also been observed (Manci et al. 1988; (Holst et al. 2011). Richardson et al. (1995) noted that marine mammal reactions to aircraft overflight largely consisted of opportunistic and anecdotal observations lacking clear distinction between reactions potentially caused by the noise of the aircraft and the visual cue an aircraft presents. In addition it was suggested that variations in the responses noted were due to generally other undocumented factors associated with overflight (Richardson et al. 1995). These factors could include aircraft type (single engine, multi-engine, jet turbine), flight path (centered on the animal, off to one side, circling, level and slow), environmental factors such as wind speed, sea state, cloud cover, and locations where native subsistence hunting continues.

3.6.3.5.1 Mysticetes

Mysticetes either ignore or occasionally dive in response to aircraft overflights (Efroymson et al. 2000; Koski et al. 1998). Richardson et al. (1995) reported that while data on the reactions of mysticetes is meager and largely anecdotal, there is no evidence that single or occasional aircraft

flying above mysticetes causes long-term displacement of these mammals. In general, overflights above 1,000 ft. (305 m) do not cause a reaction.

Bowhead whales in the Beaufort Sea exhibited a transient behavioral response to fixed-wing aircraft and vessels. Reactions were frequently observed at less than 1,000 ft. (305 m) above sea level, infrequently observed at 1,500 ft. (457 m), and not observed at 2,000 ft. (610 m) above sea level (Richardson et al.1995). Bowhead whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns. Behavioral reactions decreased in frequency as the altitude of the helicopter increased to 492 ft. (150 m) or higher. It should be noted that bowhead whales may have more acute responses to anthropogenic activity than many other marine mammals since these animals are often presented with limited egress due to limited open water between ice floes. Additionally many of these animals may be hunted by Alaska Natives, which could lead to animals developing additional sensitivity to human noise and presence.

3.6.3.5.2 Odontocetes

Variable responses to aircraft have been observed in toothed whales, though overall little change in behavior has been observed during flyovers. Some toothed whales dove, slapped the water with their flukes or flippers, or swam away from the direction of the aircraft during overflights; others did not visibly react (Richardson et al. 1995).

During standard marine mammal surveys at an altitude of 750 ft. (229 m), some sperm whales remained on or near the surface the entire time the aircraft was in the vicinity, while others dove immediately or a few minutes after being sighted. Other authors have corroborated the variability in sperm whales' reactions to fixed-wing aircraft or helicopters (Green et al. 1992a) (Richter et al. 2006; Richter et al. 2003a; Smultea et al. 2008; Wursig et al. 1998). In one study, sperm whales showed no reaction to a helicopter until they encountered the downdrafts from the rotors (Richardson et al. 1995). A group of sperm whales responded to a circling aircraft (altitude of 800 to 1,100 ft. [244 to 335 m]) by moving closer together and forming a defensive fan-shaped semicircle, with their heads facing outward. Several individuals in the group turned on their sides, apparently to look up toward the aircraft (Smultea et al. 2008). Whale-watching aircraft apparently caused sperm whales to turn more sharply but did not affect blow interval, surface time, time to first click, or the frequency of aerial behavior (Richter et al. 2003a). Navy aircraft do not fly at low altitude, hover over, or follow whales and so are not expected to evoke this type of response.

Smaller delphinids generally react to overflights either neutrally or with a startle response (Wursig et al. 1998). The same species that show strong avoidance behavior to vessel traffic (*Kogia* species and beaked whales) also react to aircraft (Wursig et al. 1998). Beluga whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and

altering breathing patterns to a greater extent than mysticetes in the same area (Patenaude et al. 2002). These reactions increased in frequency as the altitude of the helicopter dropped below 492 ft. (150 m).

3.6.3.5.3 Pinnipeds

Richardson et al. (1995) noted that data on pinniped reactions to aircraft overflight largely consisted of opportunistic and anecdotal observations. Richardson et al.'s (1995) summary of this variable data note that responsiveness generally was dependent on the altitude of the aircraft, the abruptness of the associated aircraft sound, and life cycle stage (breeding, molting, etc.). Hauled out pinnipeds exposed to aircraft sight or sound often react by becoming alert and in many cases rushing into the water. Stampedes resulting in mortality to pups (by separation or crushing) have been noted in some cases although it is rare. Holst et al. (2011) provides an up-to-date review of this subject.

Helicopters are used in studies of several species of seals hauled out and is considered an effective means of observation (Bester et al. 2002; Bowen et al. 2006; Gjertz and Borset 1992), although they have been known to elicit behavioral reactions such as fleeing (Hoover 1988). In other studies, harbor seals showed no reaction to helicopter overflights (Gjertz and Borset 1992).

Ringed seals near an oil production island in Alaska reacted to approaching Bell 212 helicopters generally by increasing vigilance, although one seal left its basking site for the water after a helicopter approached within approximately 328 ft. (100 m) (Blackwell et al. 2004). Seals in the study near an oil production platform were thought to be habituated and showed no reactions to industrial noise in water or in air, including impact pile-driving, during the rest of the observations.

Pinniped reactions to rocket launches and overflight at San Nicolas Island, California were studied for the time period of August 2001–October 2008 (Holst et al. 2011). Consistent with other reports, behavioral reactions were found to differ between species. California sea lions startled and increased vigilance for up to 2 minutes after a rocket overflight, with some individuals moving down the beach or returning to the water. Northern elephant seals showed little reaction to any overflight. Harbor seals had the most pronounced reactions of the three species observed with most animals within approximately 2.5 mi. (4 km) of the rocket trajectory leaving their haul-out sites for the water and not returning for several hours. The authors concluded that the effects of the rocket launches were minor with no effects on local populations evidenced by the increasing populations of pinnipeds on San Nicolas Island (Holst et al. 2011).

3.6.3.6 **Repeated Exposures**

Repeated exposures of an individual to multiple sound-producing activities over a season, year, or life stage could cause reactions with costs that can accumulate over time to cause long-term

consequences for the individual. Conversely, some animals habituate to or become tolerant of repeated exposures over time, learning to ignore a stimulus that in the past has not accompanied any overt threat.

Repeated exposure to acoustic and other anthropogenic stimuli has been studied in several cases, especially as related to vessel traffic and whale watching. Common dolphins in New Zealand responded to dolphin-watching vessels by interrupting foraging and resting bouts, and took longer to resume behaviors in the presence of the vessel (Stockin et al. 2008). The authors speculated that repeated interruptions of the dolphins foraging behaviors could lead to long-term implications for the population. Bejder et al. (2006b) studied responses of bottlenose dolphins to vessel approaches and found stronger and longer lasting reactions in populations of animals that were exposed to lower levels of vessel traffic overall. The authors indicated that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or tolerate the disturbance and remain in the area. Marine mammals that are more tolerant may stay in a disturbed area, whereas individuals that are more sensitive may leave for areas with less human disturbance. However, animals that remain in the area throughout the disturbance may be unable to leave the area for a variety of physiological or environmental reasons. Terrestrial examples of this abound as human disturbance and development displace more sensitive species, and tolerant animals move in to exploit the freed resources and fringe habitat. Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region if they do not become acclimated to the presence of the sound (Bejder et al. 2006c; Blackwell et al. 2004; Teilmann et al. 2006). Gray whales in Baja California abandoned an historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. Whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al. 1984). Over a shorter time scale, studies on the Atlantic Undersea Test and Evaluation Center (AUTEC) instrumented range in the Bahamas have shown that some Blaineville's beaked whales may be resident during all or part of the year in the area, and that individuals may move off of the range for several days during and following a sonar event. However animals are thought to continue feeding at short distances (a few kilometers) from the range out of the louder sound fields (less than 157 dB re 1 µPa) (McCarthy et al. 2011; Tyack et al. 2011b). Mysticetes in the northeast tended to adjust to vessel traffic over a number of years, trending towards more neutral responses to passing vessels (Watkins 1986) indicating that some animals may habituate or otherwise learn to cope with high levels of human activity. Nevertheless, the long-term consequences of these habitat utilization changes are

unknown, and likely vary depending on the species, geographic areas, and the degree of acoustic or other human disturbance.

Moore and Barlow (2013) have noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 300 nm from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico. There are scientific caveats and limitations to the data used for that analysis, as well as oceanographic and species assemblage changes not thoroughly addressed in Moore and Barlow (2013), although the authors suggest Navy sonar as one possible explanation for the apparent decline in beaked whale numbers over that broad area. In the small portion of the Pacific coast overlapping the Navy's Southern California Range Complex, long-term residency by individual Cuvier's beaked whales and documented higher densities of beaked whales provide indications that the proposed decline in numbers elsewhere along the Pacific coast is not apparent where the Navy has been intensively training with sonar and other systems for decades. While it is possible that a downward trend in beaked whales may have gone unnoticed at the range complex (due to a lack of survey precision) or that beaked whale densities may have been higher before the Navy began using sonar more than 60 years ago, there is no data available to suggest that beaked whale numbers have declined on the range where Navy sonar use has routinely occurred. As Moore and Barlow (2013) point out, it remains clear that the Navy range in Southern California continues to support high densities of beaked whales.

Establishing a causal link between anthropogenic noise, animal communication, and individual impacts as well as population viability is difficult to quantify and assess (McGregor 2013) (Reed et al. 2014). Reed et al. (2014) for instance reviewed select terrestrial literature on individual and population response to sound as well as discuss a necessary framework in order to assess future direct and indirect fitness impacts. The difficulty with assessing marine behavioral noise effects individually and cumulatively is the confounding nature of the issue where there may or may not be indirect effects with a complex interactive dependence based on age class, prior experience, and behavioral state at the time of exposure, as well as influences by other non-sound related factors (Ellison et al. 2011) (Kight and Swaddle 2011) (Goldbogen et al. 2013) (McGregor et al. 2013) (Reed et al. 2014), (Williams et al. 2014a). McGregor et al. (2013) summarized some studies on sound impacts and described two types of possible effects based on the studies they reviewed: 1) an apparent effect of noise on communication, but with a link between demonstrated proximate cost and ultimate cost in survival or reproductive success being inferred rather than demonstrated, and 2) studies showing a decrease in population density or diversity in relation to noise, but with a relationship that is usually a correlation, so factors other than noise or its effect on communication might account for the relationship (McGregor et al. 2013). Within the ocean environment, there is a complex interaction of considerations needed in terms of defining cumulative anthropogenic impacts that has to also be considered in context of natural variation and climate change (Boyd and Hutchins 2012). These can include environmental

enhancers that improve fitness, additive effects from two or more factors, multiplicity where response from two or more factors is greater than the sum of individual effects, synergism between factors and response, antagonism as a negative feedback between factors, acclimation as a short-term individual response, and adaptation as a long-term population change (Boyd and Hutchins 2012). To address determination of cumulative effects and responses from any changes due to processes such as habituation, tolerance, and sensitization, future experiments over an extended period of time still need further research (Bejder et al. 2009) (Blickley et al. 2012, Reed et al 2014).

3.6.3.7 **Stranding**

When a marine mammal swims or floats (live or dead) onto shore and becomes "beached" or incapable of returning to sea, the event is termed a "stranding" (Geraci et al. 1999; Geraci and Lounsbury 2005). Animals outside of their "normal" habitat are also sometimes considered "stranded" even though they may not have beached themselves. The legal definition for a stranding within the United States is that: (A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is apparently in need of medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance" (16 United States Code Section 1421h).

Marine mammals are subjected to a variety of natural and anthropogenic factors, acting alone or in combination, which may cause a marine mammal to strand on land or die at-sea (Geraci et al. 1999; Geraci and Lounsbury 2005). Even for the fractions of more thoroughly investigated strandings involving post-stranding data collection and necropsies, the cause (or causes) for the majority of strandings remain undetermined. Natural factors related to strandings include, for example, the availability of food, predation, disease, parasitism, climatic influences, and aging (Bradshaw et al. 2006; Culik 2004; Geraci et al. 1999; Geraci and Lounsbury 2005; Perrin and Geraci 2002; Walker et al. 2005)(NRC 2003) (Hoelzel 2003). Anthropogenic factors include, for example, pollution (Anonmyous 2010; Elfes et al. 2010; Hall et al. 2006a; Hall et al. 2006b; Jepson et al. 2005; Tabuchi et al. 2006), vessel strike (Berman-Kowalewski et al. 2010; De Stephanis and Urquiola 2006; Geraci and Lounsbury 2005; Jensen and Silber 2003; Laist et al. 2001), fisheries interactions (Read et al. 2006)(Look 2011), entanglement (Baird and Gorgone 2005)(Johnson et al. 2005; Saez et al. 2013), and noise (Richardson et al. 1995a)(NRC 2003)(Cox et al. 2006).

Along the coasts of the continental United States and Alaska between 2001 and 2009, there were on average approximately 1,400 cetacean strandings and 4,300 pinniped strandings (5,700 total)

per year (National Marine Fisheries Service 2011a, b, c, d). Several "mass stranding" events—strandings that involve two or more individuals of the same species (excluding a single cow-calf pair)—that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduced sound into the marine environment. An in-depth discussion of strandings is presented in U.S. Department of the Navy (2013). For the general environment around the Action Area in particular, see, for example, Barbieri et al. (2013), Calambokidis and Huggins (2008), Cascadia Research (2010a, b, 2012a, b, 2013), Engelhard et al. (2012), Norman et al. (2004), Osborne (2003), Rice et al. (1986), Saez et al. (2013), and Willis and Baird et al. (1998).

Sonar use during exercises involving U.S. Navy (most often in association with other nations' defense forces) has been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira Island, Portugal in 2000; the Canary Islands in 2002, and Spain in 2006 (Marine Mammal Commission 2006). These five mass stranding events have resulted in about 40 known stranding deaths among cetaceans, consisting mostly of beaked whales, with a potential link to sonar (International Council for the Exploration of the Sea 2005a, b, c). The U.S.-Navy-funded research involving Behavioral Response Studies in Southern California and the Bahamas discussed previously were motivated by the desire to understand any links between the use of mid-frequency sonar and cetacean behavioral responses, including the potential for strandings. Although these events have served to focus attention on the issue of impacts resulting from the use of sonar, as Ketten (2012) recently pointed out, "ironically, to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result [of] anthropogenic noise exposures, including sonar."

In these previous circumstances, exposure to non-impulsive acoustic energy has been considered a potential indirect cause of the death of marine mammals (Cox et al. 2006). One hypothesis regarding a potential cause of the strandings is tissue damage resulting from "gas and fat embolic syndrome" (Jepson et al. 2003; Fernandez et al. 2005; Jepson et al. 2005). Models of nitrogen saturation in diving marine mammals have been used to suggest that altered dive behavior might result in the accumulation of nitrogen gas such that the potential for nitrogen bubble formation is increased (Houser et al. 2001, 2010a; Zimmer and Tyack 2007). If so, this mechanism might explain the findings of gas and bubble emboli in stranded beaked whales. It is also possible that stranding is a behavioral response to a sound under certain contextual conditions and that the subsequently observed physiological effects (e.g., overheating, decomposition, or internal hemorrhaging from being on shore) were the result of the stranding rather than direct physical impact from exposure to sonar (Cox et al. 2006).

As additional background and specific to the Action Area, in May 2003 there was an incident involving the use of mid-frequency sonar by the USS SHOUP, which was portrayed in some

media reports at the time as having potentially causing harbor porpoise strandings in the region. On 5 May 2003 in the area of Admiralty Inlet, the USS SHOUP began the use of mid-frequency sonar as part of a training event, which continued until later that afternoon and ended as the USS SHOUP transited Haro Strait heading north. Between 2 May and 2 June 2003, approximately 16 strandings involving 15 harbor porpoises (*Phocoena phocoena*) and 1 Dall's porpoise (*Phocoenoides dalli*) had been reported to the Northwest Marine Mammal Stranding Network, and allegations were made that these strandings had been caused by the USS SHOUP's use of sonar. A comprehensive review of all strandings and the events involving USS SHOUP on 5 May 2003, were subsequently presented in a report by U.S. Department of Navy (2004).

Additionally National Marine Fisheries Service undertook a series of necropsy analyses on the stranded animals to determine the cause of the strandings (National Marine Fisheries Service 2005b, Norman et al. 2004). Necropsies were performed on 10 of the porpoises and two heads were selected for computed tomographic imaging (Norman et al. 2004).

None of the 11 harbor porpoises demonstrated signs of acoustic trauma. A putative cause of death was determined for five of the porpoises based only on the necropsy results; two animals had blunt trauma injuries and three animals had indication of disease processes. A cause of death could not be determined in the remaining animals, which is consistent with the expected percentage of marine mammal necropsies conducted within the northwest region. It is important to note, that these determinations were based only on the evidence from the necropsy to avoid bias with regard to determinations of the potential presence or absence of acoustic trauma. For example, the necropsy investigators had no knowledge of other potential external causal factors, such as Specimen 33NWR05005 having been found tangled in a fishing net, which may have otherwise assisted in their determination regarding the likely cause of death for that animal. Additionally, seven of the porpoises collected and analyzed died prior to SHOUP departing to sea on 5 May 2003. Of these seven, one, discovered on 5 May 2003, was in a state of moderate decomposition, indicating it died before May 5; the cause of death was determined, most likely, to be Salmonella septicemia. Another porpoise, discovered at Port Angeles on 6 May 2003, was in a state of moderate decomposition, indicating that this porpoise also died prior to May 5. One stranded harbor porpoise discovered fresh on May 6 is the only animal that could potentially be linked in time to the USS SHOUP's May 5 active sonar use. Necropsy results for this porpoise found no evidence of acoustic trauma. The remaining eight strandings were discovered 1–3 weeks after the USS SHOUP's May 5 use of sonar. Two of the eight porpoises died from blunt trauma injury and a third suffered from parasitic infestation, which possibly contributed to its death (Norman et al. 2004). For the remaining five porpoises, NMFS was unable to identify the causes of death.

NMFS concluded from a retrospective analysis of stranding events that the number of harbor porpoise stranding events in the approximate month surrounding the USS SHOUP's use of sonar

was higher than expected based on annual strandings of harbor porpoises (Norman et al. 2004). This conclusion in the NMFS report also conflicts with data from The Whale Museum, which has documented and responded to harbor porpoise strandings since 1980 (Osborne 2003). According to The Whale Museum, the number of strandings as of 15 May 2003 was consistent with what was expected based on historical stranding records and was less than that occurring in certain years. For example, since 1992, the San Juan Stranding Network has documented an average of 5.8 porpoise strandings per year. In 1997, there were 12 strandings in the San Juan Islands, with more than 30 strandings throughout the general Puget Sound area. In reporting their findings, NMFS acknowledged that the intense level of media attention to the 2003 strandings likely resulted in increased reporting effort by the public over that which is normally observed (Norman et al. 2004). NMFS also noted in its report that the "sample size is too small and biased to infer a specific relationship with respect to sonar usage and subsequent strandings." It was also clear that in 2003, the number of strandings in the May–June timeframe that year was also higher for the outer coast, indicating a much wider phenomena than use of sonar by USS SHOUP in Puget Sound for one day in May. It was in fact later determined by NMFS that the number of harbor porpoise strandings in the northwest had been increased beginning in 2003 and through 2006. On 3 November 2006, an Unusual Mortality Event in the Pacific Northwest was declared by NMFS (see U.S. Department of the Navy [2013], Cetacean Stranding Report for more detail on this Unusual Mortality Event).

The speculative association of the harbor porpoise strandings to the use of sonar by the USS SHOUP was inconsistent with prior stranding events linked to the use of mid-frequency sonar. Specifically, in prior events (strandings shortly after the use of sonar [less than 36 hours]), stranded individuals were spatially co-located. Although MFA sonar was used by the USS SHOUP, the distribution of harbor porpoise strandings by location and with respect to time surrounding the event do not support the suggestion that MFA sonar was a cause of harbor porpoise strandings. Rather, a lack of evidence of any acoustic trauma within the harbor porpoises, and the identification of probable causes of stranding or death in several animals, supports the conclusion that harbor porpoise strandings in 2003 in the Pacific Northwest were unrelated to the sonar activities by the USS SHOUP.

As International Council for the Exploration of the Sea (2005b) noted, taken in context of marine mammal populations in general, sonar is not a major threat, or significant portion of the overall ocean noise budget. This has also been demonstrated by monitoring in areas where Navy operates (McDonald et al. 2006; (Bassett et al. 2010); Baumann-Pickering et al. 2010; Hildebrand et al. 2011; Tyack et al. 2011). Regardless of the direct cause, the Navy considers potential sonar related strandings important and continues to fund research and work with scientists to better understand circumstances that may result in strandings. During a Navy training event on 4 March 2011 at the Silver Strand Training Complex in San Diego, California,

four long-beaked common dolphins were killed by the detonation of an underwater explosive (Danil and St. Leger 2011). This area has been used for underwater demolitions training for at least 3 decades without incident. During this underwater detonation training event, a pod of 100–150 long-beaked common dolphins were observed moving towards the explosive event's 700 yd. (640 m) exclusion zone monitored by a personnel in a safety boat and participants in a dive boat. Within the exclusion zone, approximately 5 minutes remained on a time-delayed firing device connected to a single 8.76 lb. (3.8 kg) explosive charge weight (C-4 and detonation cord) set at a depth of 48 ft. (14.6 m), approximately 0.5–0.75 nm from shore. Although the dive boat was placed between the pod and the explosive in an effort to guide the dolphins away from the area, that effort was unsuccessful and three long-beaked common dolphins died as a result of being in proximity to the explosion. In addition, to the three dolphins found dead on 4 March at the event site, the remains of a fourth dolphin were discovered on 7 March (3 days later and approximately 42 mi. (68 km) from the location where the training event occurred), which was assessed as being related to this event (Danil and St. Leger 2011). Details such as the dolphins' depth and distance from the explosive at the time of the detonation could not be estimated from the 250 yd. (229 m) standoff point of the observers in the dive boat or the safety boat.

These dolphin mortalities are the only known occurrence of a U.S. Navy training event involving impulsive energy (underwater detonation) that has resulted in injury to a marine mammal. Despite this being a rare occurrence, the Navy has reviewed training requirements, safety procedures, and potential mitigation measures and, along with NMFS, is determining appropriate changes to implement to reduce the potential for this to occur in the future.

In comparison to potential strandings or injury resulting from events associated with Navy activities, marine mammal strandings and injury from commercial vessel ship strike (e.g., Berman-Kowalewski et al. 2010; Silber et al. 2010), impacts from urban pollution (e.g., O'Shea & Brownell 1994; Hooker et al. 2007), and annual fishery-related entanglement, bycatch, injury, and mortality (e.g., Baird and Gorgone 2005; Forney and Kobayashi 2007; Saez et al. 2013), have been estimated worldwide to be orders of magnitude greater (hundreds of thousands of animals versus tens of animals; Culik 2004, International Council for the Exploration of the Sea 2005b, Read et al. 2006) than the few potential injurious impacts that could be possible as a result of Navy activities. This does not negate the potential influence of mortality or additional stress to small, regionalized sub-populations which may be at greater risk from human related mortalities (fishing, vessel strike, sound) than populations with larger oceanic level distributions, but overall the Navy's impact in the oceans and inland water areas where training occurs is small by comparison to other human activities. Nonetheless, the focus of our analysis is the impacts of the Navy's planned activities to determine, considering the status of the resources, the environmental baseline and effects from future non-federal activities, whether the Navy's

activities are likely to jeopardize listed species or are likely to destroy or adversely modify critical habitat.

3.6.3.8 **Long-Term Consequences to the Individual and the Population**

Long-term consequences to a population are determined by examining changes in the population growth rate. Individual effects that could lead to a reduction in the population growth rate include mortality or injury (that removes animals from the reproductive pool), hearing loss (which depending on severity could impact navigation, foraging, predator avoidance, or communication), chronic stress (which could make individuals more susceptible to disease), displacement of individuals (especially from preferred foraging or mating grounds), and disruption of social bonds (due to masking of conspecific signals or displacement). However, the long-term consequences of any of these effects are difficult to predict because individual experience and time can create complex contingencies, especially for intelligent, long-lived animals like marine mammals. While a lost reproductive opportunity could be a measureable cost to the individual, the outcome for the animal, and ultimately the population, can range from insignificant to significant. Any number of factors, such as maternal inexperience, years of poor food supply, or predator pressure, could produce a cost of a lost reproductive opportunity, but these events may be "made up" during the life of a normal healthy individual. The same holds true for exposure to human-generated noise sources. These biological realities must be taken into consideration when assessing risk, uncertainties about that risk, and the feasibility of preventing or recouping such risks. All too often, the long-term consequence of relatively trivial events like short-term masking of a conspecific's social sounds, or a single lost feeding opportunity, is exaggerated beyond its actual importance by focus on the single event and not the important variable, which is the individual and its lifetime parameters of growth, reproduction and survival.

The linkage between a stressor such as sound and its immediate behavioral or physiological consequences for the individual, and then the subsequent effects on that individual's vital rates (growth, survival and reproduction), and the consequences, in turn, for the population have been reviewed in National Research Council of the National Academies (2005). The Population Consequences of Acoustic Disturbance (PCAD) model (National Research Council of the National Academies 2005) proposes a quantitative methodology for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translate into biologically significant consequences to the population. Population models are well known from many fields in biology including fisheries and wildlife management. These models accept inputs for the population size and changes in vital rates of the population such as the mean values for survival age, lifetime reproductive success, and recruitment of new individuals into the population. The time-scale of the inputs in a population model for long-lived animals such as marine mammals is on the order of seasons, years, or life stages (e.g., neonate, juvenile, reproductive adult), and are often concerned only with the success of individuals from one time

period or stage to the next. Unfortunately, for acoustic and explosive impacts to marine mammal populations, many of the inputs required by population models are not known.

Long-term impacts, noise impacts, habitat deterioration, and beaked whale responses to various stressors were evaluated as part of the assessment of potential impacts. Recently New et al. (2013) developed a mathematical model simulating a functional link between feeding energetics and a species' requirements for survival and reproductions for 21 species of beaked whale. New et al. (2013) report "reasonable confidence" in their model, although approximately 29 percent (6 of 21 beaked whale species modeled) failed to survive or reproduce, which the authors attribute to possible inaccuracies in the underlying parameters. Based on the model simulation, New et al. (2013) determined that if habitat quality and "accessible energy" (derived from the availability of either plentiful prey or prey with high energy content) are both high, then survival rates are high as well. If these variables are low, then adults may survive but calves will not. For the 29 percent of beaked whale species for which the model failed (within the assumed range of current inputs), the assumption was a 2-year calving period (or inter-calf interval), however, for species with longer gestation periods (such as the 17-month gestation period of Baird's beaked whale (*Berardius bairdii*), this inter-calf interval may be too short. For Blainville's beaked whale, Claridge (2013) has shown that calf age at separation is at least 3 years, and that the inter-calf interval at Abaco in the Bahamas may be 4 years. New et al. (2013) acknowledge that an assumed 2-year calving period in the modeling may not be long enough to build up the energetic resources necessary for mother and calf survival.

As another critical model assumption, prey preferences were modeled based on stomach content analyses of stranded animals, which the authors acknowledge are traditionally poor estimates of the diets of healthy animals, as stranded animals are often sick prior to stranding. Stomach content remnants of prey species do not digest equally, as only the hard parts of some prey types remain (e.g., fish otoliths, beaks of cephalopods) and thus often provide an incomplete picture of diet. Given these unknowns and the failure of the simulation to work for 29 percent of beaked whale species, the modeled survival rates of all beaked whales, particularly those modeled with prey having low energy content, may be better than simulated if higher-energy prey makes up a larger part of the diet than assumed by the model simulations.

In short, for the model output New et al. (2013) created to correctly represent links between the species and their environment, that model must identify all the critical and relevant ecological parameters as input variables, provide the correct values for those parameters, and then the model must appropriately integrate modeling functions to duplicate the complex relationships the model intends to represent. If an assumption (model input) such as calving period or prey preferences is incorrect (and there is presently no way to know), then the model would not be representing what may actually be occurring. New et al. (2013) report that their simulations suggest that adults will survive but not reproduce if anthropogenic disturbances result in being displaced to areas of

"impaired foraging." Underlying this suggestion is the additional unstated assumption that habitat capable of sustaining a beaked whale is limited in proximity to where any disturbance has occurred and there are no data to indicate that is a valid assumption.

While the New et al. (2013) model provides a test case for future research, this pilot study has very little of the critical data necessary to form any conclusions applicable to current management decisions. The authors note the need for more data on prey species and reproductive parameters including gestation and lactation duration, as the model results are particularly affected by these assumptions. Therefore, any suggestion of biological sensitivity to the simulation's input parameters is uncertain. Given this level of uncertainty, the Navy has indicated that it will continue to follow developments in the mathematical modeling of energetics to estimate specific sensitivity to disturbance. As discussed in the draft NWTT EIS/OEIS, January 2014, the Navy continues to fund the Behavioral Response Studies in the Bahamas and Southern California specifically to better understand, via direct field observations, the potential for anthropogenic activities to disturb marine mammals. In cooperation with NMFS, the Navy will continue to develop the most effective management and conservation actions needed to protect marine mammals while accomplishing the Navy's mission to train and test safely and effectively.

Claridge (2013) used photo-recapture methods to estimate population abundance and demographics of Blainville's beaked whale (*Mesoplodon densirostris*) in the Bahamas at two sample locations; one within the bounds of the AUTEC where sonar training occurs and the second along the edge of Abaco Island approximately 170 km to the north. To investigate the potential effect of beaked whale exposure to MFA sonar, Claridge assumed that the two sample sites should have should have equal potential abundances and hypothesized that a lower abundance found at the AUTEC was due to either reduced prey availability at AUTEC or due to population level effects from the exposure to MFA sonar at AUTEC. There are two major issues with this study. First, all of the re-sighted whales during the 5-year study at both sites were female. Claridge acknowledges that this can lead to a negative bias in the estimation of abundances. It has been shown in other cetacean species that females with calves may prefer "nursery" habitats or form nursery groups with other mother-calf pairs (e.g., Scott et al. 1990; Claridge 2006; Weir et al. 2008). It may be that the site at Abaco is a preferred site for females with calves, while the site at AUTEC is not, and therefore over the 5-year study period fewer females with calves were observed at AUTEC as these females went elsewhere in the area during the 3-year weaning period. In addition, Marques et al. (2009) estimated the Blainville's beaked whale population at AUTEC to be between 22.5 and 25.3 animals per 1,000 km^2. This density was estimated over 6 days using passive acoustic methods, which is a method Claridge identified as one that may be better for estimating beaked whale densities than visual methods. The results at AUTEC are also biased by reduced effort and a shorter overall study period that did not capture some of the emigration/immigration trends Claridge identified at Abaco. For these

reasons among others, it is unclear whether there are significant differences in the abundances between the two sites. Second, Claridge assumed that the two sites are identical and therefore should have equal potential abundances; Abaco is a "control" site with the difference being the use of sonar at AUTEC. Although the sample boundaries at each location were drawn to create samples "of comparable size," there are differences between the two sample area locations as follows: the Abaco site is along a leeward shore, AUTEC is windward; the Abaco sample area is a long narrow margin along a canyon wall, the rectangular AUTEC sample site is a portion of a deep and landlocked U-shaped trough. In addition to the physical differences, Claridge notes that it remains unclear whether or not variation in productivity between sites influenced what she refers to as the substantial differences in abundance. Claridge reports that a study investigating prey distributions at her sample locations was unable to sample prey at the beaked whale foraging depth. Claridge dismisses the possibility of differences in prey availability between the sites noting that there is no supporting evidence that prey availability differs between the two sites. As this study illustrates, the multiple and complex factors required by investigations of potential long-term cause and effect from actions at sea require a comprehensive assessment of all factors influencing potential trends in species abundances that are not likely attributable to a single cause and effect.

The best assessment of long-term consequences from training activities will be to monitor the populations over time within a given Navy range complex. A U.S. workshop on Marine Mammals and Sound (Fitch et al. 2011) indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival. The Navy has developed monitoring plans for protected marine mammals and sea turtles occurring on Navy ranges with the goal of assessing the impacts of training activities on marine species and the effectiveness of the Navy's current mitigation practices. For example, results from 2 years (2009–2010) of intensive monitoring by independent scientists and Navy observers in Southern California Range Complex and Hawaii Range Complex have recorded an estimated 161,894 marine mammals with no evidence of distress or unusual behavior observed during Navy activities. Continued monitoring efforts over time will be necessary to completely evaluate the long-term consequences of exposure to noise sources.

3.6.3.9 **Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals**

If Navy activities introduce sound or explosive energy into the marine environment, an analysis of potential impacts to marine mammals is conducted. To do this, information about the numerical sound and energy levels that are likely to elicit certain types of physiological and behavioral reactions is needed.

3.6.3.9.1 Frequency Weighting

Frequency-weighting functions are used to adjust the received sound level based on the sensitivity of the animal to the frequency of the sound. The weighting functions de-emphasize sound exposures at frequencies to which marine mammals are not particularly sensitive. This effectively makes the acoustic thresholds frequency-dependent, which means they are applicable over a wide range of frequencies and therefore applicable for a wide range of sound sources. Frequency-weighting functions, called "M-weighting" functions, were proposed by Southall et al. (2007) to account for the frequency bandwidth of hearing in marine mammals. These M-weighting functions were derived for each marine mammal hearing group based on an algorithm using the range of frequencies that are within 80 dB of an animal or group's best hearing. The Southall et al. (2007) M-weighting functions are nearly flat between the lower and upper cutoff frequencies, and thus were believed to represent a conservative approach to assessing the effects of noise (Figure 5). For the purposes of this analysis, the Navy will refer to these as Type I auditory weighting functions. Otariid seal thresholds and weighting functions were applied to sea otter as described in Finneran and Jenkins (2012).

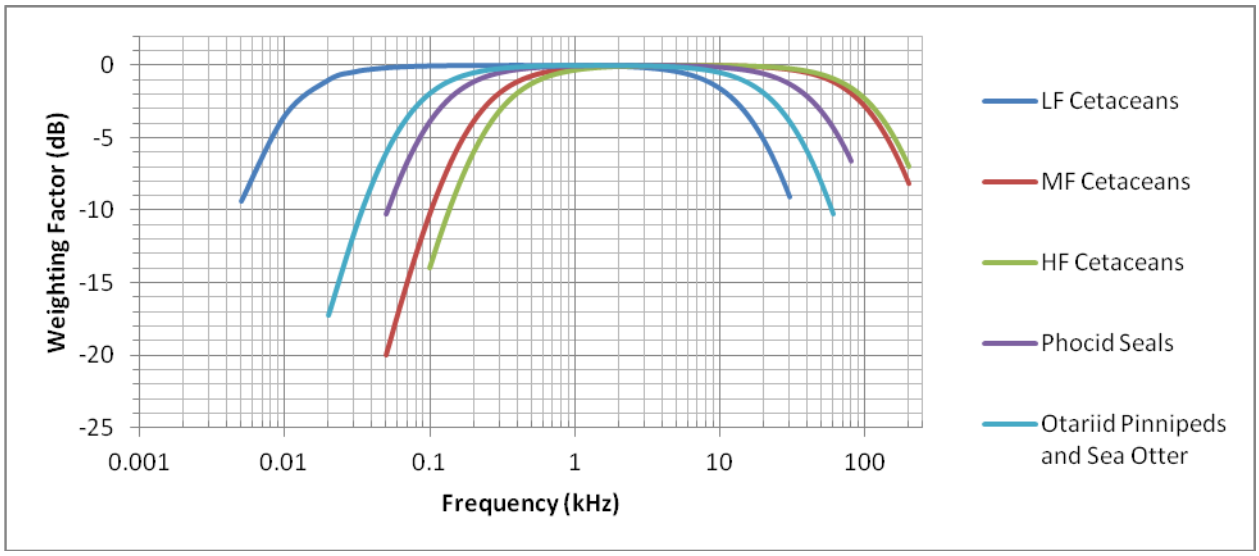

Figure 5. Type I Auditory Weighting Functions Modified from the Southall et al. (2007) M-Weighting Functions

While all data published since 2007 were reviewed to determine if any adjustments to the weighting functions were required, only two published experiments suggested that modification of the mid-frequency cetacean auditory weighting function was necessary (see Finneran and Jenkins [2012] for more details on that modification not otherwise provided below). The first experiment measured TTS in a bottlenose dolphin after exposure to pure tones with frequencies from 3 to 28 kHz (Finneran and Schlundt 2010). These data were used to derive onset-TTS values as a function of exposure frequency, and demonstrate that the use of a single numeric

threshold for onset-TTS, regardless of frequency, is not correct. The second experiment examined how subjects perceived the loudness of sounds at different frequencies to derive equal loudness contours (Finneran and Schlundt 2011). These data are important because human auditory weighting functions are based on equal loudness contours. The dolphin equal loudness contours provide a means to generate auditory weighting functions in a manner directly analogous to the approach used to develop safe exposure guidelines for people working in noisy environments (National Institute for Occupational Safety and Health 1998).

Taken together, the recent higher-frequency TTS data and equal loudness contours provide the underlying data necessary to develop new weighting functions, referred to as Type II auditory weighting functions, to improve accuracy and avoid underestimating the impacts on animals at higher frequencies as shown in Figure 6. To generate the new Type II weighting functions, Finneran and Schlundt (2011) substituted lower and upper frequency values which differ from the values used by Southall et al. (2007).

The new weighting curve predicts appreciably higher (almost 20 dB) susceptibility for frequencies above 3 kHz for bottlenose dolphins, a mid-frequency cetacean. Since data below 3 kHz are not available, the original weighting functions from Southall et al. (2007) were substituted below this frequency. Low- and high-frequency cetacean weighting functions were extrapolated from the dolphin data as well, because of the suspected similarities of greatest susceptibility at best frequencies of hearing. Similar Type II weighting curves were not developed for pinnipeds since their hearing is markedly different from cetaceans, and because they do not hear as well at higher frequencies. Their weighting curves do not require the same adjustment (see Finneran and Jenkins 2012 for additional details).

The Type II auditory cetacean weighting functions (Figure 6) are applied to the received sound level before comparing it to the appropriate sound exposure level thresholds for TTS or PTS, or the impulse behavioral response threshold (note that for pinnipeds and sea otters, the Southall et al. (2007) weighting functions (Figure 6) are used in lieu of any new weighting functions). For some criteria, received levels are not weighted before being compared to the thresholds to predict effects. These include the peak pressure criteria for predicting TTS and PTS from underwater explosions; the acoustic impulse metrics used to predict onset-mortality and slight lung injury; and the thresholds used to predict behavioral responses from harbor porpoises and beaked whales from sonar and other active acoustic sources.

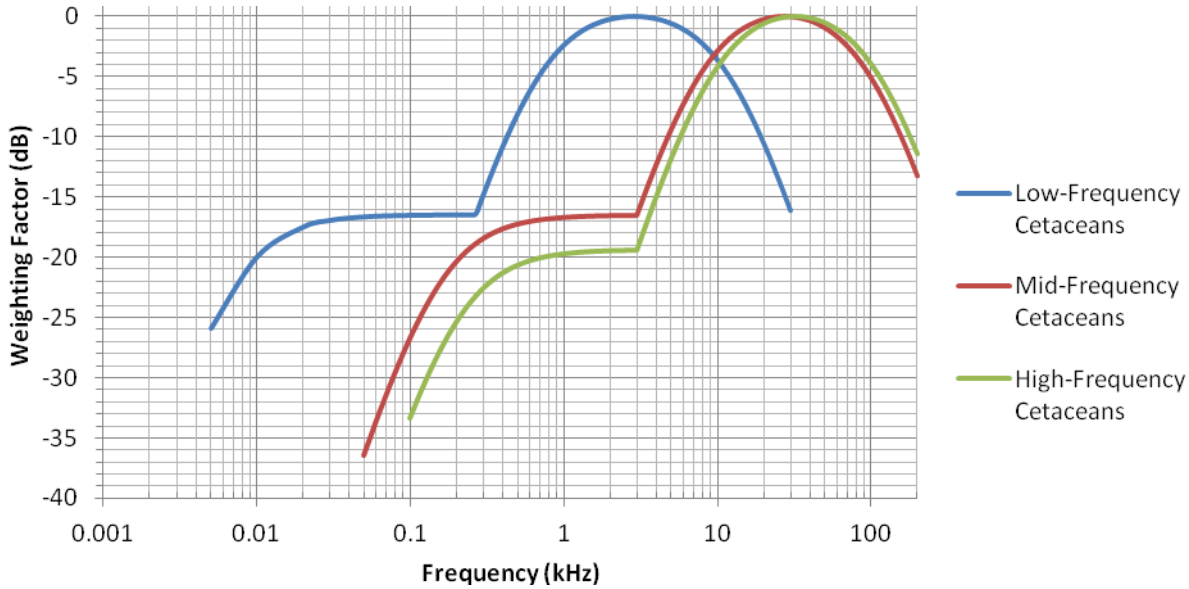

Figure 6. Type II Weighting Functions for Low-, Mid-, and High-Frequency Cetaceans

3.6.3.9.2 Summation of Energy from Multiple Sources

In most cases, an animal's received level will be the result of exposure to a single sound source. In some scenarios, however, multiple sources will be operating simultaneously, or nearly so, creating the potential for accumulation of energy from multiple sources. Energy is summed for multiple exposures of similar source types. For sonar, including use of multiple systems within any scenario, energy will be summed for all exposures within a cumulative exposure band, with the cumulative exposure bands defined in four bands: 0–1.0 kHz (low-frequency sources), 1.1–10.0 kHz (mid-frequency sources), 10.1–100.0 kHz (high-frequency sources), and above 100.0 kHz (very high-frequency sources). Sources operated at frequencies above 200 kHz are considered to be inaudible to all groups of marine mammals and are not analyzed in the quantitative modeling of exposure levels. After the energy has been summed within each frequency band, the band with the greatest amount of energy is used to evaluate the onset of PTS or TTS. For explosives, including use of multiple explosives in a single scenario, energy is summed across the entire frequency band.

3.6.3.10 Hearing Loss – Temporary and Permanent Threshold Shift

Criteria for physiological effects from sonar and other active acoustic sources are based on TTS and PTS with thresholds based on cumulative sound exposure levels. The onset of TTS or PTS from exposure to impulsive sources is predicted using a sound exposure level-based threshold in conjunction with a peak pressure threshold. The horizontal ranges are then compared, with the threshold producing the longest range being the one used to predict effects. For multiple exposures within any 24-hour period, the received sound exposure level for individual events is accumulated for each animal. Since no studies have been designed to intentionally induce PTS in

marine mammals, onset-PTS levels have been estimated using empirical TTS data obtained from marine mammals and relationships between TTS and PTS established in terrestrial mammals.

Temporary and permanent threshold shift thresholds are based on TTS onset values for impulsive and non-impulsive sounds obtained from representative species of mid- and high-frequency cetaceans and pinnipeds. These data are then extended to the other marine mammals for which data are not available. The Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis Technical Report provides a detailed explanation of the selection of criteria and derivation of thresholds for temporary and permanent hearing loss for marine mammals (Finneran and Jenkins 2012).

Table 3. Acoustic Criteria and Thresholds for Predicting Physiological Effects to Marine Mammals Underwater from Sonar and Other Active Acoustic Sources

Hearing Group	Species	Onset temporary threshold shift	Onset permanent threshold shift
Low-Frequency Cetaceans	All mysticetes	178 dB re 1 μPa^2-s SEL (Type II weighting)	198 dB re 1 μPa^2-s SEL (Type II weighting)
Mid-Frequency Cetaceans	Dolphins, beaked whales, and medium and large toothed whales	178 dB re 1 μPa^2-s SEL (Type II weighting)	198 dB re 1 μPa^2-s SEL (Type II weighting)
High-Frequency Cetaceans	Porpoises and *Kogia* spp.	152 dB re 1 μPa^2-s SEL (Type II weighting)	172 dB re 1 μPa^2-s SEL (Type II weighting)
Phocid Seals (underwater)	Northern Elephant & Harbor Seals	183 dB re 1 μPa^2-s SEL (Type I weighting)	197 dB re 1 μPa^2-s SEL (Type I weighting)
Otariidae (underwater)	Sea Lion & Fur Seals	206 dB re 1 μPa^2-s SEL (Type I weighting)	220 dB re 1 μPa^2-s SEL (Type I weighting)
Mustelidae (underwater)	Sea Otters		

Notes: dB = decibels, SEL = Sound Exposure Level, dB re 1 μPa^2-s = decibels referenced to 1 micropascal squared second

Table 4. Criteria and Thresholds for Predicting Physiological Effects to Marine Mammals Underwater for Explosives

Group	Species	Onset TTS	Onset PTS	Onset Slight GI Tract Injury	Onset Slight Lung Injury	Onset Mortality

Low-Frequency Cetaceans	Mysticetes	172 dB re 1 μPa^2-s (low-freq weighting) or 224 dB Peak SPL	187 dB re 1 μPa^2-s (low-freq weighting) or 230 dB Peak SPL	237 dB re 1 μPa	Equation 1	Equation 2
Mid-Frequency Cetaceans	Odontocetes (Toothed Whales)	172 dB re 1 μPa^2-s (mid-freq weighting) or 224 dB Peak SPL	187 dB re 1 μPa^2-s (mid-freq weighting) or 230 dB Peak SPL			
High-Frequency Cetaceans	Porpoises and *Kogia* spp.	146 dB re 1 μPa^2-s (mid-freq weighting) or 195 dB Peak SPL	161 dB re 1 μPa^2-s (mid-freq weighting) or 201 dB Peak SPL			
Phocid Seals (In-Water)	Harbor, beared, hooded common, spotted, ringed, harp, ribbon and gray seals	177 dB re 1 μPa^2-s (phocid weighting) or 212 dB Peak SPL	192 dB re 1 μPa^2-s (phocid weighting) or 218 dB Peak SPL			

Equations:

(1) $$= 39.1M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec$$

(2) $$= 91.4M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec$$

D_{rm} = depth of the receiver (animal) in meters; M = mass of the animals in kg; SPL = sound pressure level

[1] **Impulse calculated over a delivery time that is the lesser of the initial positive pressure duration or 20 percent of the natural period of the assumed-spherical lung adjusted for animal size and depth.**

Notes: TTS = temporary threshold shift, PTS = permanent threshold shift, GI = gastrointestinal, M = mass of animals in kilograms, D_{Rm} = depth of receiver (animal) in meters, SEL = Sound Exposure Level, SPL = Sound Pressure Level (re 1 μPa), dB = decibels, dB re 1 μPa = decibels referenced to 1 micropascal, dB re 1 μPa^2-s = decibels referenced to 1 micropascal squared second

3.6.3.10.1 Temporary Threshold Shift for Sonar and Other Active Acoustic Sources

TTS involves no tissue damage, is by definition temporary, and therefore is not considered injury. TTS values for mid-frequency cetaceans exposed to non-impulsive sound are derived from multiple studies ((Schlundt et al. 2000a); Finneran et al. 2005; Mooney 2009a; Finneran et al. 2010b; Finneran and Schlundt 2010) from two species, bottlenose dolphins and beluga whales. Especially notable are data for frequencies above 3 kHz, where bottlenose dolphins have exhibited lower TTS onset thresholds than at 3 kHz (Finneran and Schlundt 2010; Finneran

2011). This difference in TTS onset at higher frequencies is incorporated into the weighting functions.

Previously, there were no direct measurements of TTS from non-impulsive sound in high-frequency cetaceans. Lucke et al. (2009) measured TTS in a harbor porpoise exposed to a small seismic air gun and those results are reflected in the current impulsive sound TTS thresholds described below. The beluga whale, which had been the only species for which both impulsive and non-impulsive TTS data exist has a non-impulsive TTS onset value about 6 dB above the (weighted) impulsive threshold ((Schlundt et al. 2000a); Finneran et al. 2002). Therefore, 6 dB was added to the harbor porpoise's impulsive TTS threshold demonstrated by Lucke et al. (2009) to derive the non-impulsive TTS threshold used in the current Navy modeling for high frequency cetaceans. Report on the first direct measurements of TTS from non-impulsive sound has been recently presented by Kastelein et al. (2012b) for harbor porpoise. These new data are fully consistent with the current harbor porpoise thresholds used in the modeling of effects from non-impulsive sources.

There are no direct measurements of TTS or hearing abilities for low-frequency cetaceans. The Navy uses mid-frequency cetacean thresholds to assess PTS and TTS for low-frequency cetaceans, since mid-frequency cetaceans are the most similar to the low frequency group (see Finneran and Jenkins (2012) on the development of the thresholds and criteria).

Pinniped TTS criteria are based on data provided by Kastak et al. (2005) for representative species of both of the pinniped hearing groups: harbor seals (Phocidae) and California sea lions (Otariidae). Kastak et al. (2005) used octave band noise centered at 2.5 kHz to extrapolate an onset TTS threshold. More recently Kastelein et al. (2012c) used octave band noise centered at 4 kHz to obtain TTS thresholds in the same two species resulting in similar levels causing onset-TTS as those found in Kastak et al. (2005). For sea otters, the otariid TTS threshold and weighting function are applied due to similarities in taxonomy and auditory performance. The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict TTS.

3.6.3.10.2 Temporary Threshold Shift for Explosives

The TTS sound exposure level thresholds for cetaceans are consistent with the USS MESA VERDE ship shock trial that was approved by NMFS (73 Federal Register [FR] 143) and are more representative of TTS induced from impulses (Finneran et al. 2002) rather than pure tones (Schlundt et al. 2000a). In most cases, a total weighted sound exposure level is more conservative than greatest sound exposure level in one-third octave bands, which was used prior to the USS MESA VERDE ship shock trials. There are no data on TTS obtained directly from low-frequency cetaceans, so mid-frequency cetacean impulse threshold criteria from Finneran et al.

(2002) have been used. High frequency cetacean TTS thresholds are based on research by Lucke et al. (2009), who exposed harbor porpoises to pulses from a single air gun.

Pinniped criteria were not included for prior ship shock trials, as pinnipeds were not expected to occur at the shock trial sites, and TTS criteria for previous Navy EIS/OEISs also were not differentiated between cetaceans and pinnipeds (National Marine Fisheries Service 2008a, 2008b). TTS values for impulse sound criteria have not been obtained for pinnipeds, but there are TTS data for octave band sound from representative species of both major pinniped hearing groups (Kastak et al. 2005). Impulsive sound TTS criteria for pinnipeds were estimated by applying the difference between mid-frequency cetacean TTS onset for impulsive and non-impulsive sounds to the pinniped non-impulsive TTS data (Kastak et al. 2005), a methodology originally developed by Southall et al. (2007). Therefore, the TTS criteria for impulsive sounds from explosions for pinnipeds is 6 dB less than the non-impulsive onset-TTS criteria derived from Kastak et al. (2005).

3.6.3.10.3 Permanent Threshold Shift for Sonar and Other Active Acoustic Sources

There are no direct measurements of PTS onset in marine mammals. Well understood relationships between terrestrial mammalian TTS and PTS have been applied to marine mammals. Threshold shifts up to 40–50 dB have been induced in terrestrial mammals without resultant PTS (Ward et al. 1958, 1959a, b; Miller et al. 1963). These data would suggest that a PTS criteria of 40 dB would be reasonable for conservatively predicting (overestimating) PTS in marine mammals. Data from terrestrial mammal testing (Ward et al. 1958, 1959a, b) show growth of TTS by 1.5 to 1.6 dB for every 1 dB increase in exposure level. The difference between measureable TTS onset (6 dB) and the selected 40 dB upper safe limit of TTS yields a difference in TTS of 34 dB which, when divided by a TTS growth function of 1.6 indicates that an increase in exposure of 21 dB would result in 40 dB of TTS. For simplicity and additional conservatism we have rounded that number down to 20 dB (Southall et al. 2007).

Therefore, exposures to sonar and other active acoustic sources with levels 20 dB above those producing TTS are assumed to produce a PTS. For example, an onset-TTS criteria of 95 dB re 1 μPa^2-s would have a corresponding onset-PTS criteria of 215 dB re 1 μPa^2-s. This extrapolation process is identical to that recently proposed by Southall et al. (2007). The method overestimates or predicts greater effects than have actually been observed in tests on a bottlenose dolphin (Schlundt et al. 2006; (Finneran and Schlundt 2010) and is therefore protective.

Kastak et al. (2007) obtained different TTS growth rates for pinnipeds than Finneran and colleagues obtained for mid-frequency cetaceans. NMFS recommended reducing the estimated PTS criteria for both groups of pinnipeds, based on the difference in TTS growth rate reported by Kastak et al. (2007) (14 dB instead of 20 dB).

The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict PTS.

3.6.3.10.4 Permanent Threshold Shift for Explosions

Since marine mammal PTS data from impulsive exposures do not exist, onset PTS levels for these animals are estimated by adding 15 dB to the sound exposure level-based TTS threshold and by adding 6 dB to the peak pressure based thresholds. These relationships were derived by Southall et al. (2007) from impulsive noise TTS growth rates in chinchillas. The appropriate frequency weighting function for each species group is applied when using the resulting sound exposure level-based thresholds, as shown in Figure 6, to predict PTS.

3.6.4 Background and Framework of U.S. Navy Analysis for Sea Turtles

The following is a brief summary of the Navy's current approach.

3.6.4.1 Direct Injury of Sea Turtles

Direct injury from non-explosive sound sources, such as sonar, is unlikely because of relatively lower peak pressures and slower rise times than potentially injurious sources such as explosions. Nonexplosive sources also lack the strong shock waves that are associated with explosions. Therefore, primary blast injury and barotrauma would not result from exposure to non-impulsive sources such as sonar, and are only considered for explosive detonations.

The potential for trauma in sea turtles exposed to explosive sources has been inferred from tests of submerged terrestrial mammals exposed to underwater explosions (Ketten et al. 1993; Richmond et al. 1973; Yelverton et al. 1973). The effects of an underwater explosion on a sea turtle depend upon several factors, including size, type, and depth of both the animal and the explosive, depth of the water column, and distance from the charge to the animal. Smaller sea turtles would generally be more susceptible to injury. The compression of blast-sensitive, gas-containing organs when a sea turtle increases depth reduces likelihood of injury to these organs. The location of the explosion in the water column and the underwater environment determines whether most energy is released into the water or the air and influences the propagation of the blast wave.

3.6.4.1.1 Primary Blast Injury and Barotrauma

The greatest potential for direct, non-auditory tissue impacts is primary blast injury and barotrauma after exposure to the shock waves of high-amplitude impulsive sources, such as explosions. Primary blast injury refers to those injuries that result from the initial compression of a body exposed to the high pressure of a blast or shock wave. Primary blast injury is usually limited to gas-containing structures (e.g., lung and gut) and the pressure-sensitive components of the auditory system (discussed below) (Office of the Surgeon General 1991; Craig and Hearn 1998), although additional injuries could include concussive brain damage and cranial, skeletal, or shell fractures (Ketten 1995). Barotrauma refers to injuries caused when large pressure

changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system, as measured in terrestrial mammals, may consist of lung bruising, collapsed lung, traumatic lung cysts, or air in the chest cavity or other tissues (Office of the Surgeon General 1991). These injuries may be fatal depending on the severity of the trauma. Rupture of the lung may introduce air into the vascular system, possibly producing air blockage that can cause a stroke or heart attack by restricting oxygen delivery to these organs. Although often secondary in life-threatening severity to pulmonary blast trauma, the gastrointestinal tract can also suffer bruising and tearing from blast exposure, particularly in air-containing regions of the tract. Potential traumas include internal bleeding, bowel perforation, tissue tears, and ruptures of the hollow abdominal organs. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered. Non-lethal injuries could increase a sea turtle's risk of predation, disease, or infection.

3.6.4.1.2 Auditory Trauma

Components of the auditory system that detect smaller or more gradual pressure changes can also be damaged when overloaded at high pressures with rapid rise times. Rupture of the tympanic membrane, while not necessarily a serious or life-threatening injury, may lead to permanent hearing loss (Ketten 1995, 1993). No data exist to correlate the sensitivity of the tympanic membrane and middle and inner ear to trauma from shock waves from underwater explosions (Viada et al. 2008).

The specific impacts of bulk cavitation (the collapse of air spaces created by explosive detonations) on sea turtles are unknown. The presence of a sea turtle within the cavitation region created by the detonation of small charges could annoy, injure, or increase the severity of the injuries caused by the shock wave, including injuries to the auditory system or lungs. The area of cavitation from a large charge, such as those used in ship shock trials, is expected to be an area of almost complete total physical trauma for smaller animals (Craig and Rye 2008). An animal located at (or near) the cavitation closure depth would be subjected to a short duration ("water hammer") pressure pulse; however, direct shock wave impacts alone would be expected to cause auditory system injuries and could cause internal organ injuries.

3.6.4.1.3 Hearing Loss

Hearing loss could effectively reduce the distance over which sea turtles can detect biologically relevant sounds. Both auditory trauma (a direct injury discussed above) and auditory fatigue may result in hearing loss, but the mechanisms responsible for auditory fatigue differ from auditory trauma. Hearing loss due to auditory fatigue is also known as threshold shift, a reduction in hearing sensitivity at certain frequencies. Threshold shift is the difference between hearing thresholds measured before and after an intense, fatiguing sound exposure. Threshold shift occurs when hair cells in the ear fatigue, causing them to become less sensitive over a small

range of frequencies related to the sound source to which an animal was exposed. The actual amount of threshold shift depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure. No studies are published on inducing threshold shift in sea turtles; therefore, the potential for the impact on sea turtles is inferred from studies of threshold shift in other animals.

Temporary threshold shift (TTS) is a hearing loss that recovers to the original hearing threshold over a period. An animal may not even be aware of a TTS. It does not become deaf, but requires a louder sound stimulus (relative to the amount of TTS) to detect a sound within the affected frequencies. TTS may last several minutes to several days, depending on the intensity and duration of the sound exposure that induced the threshold shift (including multiple exposures).

Permanent threshold shift (PTS) is a permanent hearing loss at a certain frequency range. PTS is non-recoverable due to the destruction of tissues within the auditory system. The animal does not

become deaf, but requires a louder sound stimulus (relative to the amount of PTS) to detect a sound within the affected frequencies. As the name suggests, the effect is permanent.

3.6.4.1.4 Auditory Masking

Auditory masking occurs when a sound prevents or limits the distance over which an animal detects other biologically relevant sounds. When a noise has a sound level above the sound of interest, and in a similar frequency band, auditory masking could occur. Any sound above ambient noise levels and within an animal's hearing range could cause masking. The degree of masking increases with increasing noise levels; a noise that is just-detectable over ambient levels is unlikely to actually cause any substantial masking, whereas a louder noise may mask sounds over a wider frequency range. In addition, a continuous sound would have more potential for masking than a sound with a low duty cycle. In the open ocean, ambient noise levels are between about 60 and 80 dB re 1 μPa (National Research Council 2003), especially at lower frequencies (below 100 Hz) and inshore, ambient noise levels, especially around busy ports, can exceed 120 dB re 1 μPa.

Unlike auditory fatigue, which always results in a localized stress response, behavioral changes resulting from auditory masking may not be coupled with a stress response. Another important distinction between masking and hearing loss is that masking only occurs in the presence of the sound stimulus, whereas hearing loss can persist after the stimulus is gone.

Little is known about how sea turtles use sound in their environment. Based on knowledge of their sensory biology (Moein Bartol and Ketten 2006; Bartol and Musick 2003), sea turtles may be able to detect objects within the water column (e.g., vessels, prey, predators) via some combination of auditory and visual cues. However, research examining the ability of sea turtles to avoid collisions with vessels shows they may rely more on their vision than auditory cues

(Hazel et al. 2007). Similarly, while sea turtles may rely on acoustic cues to identify nesting beaches, they appear to rely on other non-acoustic cues for navigation, such as magnetic fields (Lohmann and Lohmann 1996a, b) and light (Avens and Lohmann 2003). Additionally, they are not known to produce sounds underwater for communication. As a result, sound may play a limited role in a sea turtle's environment. Therefore, the potential for masking may be limited.

3.6.4.1.5 Physiological Stress

Sea turtles may exhibit a behavioral response or combinations of behavioral responses upon exposure to anthropogenic sounds. If a sound is detected, a stress response (i.e., startle or annoyance) or a cueing response (based on a past stressful experience) can occur. Sea turtles naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, nesting, and interactions with predators all contribute to stress. Anthropogenic activities could provide additional stressors above and beyond those that occur in the absence of human activity.

Repeated exposure to stressors, including human disturbance such as vessel disturbance and anthropogenic sound, may result in negative consequences to the health and viability of an individual or population (Gregory and Schmid 2001). Immature Kemp's ridley turtles show physiological responses to the acute stress of capture and handling through increased levels of the stress hormone corticosterone, along with biting and rapid flipper movement (Gregory and Schmid 2001). Captive olive ridley hatchlings showed heightened blood glucose levels indicating physiological stress (Rees et al. 2008, Zenteno et al. 2007).

Factors to consider when predicting a stress or cueing response is whether an animal is naïve or has prior experience with a stressor. Prior experience with a stressor may be of particular importance as repeated experience with a stressor may dull the stress response via acclimation (Hazel et al. 2007).

3.6.4.1.6 Behavioral Reactions

Little is known about the hearing ability of sea turtles and their response to acoustic disturbance and thus analogous species for which data are available are used to estimate the potential behavioral reactions to sound. The response of a sea turtle to an anthropogenic sound will depend on the frequency, duration, temporal pattern, and amplitude of the sound, as well as the animal's prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure). Distance from the sound source and whether it is perceived as approaching or moving away could also affect the way a sea turtle responds to a sound. Potential behavioral responses to anthropogenic sound could include startle reactions, disruption of feeding, disruption of migration, changes in respiration, alteration of swim speed, alteration of swim direction, and area avoidance.

Studies of sea turtle responses to sounds are limited, though a few studies examined sea turtle reactions to airguns, which produce broadband impulse sound. O'Hara and Wilcox (1990) attempted to create a sound barrier at the end of a canal using seismic airguns. They reported that loggerhead turtles kept in a 984 ft. by 148 ft. (300 m by 45 m) enclosure in a 10 m deep canal maintained a standoff range of 98 ft. (30 m) from airguns fired simultaneously at intervals of 15 seconds, with strongest sound components within the 25–1,000 Hz frequency range. McCauley et al. (2000) estimated that the received level at which turtles avoided sound in the O'Hara and Wilcox (1990) experiment was 175–176 dB re 1 μPa root mean square.

Moein Bartol et al. (1995) investigated the use of air guns to repel juvenile loggerhead sea turtles from hopper dredges. Sound frequencies of the airguns ranged from 100 to 1,000 Hz at three levels: 175, 177, and 179 dB re 1 μPa at 1 m. The turtles avoided the airguns during the initial exposures (mean range of 24 m), but additional trials several days afterward did not elicit statistically significant avoidance. They concluded that this was due to either habituation or a temporary shift in the turtles' hearing capability.

McCauley et al. (2000) exposed caged green and loggerhead sea turtles to an approaching-departing single air gun to gauge behavioral responses. The trials showed that above a received level of 166 dB re 1 μPa root mean square, the turtles noticeably increased their swimming activity compared to non-operational periods, with swimming time increasing as air gun levels increased during approach. Above 175 dB re 1 μPa root mean square, behavior became more erratic, possibly indicating the turtles were in an agitated state (McCauley et al. 2000). The authors noted that the point at which the turtles showed the more erratic behavior and exhibited possible agitation would be expected to approximately equal the point at which active avoidance would occur for unrestrained turtles (McCauley et al. 2000).

No obvious avoidance reactions by free-ranging sea turtles, such as swimming away, were observed during a multi-month seismic survey using airgun arrays, although fewer sea turtles were observed when the seismic airguns were active than when they were inactive (Weir 2007). The author noted that sea state and the time of day affected both airgun operations and sea turtle surface basking behavior, making it difficult to draw conclusions from the data. Further, DeRuiter and Doukara (2012) noted diving behavior following airgun shots in loggerhead turtles, and noted a decreased dive probability with increasing distance from the airgun array.

No studies have been performed to examine the response of sea turtles to sonar. However, based on the limited range of hearing, they may respond to sources operating below 2 kHz but are unlikely to sense higher frequency sounds, as described in Section 3.5.2.2 (Hearing and Vocalization).

3.6.4.1.7 Repeated Exposures

Repeated exposures of an individual to sound-producing activities over a season, year, or life stage could cause reactions with energetic costs that can accumulate over time to cause long-term consequences for the individual. Conversely, some sea turtles may habituate to or become tolerant of repeated exposures over time, learning to ignore a stimulus that in the past was not accompanied by any overt threat, such as high levels of ambient noise found in areas of high vessel traffic (Hazel et al. 2007). In an experiment, after initial avoidance reactions, loggerhead sea turtles habituated to repeated exposures to airguns of up to a source level of 179 dB re 1 μPa in an enclosure. The habituation behavior was retained by the sea turtles when exposures were separated by several days (Moein Bartol et al. 1995).

3.6.4.2 **Acoustic and Explosive Threshold Criteria for Turtles**

In this Opinion, we consider two primary categories of sound sources that the U.S. Navy used in its analyses of sound impacts on sea turtles: impulsive sources (e.g., explosives, airguns, weapons firing) and non-impulsive sources (e.g., sonar, pingers, and countermeasure devices). Acoustic impacts criteria and thresholds were developed in cooperation with NMFS for sea turtle exposures to various sound sources.

3.6.4.2.1 Criteria for Mortality and Slight Lung Injury

In air or submerged, the most commonly reported internal bodily injury to sea turtles from explosive detonations is hemorrhaging in the fine structure of the lungs. The likelihood of internal bodily injury is related to the received impulse of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al. 1973; Yelverton and Richmond 1981; Yelverton et al. 1973; Yelverton et al. 1975). Therefore, impulse is used as a metric upon which internal organ injury can be predicted. Onset mortality and onset slight lung injury are defined as the impulse level that would result in 1 percent mortality (most survivors have moderate blast injuries and should survive) and 0 percent mortality (recoverable, slight blast injuries) in the exposed population, respectively. Criteria for onset mortality and onset slight lung injury were developed using data from explosive impacts on mammals (Yelverton and Richmond 1981).

The impulse required to cause lung damage is related to the volume of the lungs. The lung volume is related to both the size (mass) of the animal and compression of gas-filled spaces at increasing water depth. Turtles have relatively low lung volume to body mass and a relatively stronger anatomical structure compared to mammals; therefore application of the criteria derived from studies of impacts of explosions on mammals may be conservative. Table 5 provides a nominal conservative body mass for each sea turtle species based on juvenile mass.

Juvenile body mass was selected for analysis given the early rapid growth of these reptiles (newborn turtles weigh less than 0.5 percent of maximum adult body mass). In addition, small

turtles tend to remain at shallow depths in the surface pressure release zone, reducing potential exposure to injurious impulses. Therefore, use of hatchling weight would provide unrealistically low thresholds for estimating injury to sea turtles. The use of juvenile body mass rather than hatchling body mass was chosen to produce reasonably conservative estimates of injury. The juvenile body mass of the leatherback turtle used for determining onset of extensive and slight lung injury is 34.8 kilograms (kg) (Jones 2009).

Table 5. Species-Specific Sea Turtle Masses for Determining Onset of Extensive and Slight Lung Injury Thresholds

Common Name	Juvenile Mass (kg)	Reference
Loggerhead sea turtle	8.4	Southwood et al. (2007)
Green sea turtle	8.7	Wood and Wood (1993)
Hawksbill sea turtle	7.4	Okuyama et al. (2010)
Kemp's ridley sea turtle	6.3	McVey and Wibbels (1984) and Caillouet (1986)
Leatherback sea turtle	34.8	Jones (2009)

The scaling of lung volume to depth is conducted because data come from experiments with terrestrial animals held near the water's surface. The calculation of impulse thresholds consider depth of the animal to account for compression of gas-filled spaces that are most sensitive to impulse injury. The impulse required for a specific level of injury (impulse tolerance) is assumed to increase proportionally to the square root of the ratio of the combined atmospheric and hydrostatic pressures at a specific depth with the atmospheric pressure at the surface (Goertner 1982).

Very little information exists about the impacts of underwater detonations on sea turtles. Impacts of explosive removal operations on sea turtles range from non-injurious impacts (e.g., acoustic annoyance, mild tactile detection, or physical discomfort) to varying levels of injury (i.e., non-lethal and lethal injuries) (Klima et al. 1988; Viada et al. 2008). Often, impacts of explosive events on turtles must be inferred from documented impacts on other vertebrates with lungs or other-gas containing organs, such as mammals and most fishes (Viada et al. 2008). The methods used by Goertner (1982) to develop lung injury criteria for marine mammals may not be directly applicable to sea turtles, as it is not known what degree of protection to internal organs from the shock waves is provided to sea turtles by their shell (Viada et al. 2008). However, the general principles of the Goertner model are applicable, and should provide a protective approach to assessing potential impacts on sea turtles. The Goertner method predicts a minimum primary positive impulse value for onset of slight lung injury and onset of mortality, adjusted for assumed lung volume (correlated to animal mass) and depth of the animal. These equations are shown in Table **6**.

Table 6. Sea Turtle Impact Threshold Criteria for Impulsive Sources

Impulsive Sound Exposure Impact	Threshold Value
Onset Mortality[1] (1% Mortality Based on Extensive Lung Injury)	$= 91.4M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2}\ Pa-s$
Onset Slight Lung Injury[1]	$= 39.1M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2}\ Pa-s$
Onset Slight Gastrointestinal Tract Injury	237 dB re 1 µPa SPL (104 psi)
Onset PTS	187 dB re 1 µPa^2 - s SEL (T^2) or 230 dB re 1 µPa Peak SPL
Onset TTS	172 dB re 1 µPa^2 - s SEL (T^2) or 224 dB re 1 µPa Peak SPL
Injury (Airguns)	190 dB re 1 µPa SPL root mean square[3]

dB: decibels, µPa: micropascals, PTS: permanent threshold shift, SEL: sound exposure level, SPL: sound pressure level, TTS: temporary threshold shift

[1] M=Mass of animals (kg) as shown for each species, DRm=depth of animal (m)

[2] (T): Turtle weighting function

[3] The time interval for determining the root mean square that which contains 90% of the total energy within the envelope of the pulse. This windowing procedure for impulse signals removes uncertainty about where to set the exact temporal beginning or end of the signal, which may be obscured by ambient noise.

3.6.4.2.2 Criteria for Onset of Gastrointestinal Tract Injury

Without data specific to sea turtles, data from tests with terrestrial animals are used to predict onset of gastrointestinal tract injury. Gas-containing internal organs, such as lungs and intestines, were the principle damage sites from shock waves in submerged terrestrial mammals (Richmond et al. 1973; Yelverton et al. 1973). Furthermore, slight injury to the gastrointestinal tract may be related to the magnitude of the peak shock wave pressure over the hydrostatic pressure, and would be independent of the animal's size and mass (Goertner 1982). Slight contusions to the gastrointestinal tract were reported during small charge tests (Richmond et al. 1973), when the peak was 237 dB re 1 µPa. Therefore, this value is used to predict onset of gastrointestinal tract injury in sea turtles exposed to explosions.

3.6.4.2.3 Predicted Ranges to Effects from In-Water Explosions

The ranges to the PTS threshold (i.e., range to the onset of PTS: the maximum distance to which PTS would be expected) are shown in Table **7** relative to the marine mammal's functional hearing group. For a SQS-53 sonar transmitting for 1 second at 3 kHz and a representative source level of 235 dB re 1 µPa^2-s at 1 m, the range to PTS for the most sensitive species (the high-frequency cetaceans) extends from the source to a range of 100 m (110 yd.). Since any hull mounted sonar, such as the SQS-53, engaged in anti-submarine warfare training would be moving at between 10–15 knots (5.1–7.7 m/second) and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 260 m (280 yd) during the time between those pings (10 knots is the speed used in the Navy Acoustic Effects Model). As a result, there is little overlap of PTS footprints from successive pings, indicating that in most cases, an animal predicted to receive PTS would do so from a single exposure (i.e., ping). For all

other functional hearing groups (low-frequency cetaceans, mid-frequency cetaceans, and phocid seals and manatees) single-ping PTS zones are within 100 m of the sound source. A scenario could occur where an animal does not leave the vicinity of a ship or travels a course parallel to the ship within the PTS zone; however, as indicated in Table **7**, the distances required make PTS exposure less likely. For a Navy vessel moving at a nominal 10 knots, it is unlikely a marine mammal could maintain the speed to parallel the ship and receive adequate energy over successive pings to suffer PTS. For all sources except hull-mounted sonar (e.g., SQS-53 and BQQ-10) ranges to PTS are well within 50 m (55 yd), even for multiple pings (up to five pings) and the most sensitive functional hearing group (high-frequency cetaceans).

Table 7. Range to impacts from In-Water Explosives on Sea Turtles from Representative Sources

Criteria Predicted Impact	Impact Predicted to Occur When Sea Turtle is at this Range (m) or Closer to a Detonation							
	Bin E-1 (0.0-0.5 lb. NEW)	Bin E-3 (0.6-2.6 lb. NEW)	Bin E-4 (2.6-6.0 lb. NEW)	Bin E-5 (6.0-10.0 lb. NEW)	Bin E-8 (21.0-60.0 lb. NEW)	Bin E-10 (251-500 lb. NEW)	Bin E-11 (501-1,000 lb. NEW)	Bin E-12 (1000-1,651 lb. NEW)
Onset Mortality (1% Mortality)	4	26	51	46	102	164	458	199
Onset Slight Lung Injury	17	50	130	85	179	284	816	343
Onset Slight GI Tract Injury	40	60	175	55	106	184	201	250
Permanent Threshold Shift[1]	67	196	215	162	424	873	809	1,251
Temporary Threshold Shift[1]	90	724	421	288	844	1,975	1,693	2,640
Behavioral Response	144	1,512	796	565	1,458	3,217	3,015	3,962

1 Modeling for sound exposure level-based impulse criteria assumed explosive event durations of 1 second. Actual durations may be less, resulting in smaller ranges to impact.
Notes: (1) lb. = pound(s), m = meters, NEW = net explosive weight; (2) Ranges determined using REFMS, the Navy's explosive propagation model.

Some of the conservative assumptions made by the Navy for the impact modeling and criteria may cause the impact predictions to be overestimated, as follows:

- Many explosions from ordnance such as bombs and missiles actually explode upon impact with above-water targets. For this analysis, sources such as these were modeled as exploding at depths of 1 m, overestimating the amount of explosive and acoustic energy entering the water.
- For predicting TTS and PTS based on sound exposure level, the duration of an explosion is assumed to be 1 second. Actual detonation durations may be much shorter, so the actual sound exposure level at a particular distance may be lower.
- Mortality and slight lung injury criteria are based on juvenile turtle masses, which substantially increases that range to which these impacts are predicted to occur compared to the ranges that would be predicted using adult turtle masses.

- Animats are assumed to receive the full impulse of the initial positive pressure wave due to an explosion, although the impulse-based thresholds (onset mortality and onset slight lung injury)

3.6.4.3 **Non-impulsive Sound Criteria**

These acoustic impacts criteria are summarized in Table 8 below.

Table 8. Sea Turtle Impact Threshold Criteria Used in Acoustic Modeling for Non-Impulse Sources

Physiological Thresholds	
Onset PTS	**Onset TTS**
198 dB SEL (T)	**178 dB SEL (T)**

dB: decibels; µPa: micropascals; PTS: permanent threshold shift; SEL: sound exposure level; SPL: sound pressure level; TTS: temporary threshold shift; (T): Turtle weighting function

3.6.4.4 **Quantitative Analysis**

The Navy performed a quantitative analysis to estimate the number of marine mammals that could be affected by acoustic sources or explosives used during Navy training activities. Inputs to the quantitative analysis include marine mammal density estimates; marine mammal depth occurrence distributions; oceanographic and environmental data; marine mammal hearing data; and criteria and thresholds for levels of potential effects. The quantitative analysis consists of computer modeled estimates and a post-model analysis to determine the number of potential mortalities and harassments. The model calculates sound energy propagation from sonar, other active acoustic sources, and explosives during naval activities; the sound or impulse received by animat dosimeters representing marine mammals distributed in the area around the modeled activity; and whether the sound or impulse received by a marine mammal exceeds the thresholds for effects. The model estimates are then further analyzed to consider animal avoidance and implementation of mitigation measures, resulting in final estimates of potential effects due to Navy training.

Various computer models and mathematical equations can be used to predict how energy spreads from a sound source (e.g., sonar or underwater detonation) to a receiver (e.g., dolphin or sea turtle). See Introduction to Acoustics (Section 3.0.4) and Acoustic Primer (Appendix G) for background information about how sound travels through the water. Basic underwater sound models calculate the overlap of energy and marine life using assumptions that account for the many, variable, and often unknown factors that can influence the result. Assumptions in previous and current Navy models have intentionally erred on the side of overestimation when there are unknowns or when the addition of other variables was not likely to substantively change the final analysis. For example, because the ocean environment is extremely dynamic and information is

often limited to a synthesis of data gathered over wide areas and requiring many years of research, known information tends to be an average of a seasonal or annual variation. El Niño Southern Oscillation events of the ocean-atmosphere system are an example of dynamic change where unusually warm or cold ocean temperatures are likely to redistribute marine life and alter the propagation of underwater sound energy. Previous Navy modeling (U.S. Department of the Navy 2009) therefore made some assumptions indicative of a maximum theoretical propagation for sound energy (such as a perfectly reflective ocean surface and a flat seafloor).

More complex computer models build upon basic modeling by factoring in additional variables in an effort to be more accurate by accounting for such things as variable bathymetry and an animal's likely presence at various depths. NAEMO accounts for the variability of the sound propagation data in both distance and depth when computing the received sound level on the animals. Previous models captured the variability in sound propagation over range and used a conservative approach to account for only the maximum received sound level within the water column.

3.6.5 Background and Framework of U.S. Navy Analysis for Fish

This section is largely based on a technical report prepared for the Navy: Effects of Mid- and High-Frequency Sonars on Fish (Popper 2008). Additionally, Popper and Hastings (2009) provide a critical overview of some of the most recent research regarding potential effects of anthropogenic sound on fish.

Studies of the effects of human-generated sound on fish have been reviewed in numerous places (e.g., National Research Council 1994, 2003; Popper 2003; Popper et al. 2004; Hastings and Popper 2005; Popper 2008; Popper and Hastings 2009a, 2009b). Most investigations, however, have been in the gray literature (non-peer-reviewed reports—see Hastings and Popper 2005; Popper 2008; and Popper and Hastings 2009b for extensive critical reviews of this material). Studies have been published assessing the effect on fish of short-duration, high-intensity signals such as might be found near high-intensity sonar, pile driving, or seismic air guns. The investigators in such studies examined short-term effects that could result in death to the exposed fish, as well as hearing loss and long-term consequences (Doksæter et al. 2009; Govoni et al. 2003; McCauley et al. 2003; Popper et al. 2005, 2007).

3.6.5.1 **Direct Injury from Acoustic Stressors**

3.6.5.1.1 Non-impulsive Sound Sources

Potential direct injuries from non-impulsive sound sources, such as sonar, are unlikely because of the relatively lower peak pressures and slower rise times than potentially injurious sources such as explosives. Non-impulsive sources also lack the strong shock wave such as that associated with an explosion. The theories of sonar induced acoustic resonance, bubble formation, neurotrauma, and lateral line system injury are discussed below, although these would

likely occur only in fish very close to the sound source and are therefore unlikely to impact entire populations of fish or have an impact in a large area.

Two unpublished reports examined the effects of mid-frequency sonar-like signals (1.5–6.5 kHz) on larval and juvenile fish of several species (Jørgensen et al. 2005; Kvadsheim and Sevaldsen 2005). No studies have indicated any physiological damage to adult fish from mid-frequency active sonar. In the first study, Kvadsheim and Sevaldsen (2005) showed that intense sonar activities in herring spawning areas affected less than 0.3 percent of the total juvenile stock. The second study, Jørgensen et al. (2005) exposed larval and juvenile fish to various sounds in order to investigate potential effects on survival, development, and behavior. The study used herring (*Clupea harengus*) (standard lengths 0.75–2 in. [2–5 cm]), Atlantic cod (*Gadus morhua*) (standard length 0.75–2.4 in. [2–6 cm]), saithe (*Pollachius virens*) (1.6 in. [4 cm]), and spotted wolffish (*Anarhichas minor*) (1.6 in. [4 cm]) at different developmental stages. The researchers placed the fish in plastic bags 10 ft. (3 m) from the sound source and exposed them to between four and 100 pulses of one-second duration of pure tones at 1.5, 4, and 6.5 kHz. Sound exposure performed at these frequencies, with sound simulating real sonar-signals, did not result in any significant direct mortality among the fish larvae or juveniles exposed, except for two (of a total of 42) experiments repeated on juvenile herring where significant mortality (20-30 percent) was observed.

Among fish kept in tanks 1–4 weeks after sound exposure, no significant differences in mortality or growth related parameters (length, weight and condition) between exposed groups and unexposed groups were observed. Studies of organs and tissues from selected herring experiments did not reveal obvious differences between unexposed and exposed groups (Jorgensen et al. 2005).

These two groups were both composed of herring, a hearing specialist, and were tested with sound pressure levels of 189 dB re 1 μPa, which resulted in a post-exposure mortality of 20 to 30 percent. In the remaining 80 tests, there were no observed effects on behavior, growth (length and weight), or the survival of fish that were kept as long as 34 days post exposure. While statistically significant losses were documented in the two groups impacted, the researchers only tested that particular sound level once, so it is not known if this increased mortality was due to the level of the test signal or to other unknown factors.

Swim bladder resonance is a function of the size and geometry of the air cavity, depth of the fish, and frequency of the transmitted signal. Wavelengths associated with mid-frequency sounds are shorter than wavelengths associated with lower frequency sounds. It is the lower frequencies that are expected to produce swim bladder resonance in adult fishes. Resonance frequencies for juvenile fish are 1-8 kHz and can escalate physiological impact (Lø vik and Hovem 1979; Kvadsheim and Sevaldsen 2005).

High sound pressure levels may cause bubbles to form from micronuclei in the blood stream or other tissues of animals, possibly causing embolism damage (Ketten 1998). Fish have small capillaries where these bubbles could be caught and lead to the rupturing of the capillaries and internal bleeding. It has also been speculated that this phenomena could also take place in the eyes of fish due to potentially high gas saturation within the fish's eye tissues (Popper and Hastings 2009a). As reviewed in Popper and Hastings (2009b), Hastings (1990, 1995) found 'acoustic stunning' (loss of consciousness) in blue gouramis (*Trichogaster trichopterus*) following an 8-minute exposure to a 150 Hz pure tone with a peak sound pressure level (SPL) of 198 dB re 1 μPa. This species of fish has an air bubble in the mouth cavity directly adjacent to the animal's braincase that may have caused this injury. Hastings (1990, 1995) also found that goldfish exposed to two hours of continuous wave sound at 250 Hz with peak pressures of 204 dB re 1 μPa, and fathead minnows exposed to 0.5 hours of 150 Hz continuous wave sound at a peak level of 198 dB re 1 μPa did not survive. The only study on the effect of exposure of the lateral line system to continuous wave sound (conducted on one freshwater species) suggests no effect on these sensory cells by intense pure tone signals (Hastings et al. 1996).

3.6.5.1.2 Explosions and Other Impulsive Sound Sources

The greatest potential for direct, non-auditory tissue effects is primary blast injury and barotrauma following exposure to explosions. Primary blast injury refers to those injuries that result from the initial compression of a body exposed to a blast wave. Primary blast injury is usually limited to gas-containing structures (e.g., swim bladder) and the auditory system. Barotrauma refers to injuries caused when the swim bladder or other gas-filled structures vibrate in response to the signal, particularly if there is a relatively sharp rise-time and the walls of the structure strike near-by tissues and damage them.

An underwater explosion generates a shock wave that produces a sudden, intense change in local pressure as it passes through the water (U.S. Department of the Navy 1998, 2001a). Pressure waves extend to a greater distance than other forms of energy produced by the explosion (i.e., heat and light) and are therefore the most likely source of negative effects to marine life from underwater explosions (Craig 2001; Scripps Institution of Oceanography 2005; U.S. Department of the Navy 2006). The shock wave from an underwater explosion is lethal to fish at close range (see Section 3.0.5.3.1.2, Explosives, for a discussion of ranges for mortality dependent on charge size), causing massive organ and tissue damage and internal bleeding (Keevin and Hempen 1997). At greater distance from the detonation point, the extent of mortality or injury depends on a number of factors including fish size, body shape, orientation, and species (Keevin and Hempen 1997; Wright 1982). Additional factors include the current physical condition of the fish and the presence of a swim bladder. At the same distance from the source, larger fish are generally less susceptible to death or injury, elongated forms that are round in cross-section are less at risk than deep-bodied forms, and fish oriented sideways to the blast suffer the greatest impact (Edds-Walton and Finneran 2006; O'Keeffe 1984; O'Keeffe and Young 1984; Wiley et al.

1981; Yelverton et al. 1975). Species with gas-filled organs have higher mortality than those without them (Continental Shelf Associates Inc. 2004; Goertner et al. 1994).

Two aspects of the shock wave appear most responsible for injury and death to fish: the received peak pressure and the time required for the pressure to rise and decay (Dzwilewski and Fenton 2002). Higher peak pressure and abrupt rise and decay times are more likely to cause acute pathological effects (Wright and Hopky 1998). Rapidly oscillating pressure waves might rupture the kidney, liver, spleen, and sinus and cause venous hemorrhaging (Keevin and Hempen 1997). They can also generate bubbles in blood and other tissues, possibly causing embolism damage (Ketten 1998). Oscillating pressure waves might also burst gas-containing organs. The swim bladder, the gas-filled organ used by most fish to control buoyancy, is the primary site of damage from explosives (Wright 1982; Yelverton et al. 1975). Gas-filled swim bladders resonate at different frequencies than surrounding tissue and can be torn by rapid oscillation between high- and low-pressure waves. Swim bladders are a characteristic of many bony fish but are not present in sharks and rays.

Studies that have documented fish killed during planned underwater explosions indicate that most fish that die do so within one to four hours, and almost all die within a day (Hubbs and Rechnitzer 1952; Yelverton et al. 1975). Fitch and Young (1948) found that the type of fish killed changed when blasting was repeated at the same marine location within 24 hours of previous blasting. They observed that most fish killed on the second day were scavengers, presumably attracted by the victims of the previous day's blasts. However, fishes collected during these types of studies have mostly been recovered floating on the water's surface. Gitschlag et al. (2001) collected both floating fish and those that were sinking or lying on the bottom after explosive removal of nine oil platforms in the northern Gulf of Mexico. They found that 3 to 87 percent (46 percent average) of the specimens killed during a blast might float to the surface. Other impediments to accurately characterizing the magnitude of fish mortality included currents and winds that transported floating fishes out of the sampling area and predation by seabirds or other fishes.

There have been few studies of the impact of underwater explosions on early life stages of fishes (eggs, larvae, juveniles). Fitch and Young (1948) reported the demise of larval anchovies exposed to underwater blasts off California, and Nix and Chapman (1985) found that anchovy and eulachon larvae died following the detonation of buried charges. It has been suggested that impulsive sounds, such as that produced by seismic airguns, may cause damage to the cells of the lateral line in fish larvae and fry when in close proximity (15 ft. [5 m]) to the sound source (Booman et al. 1996).Similar to adult fishes, the presence of a swim bladder contributes to shock wave-induced internal damage in larval and juvenile fishes (Settle et al. 2002). Shock wave trauma to internal organs of larval pinfish and spot from shock waves was documented by

Govoni et al. (2003). These were laboratory studies, however, and have not been verified in the field.

Interim criteria for injury of fish were discussed in Stadler and Woodbury (2009). The onset of physical injury would be expected if either the peak sound pressure level exceeds 206 dB re 1 μPa, or the cumulative sound exposure level, accumulated over all pile strikes generally occurring within a single day, exceeds 187 dB re 1 micropascal squared second (μPa2-s) for fish two grams or larger, or 183 dB re 1 μPa2-s for smaller fish (Stadler and Woodbury 2009). A more recent study by Halvorsen et al. (2011) used carefully controlled laboratory conditions to determine the level of pile driving sound that may cause a direct injury to the fish tissues (barotrauma). The investigators found that juvenile Chinook salmon (*Oncorhynchus tshawytscha*) received less than a single strike sound exposure level of 179 to 181 dB re 1μ Pa2-s and cumulative sound exposure level of less than 211 dB re 1 μPa2-s over the duration of the pile driving activity would sustain no more than mild, non-life-threatening injuries.

3.6.5.2 **Hearing Loss from Acoustic Stressors**

Exposure to high intensity sound can cause hearing loss, also known as a noise-induced threshold shift, or simply a threshold shift (Miller 1974). A temporary threshold shift (TTS) is a temporary, recoverable loss of hearing sensitivity. A TTS may last several minutes to several weeks and the duration may be related to the intensity of the sound source and the duration of the sound (including multiple exposures). A permanent threshold shift (PTS) is non-recoverable, results from the destruction of tissues within the auditory system, and can occur over a small range of frequencies related to the sound exposure. As with temporary threshold shift, the animal does not become deaf but requires a louder sound stimulus (relative to the amount of PTS) to detect a sound within the affected frequencies; however, in this case, the effect is permanent.

Permanent hearing loss, or permanent threshold shift has not been documented in fish. The sensory hair cells of the inner ear in fish can regenerate after they are damaged, unlike in mammals where sensory hair cells loss is permanent (Lombarte et al. 1993; Smith et al. 2006). As a consequence, any hearing loss in fish may be as temporary as the timeframe required to repair or replace the sensory cells

3.6.5.2.1 Non-impulsive Sound Sources

Studies of the effects of long-duration sounds with sound pressure levels below 170–180 dB re 1 μPa indicate that there is little to no effect of long-term exposure on species that lack notable anatomical hearing specialization (Amoser and Ladich 2003; Scholik and Yan 2001; Smith et al. 2004a, b; Wysocki et al. 2007). The longest of these studies exposed young rainbow trout (*Onorhynchus 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) for about 9 months. The investigators found no effect on hearing (i.e., TTS) as compared to fish raised at 110 dB re 1 μPa.

In contrast, studies on fish with hearing specializations (i.e., greater sensitivity to lower sound pressures and higher frequencies) 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. 2006; Smith et al. 2004a). Smith et al. (2006; 2004b) exposed goldfish to noise at 170 dB re 1 μPa and found a clear relationship between the amount of hearing loss (TTS) and the duration of exposure until maximum hearing loss occurred after 24 hours of exposure. A 10-minute exposure resulted in a 5 dB TTS, whereas a 3-week exposure resulted in a 28 dB TTS that took over 2 weeks to return to pre-exposure baseline levels (Smith et al. 2004a) (Note: recovery time not measured by investigators for shorter exposure durations).

Similarly, Wysocki and Ladich (2005) investigated the influence of noise exposure on the auditory sensitivity of two freshwater fish with notable hearing specializations, the goldfish and the lined Raphael catfish (*Platydoras costatus*), and on a freshwater fish without notable specializations, the pumpkinseed 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 goldfish and catfish, continuous white noise of approximately 130 dB re 1 μPa at 1 m resulted in a significant TTS of 23 to 44 dB. In contrast, the auditory thresholds in the sunfish declined by 7 to 11 dB. The duration of exposure and time to recovery was not addressed in this study. Scholik and Yan (2001) demonstrated TTS in fathead minnows *(Pimephales promelas*) after a 24-hour exposure to white noise (0.3–2.0 kHz) at 142 dB re 1 μPa that did not recover as long as 14 days post-exposure.

Studies have also examined the effects of the sound exposures from Surveillance Towed Array Sensor System Low-Frequency Active sonar on fish hearing (Kane et al. 2010; Popper et al. 2007). Hearing was measured both immediately post exposure and for several days thereafter. Maximum received sound pressure levels were 193 dB re 1 μPa for 324 or 628 seconds. Catfish and some specimens of rainbow trout showed 10-20 dB of hearing loss immediately after exposure to the low-frequency active 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 were not 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 after exposure to low-frequency active sonar. Furthermore, examination of the inner ears of the fish during necropsy (note: maximum time fish were held post exposure before sacrifice was 96 hours) revealed no differences from the control groups in cilliary bundles or other features indicative of hearing loss (Kane et al. 2010).

The study of mid-frequency active sonar by the same investigators also examined potential effects onfish hearing and the inner ear (Halvorsen et al. 2012; Kane et al. 2010). Out of the four

species tested (rainbow trout, channel catfish, largemouth bass, and yellow perch) only one group of channel catfish, tested in December, showed any hearing loss after exposure to mid-frequency active sonar. The signal consisted of a 2 second (s) long, 2.8–3.8 kHz frequency sweep followed by a 3.3 kHz tone of 1 s duration.

The stimulus was repeated five times with a 25 second interval. The maximum received sound pressure level was 210 dB re 1 μPa. These animals, which have the widest hearing range of any of the species tested, experienced approximately 10 dB of threshold shift that recovered within 24 hours. Channel catfish tested in October did not show any hearing loss. The investigators speculated that the difference in hearing loss between catfish groups might have been due to the difference in water temperature of the lake where all of the testing took place (Seneca Lake, New York) between October and December.

Alternatively, the observed hearing loss differences between the two catfish groups might have been due to differences between the two stocks of fish (Halvorsen et al. 2012). Any effects on hearing in channel catfish due to sound exposure appear to be transient (Halvorsen et al. 2012; Kane et al. 2010). Investigators observed no damage to cilliary bundles or other features indicative of hearing loss in any of the other fish tested including the catfish tested in October (Kane et al. 2010). Some studies have 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. Enger (1981) found loss of cilliary bundles of the sensory cells in the inner ears of Atlantic cod following 1–5 hours of exposure to pure tone sounds between 50 and 400 Hz with a sound pressure level of 180 dB re 1 μPa.

Hastings (1995) found auditory hair-cell damage in a species with notable anatomical hearing specializations, the goldfish (*Carassius auratus*) exposed to 250 Hz and 500 Hz continuous tones with maximum peak levels of 204 dB re 1 μPa and 197 dB re 1 μPa, respectively, for about 2 hours. Similarly, Hastings et al. (1996) demonstrated damage to some sensory hair cells in oscars (*Astronotus ocellatus*) following a 1-hour exposure to a pure tone at 300 Hz with a peak pressure level of 180 dB re 1 μPa. In none of the studies was the hair cell loss more than a relatively small percent (less than a maximum of 15 percent) of the total sensory hair cells in the hearing organs.

3.6.5.2.2 Explosions and Other Impulsive Sound Sources

Popper et al. (2005) examined the effects of a seismic airgun array on a fish with hearing specializations, the lake chub (*Couesius plumbeus*), and two species that lack notable specializations, the northern pike (*Esox lucius*) and the broad whitefish (*Coregonus nasus*) (a salmonid). In this study the average received exposure levels were a mean peak pressure level of 207 dB re 1 μPa; sound pressure level of 197 dB re 1 μPa; and single-shot sound exposure level of 177 dB re 1 μPa2-s. The results showed temporary hearing loss for both lake chub and northern pike to both 5 and 20 airgun shots, but not for the broad whitefish. Hearing loss was

approximately 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. Examination of the sensory surfaces of the ears by an expert on fish inner ear structure showed no damage to sensory hair cells in any of the fish from these exposures (Song et al. 2008).

McCauley et al. (2003) showed loss of a small percent of sensory hair cells in the inner ear of the pink snapper (*Pagrus auratus*) exposed to a moving airgun array for 1.5 hours. Maximum received levels exceeded 180 dB re 1 μPa2-s for a few shots. The loss of sensory hair cells continued to increase for up to at least 58 days post exposure to 2.7 percent of the total cells. It is not known if this hair cell loss would result in hearing loss since fish have tens or even hundreds of thousands of sensory hair cells in the inner ear (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. There are many differences between the studies, including species, precise sound source, and spectrum of the sound that it is hard to speculate.

Hastings et al. (2008) exposed the pinecone soldierfish (Myripristis murdjan), a fish with anatomical specializations to enhance their hearing; and three species without notable specializations: the blue green damselfish (Chromis viridis), the saber squirrelfish (Sargocentron spiniferum), and the bluestripe seaperch (Lutjanus kasmira) to an airgun array. Fish in cages in 16 ft. (4.9 m) of water were exposed to multiple airgun shots with a cumulative sound exposure level of 190 dB re 1 μPa2-s. The authors found no hearing loss in any fish following exposures.

As with other impulsive sound sources, it is assumed that sound from pile driving may cause hearing loss in fish located near the site (Popper and Hastings 2009c); however, there is a lack of research demonstrating this.

3.6.5.3 **Auditory Masking**

Auditory masking refers to the presence of a noise that interferes with a fish's ability to hear biologically relevant sounds. Fish use sounds to detect predators and prey, and for schooling, mating, and navigating, among other uses (Myrberg 1980; Popper et al. 2003). Masking of sounds associated with these behaviors could have impacts to fish by reducing their ability to perform these biological functions.

Any noise (i.e., unwanted or irrelevant sound, often of an anthropogenic nature) detectable by a fish can prevent the fish from hearing biologically important sounds including those produced by prey or predators (Myrberg 1980; Popper et al. 2003). Auditory masking may take place whenever the noise level heard by a fish exceeds ambient noise levels, the animal's hearing threshold, and the level of a biologically relevant sound. Masking is found among all vertebrate groups, and the auditory system in all vertebrates, including fish, is capable of limiting the

effects of masking noise, especially when the frequency range of the noise and biologically relevant signal differ (Fay 1988; Fay and Megela-Simmons1999).

The frequency of the sound is an important consideration for fish because many marine fish are limited to detection of the particle motion component of low frequency sounds at relatively high sound intensities (Amoser and Ladich 2005). The frequency of the acoustic stimuli must first be compared to the animal's known or suspected hearing sensitivity to establish if the animal can potentially detect the sound.

One of the problems with existing fish auditory masking data is that the bulk of the studies have been done with goldfish, a freshwater fish with well-developed anatomical specializations that enhance hearing abilities. The data on other species are much less extensive. As a result, less is known about masking in marine species, many of which lack the notable anatomical hearing specializations. However, Wysocki and Ladich (2005) suggest that ambient sound regimes may limit acoustic communication and orientation, especially in animals with notable hearing specializations.

Tavolga (1974a, b) studied the effects of noise on pure-tone detection in two species without notable anatomical hearing specializations, the pin fish (Lagodon rhomboids) and the African mouth-breeder (Tilapia macrocephala), 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 across all hearing ranges. Chapman and Hawkins (1973b) found that ambient noise at higher sea states in the ocean has masking effects in cod, Gadus morhua (L.), haddock, Melanogrammus aeglefinus (L.), and pollock, Pollochinus pollachinus (L.), and similar results were suggested for several sciaenid species by Ramcharitar and Popper (2004c). Thus, based on limited data, it appears that for fish, as for mammals, masking may be most problematic in the frequency region near the signal. There have been a few field studies that may suggest 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. 2006a). 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. 2006b). Astrup (1999) and Mann et al. (1998) hypothesized that high frequency detecting species

(e.g., clupeids) may have developed sensitivity to high frequency sounds to avoid predation by odontocetes. Therefore, the presence of masking noise may hinder a fish's ability to detect predators and therefore increase predation.

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 their behavior. For example, the sciaenids, which are primarily inshore species, are one of 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 (2006b). If the females are not able to hear the reproductive sounds of the males, there could be a significant impact on the reproductive success of a population of sciaenids. Since most sound production in fish used for communication is generally below 500 Hz (Slabbekoorn et al. 2010a), sources with significant low-frequency acoustic energy could affect communication in fish.

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 reef fish (species not identified in study) 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 3–4 nm 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, such as the damselfish, *Pomacentrus partitus*, and bicolor damselfish, *Eupomacentrus partitus*, that have been studied (Kenyon 1996b; 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 (Atema et al. 2002).

3.6.5.4 **Phsyiological Stress and Behavioral Reactions**

As with masking, a fish must first be able to detect a sound above its hearing threshold for that particular frequency and the ambient noise before a behavioral reaction or physiological stress can occur. There are little data available on the behavioral reactions of fish, and almost no research conducted on any long-term behavioral effects or the potential cumulative effects from repeated exposures to loud sounds (Popper and Hastings 2009c).

Stress refers to biochemical and physiological responses to increases in background sound. The initial response to an acute stimulus is a rapid release of stress hormones into the circulatory system, which may cause other responses such as elevated heart rate and blood chemistry changes. Although an increase in background sound has been shown to cause stress in humans, only a limited number of studies have measured biochemical responses by fish to acoustic stress (Remage-Healey et al. 2006a; Smith et al. 2004b; Wysocki et al. 2007; Wysocki et al. 2006) and the results have varied. There is evidence that a sudden increase in sound pressure level or an increase in background noise levels can increase stress levels in fish (Popper and Hastings 2009c). Exposure to acoustic energy has been shown to cause a change in hormone levels (physiological stress) and altered behavior in some species such as the goldfish *(Carassius auratus)* (Pickering 1981; Smith et al. 2004a, b), but not all species tested to date, such as the rainbow trout *(Oncorhynchus mykiss*) (Wysocki et al. 2007).

Behavioral effects to fish could include disruption or alteration of natural activities such as swimming, schooling, feeding, breeding, and migrating. Sudden changes in sound level can cause fish to dive, rise, or change swimming direction. There is a lack of studies that have investigated the behavioral reactions of unrestrained fish to anthropogenic sound, especially in the natural environment. Studies of caged fish have identified three basic behavioral reactions to sound: startle, alarm, and avoidance (McCauley et al. 2000; Pearson et al. 1992; Scripps Institution of Oceanography and Foundation. 2008). Changes in sound intensity may be more important to a fish's behavior than the maximum sound level. Sounds that fluctuate in level tend to elicit stronger responses from fish than even stronger sounds with a continuous level (Schwartz 1985).

3.6.5.4.1 Non-Impulsive Sound Sources

Remage-Healey et al. (2006a) found elevated cortisol levels, a stress hormone, in Gulf toadfish exposed to low frequency bottlenose dolphin sounds. Additionally, the toadfish' call rates dropped by about 50 percent, presumably because the calls of the toadfish, a primary prey for bottlenose dolphins, give away the fish's location to the dolphin. The researchers observed none of these effects in toadfish exposed to an ambient control sound (i.e., low-frequency snapping shrimp 'pops').

Smith et al. (2004b) found no increase in corticosteroid, a stress hormone, in goldfish exposed to a continuous, band-limited noise (0.1 to 10 kHz) with a sound pressure level of 170 dB re 1 μPa for 1 month. Wysocki et al. (2007) exposed rainbow trout to continuous band-limited noise with a sound pressure level of about 150 dB re 1 μPa for 9 months with no observed stress effects. Growth rates and effects on the trout's immune system were not significantly different from control animals held at sound pressure level of 110 dB re 1 μPa.

Gearin et al. (2000) studied responses of adult sockeye salmon (*Oncorhynchus nerka*) and sturgeon (*Acipenser* sp.) to pinger sounds produced by acoustic devices designed to deter marine mammals from gillnet fisheries. The pingers produced sounds with broadband energy with peaks at 2 kHz or 20 kHz. They found that fish did not exhibit any reaction or behavior change to the pingers, which 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, 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 the catch rate of herring in the presence of pingers producing sounds that overlapped with the frequency range of hearing for herring (2.7 kHz to over 160 kHz). They found no change in catch rates in gill nets with or without the higher frequency (greater than 20 kHz) sounds present, although there was an increase in the 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.

Doksæter et al. (2009) studied the reactions of wild, overwintering herring to Royal Netherlands Navy experimental mid-frequency active sonar and killer whale feeding sounds. The behavior of the fish was monitored using upward looking echosounders. The received levels from the 1 to2 kHz and 6 to 7 kHz sonar signals ranged from 127 to 197 dB re 1 μPa and 139 to 209 dB re 1 μPa, respectively. Escape reactions were not observed upon the presentation of the mid-frequency active sonar signals; however, the playback of the killer whale sounds elicited an avoidance reaction. The authors concluded that mid-frequency sonar could be used in areas of overwintering herring without substantially affecting the fish.

There is evidence that elasmobranchs respond to human-generated sounds. Myrberg and colleagues did experiments in which they played back sounds and attracted a number of different shark species to the sound source (e.g., Myrberg et al. 1969; Myrberg et al. 1976; Myrberg et al. 1972; Nelson and Johnson 1972). The results of these studies showed that sharks were attracted to low-frequency sounds (below several hundred Hz), in the same frequency range of sounds that might be produced by struggling prey.

However, sharks are not known to be attracted by continuous signals or higher frequencies (which they presumably cannot hear). Studies documenting behavioral responses of fish to vessels show that Barents Sea capelin (*Mallotus villosus*) may exhibit avoidance responses to engine noise, sonar, depth finders, and fish finders (Jørgensen et al. 2004). Avoidance reactions are quite variable depending on the type of fish, its life history stage, behavior, time of day, and the sound propagation characteristics of the water (Schwartz 1985). Misund (1997a) found that

fish ahead of a ship that showed avoidance reactions did so at ranges of 160–490 ft. (48.8–149.4 m). When the vessel passed over them, some species of fish responded with sudden escape responses that included lateral avoidance or downward compression of the school.

In a study by Chapman and Hawkins (1973b) the low-frequency sounds of large vessels or accelerating small vessels caused avoidance responses by herring. Avoidance ended within 10 seconds after the vessel departed. Twenty-five percent of the fish groups habituated to the sound of the large vessel and 75 percent of the responsive fish groups habituated to the sound of small boats.

3.6.5.4.2 Explosions and Other Impulsive Sound Sources

Pearson et al. (1992) exposed several species of rockfish (*Sebastes spp.*) to a seismic airgun. The investigators placed the rockfish in field enclosures and observed the fish's behavior while firing the airgun at various distances for 10 minute trials. Dependent upon the species, rockfish exhibited startle or alarm reactions between peak to peak sound pressure level of 180 dB re 1 μPa and 205 dB re 1 μPa. The authors reported the general sound level where behavioral alterations became evident was at about 161 dB re 1 μPa for all species. During all of the observations, the initial behavioral responses only lasted for a few minutes, ceasing before the end of the 10-minute trial.

Similarly, Skalski et al. (1992) showed a 52 percent decrease in rockfish (*Sebastes* sp.) caught with hook-and-line (as part of the study—fisheries independent) when the area of catch was exposed to a single airgun emission at 186–191 dB re 1 μPa (mean peak level) (See also Pearson et al. 1987, 1992). They also demonstrated that fish would show a startle response to sounds as low as 160 dB re 1 μPa, but this level of sound did not appear to elicit decline in catch. Wright (1982) also observed changes in fish behavior as a result of the sound produced by an explosion, with effects intensified in areas of hard substrate.

Wardle et al. (2001) used a video system to examine the behaviors of fish and invertebrates on reefs in response to emissions from seismic airguns. The researchers carefully calibrated the airguns to have a peak level of 210 dB re 1 μPa at 16 m and 195 dB re 1 μPa at 109 m from the source. There was no indication of any observed damage to the marine organisms. 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 marine organisms appeared to leave the reef.

Engås et al. (1996) and Engås and Løkkeborg (2002) examined movement of fish during and after a seismic airgun study by measuring catch rates of haddock (*Melanogrammus aeglefinus*) and Atlantic cod as an indicator of fish behavior using both trawls and long-lines as part of the experiment. These investigators found a significant decline in catch of both species that lasted for several days after termination of airgun 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 airgun sounds at the fishing site. However, the investigators did not actually observe behavior, and it is possible that the fish just changed depth.

The same research group showed, more recently, parallel results for several additional pelagic species including blue whiting and Norwegian spring spawning herring (Slotte et al. 2004). However, unlike earlier studies from this group, the researchers used fishing sonar to observe behavior of the local fish schools. They reported that fish in the area of the airguns appeared to go to greater depths after the airgun exposure compared to their vertical position prior to the airgun usage. Moreover, the abundance of animals 18 to 31 miles (29 to 50 km) away from the ensonification increased, suggesting that migrating fish would not enter the zone of seismic activity.

Alteration in natural behavior patterns due to exposure to pile driving noise has not been well studied. However, one study (Mueller-Blenkle et al. 2010), which took place with fish enclosed in a mesocosm (an enclosure providing a limited body of water with close to natural conditions), demonstrated behavioral reactions of cod and Dover sole (*Solea solea*) to pile driving sounds. Sole showed a significant increase in swimming speed. Cod reacted, but not significantly, and both species showed directed movement away from the sources with signs of habituation after multiple exposures. For sole, reactions were seen with peak sound pressure levels of 144–156 dB re 1 μPa; and cod showed altered behavior at peak sound pressure levels of 140–161 dB re 1 μPa. For both species, this corresponds to a peak particle motion between 6.51x10-3 and 8.62x10-4 meters per second squared (m/s2).

4 STATUS OF LISTED RESOURCES

This section identifies the ESA-listed species that occur within the Action Area that may be affected by the Navy's military readiness activities in the NWTRC. It then summarizes the biology and ecology of those species and what is known about their life histories in the Action Area. The listed species including distinct population segments (DPS) or evolutionarily significant units (ESU) occurring within the action area that may be affected by the Action are listed in Table 9, along with their ESA listing status.

Table 9. Species listed under the Federal Endangered Species Act (ESA) under NMFS jurisdiction that may occur in the Action Area for the NWTRC.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus*)	E - 35 FR 18319	-- --	07/1998
Fin Whale (*Balaenoptera physalus*)	E - 35 FR 18319	-- --	75 FR 47538
Humpback Whale (*Megaptera novaeangliae*)	E - 35 FR 18319	-- --	55 FR 29646
North Pacific Right Whale (*Eubalaena japonica*)	E - 73 FR 12024	73 FR 19000	-- --

Species	ESA Status	Critical Habitat	Recovery Plan
Sei Whale (*Balaenoptera borealis*)	E - 35 FR 18319	-- --	*
Sperm Whale (*Physeter macrocephalus*)	E - 35 FR 18619	-- --	75 FR 81584
Southern resident killer whale *(Orcinus orca*)	E - 70 FR 69903	71 FR 69054	73 FR 4176
Marine Mammals – Pinnipeds			
Guadalupe Fur Seal (*Arctocephalus townsendi*)	T - 50 FR 51252	-- --	-- --
Sea Turtles			
Green Turtle (*Chelonia mydas*)	E - 43 FR 32800	63 FR 46693	63 FR 28359
Loggerhead Turtle (*Caretta caretta*)	E - 76 FR 58868	-- --	63 FR 28359
Olive Ridley Turtle (*Lepidochelys olivacea*)	E - 61 FR 17	-- --	63 FR 28359
Leatherback Turtle (*Dermochelys coriacea*)	E - 61 FR 17	77 FR 4170	63 FR 28359
Fish – Rockfish			
Bocaccio *(Sebastes paucispinus*)			
Puget Sound/Georgia Basin DPS	E - 75 FR 22276	78 FR 47635	-- --
Georgia Basin Canary rockfish (*Sebastes pinniger*)	T - 75 FR 22276	78 FR 47635	-- --
Georgia Basin Yelloweye rockfish *(Sebastes ruberrimus*)	T - 75 FR 22276	78 FR 47635	-- --
Fish – Sturgeon			
Green sturgeon (*Acipenser medirostris*)			
Southern DPS	T - 71 FR 17757	74 FR 52300	-- --
Fish – Pacific Eulachon / Smelt (*Thaleichthys pacificus*)			
Southern DPS	T - 75 FR 13012	76 FR 65324	78 FR 40104
Fish – Salmonids			
Chinook Salmon (*Oncorhynchus tshawytscha)* Evolutionarily Significant Units (ESU)			
Puget Sound ESU	T - 70 FR 37160	70 FR 52685	72 FR 2493
Lower Columbia River ESU	T - 70 FR 37160	70 FR 52706	-- --
Upper Columbia River spring-run ESU	E- 64 FR 14307	70 FR 52703	72 FR 57303
Upper Willamette River ESU	T – 65 FR 42422	70 FR 52720	76 FR 52317
Snake River spring/summer-run ESU	T – 65 FR 42422		
Snake River fall-run ESU	T – 65 FR 42422		
Central Valley, fall and late run ESU	T – 65 FR 42422		
Central Valley, spring-run ESU	T – 65 FR 42422	70 FR 52590	
California Coast ESU	T – 64 FR 50394	70 FR 52537	-- --
Sacramento River, Winter-run ESU	E – 59 FR 440		
Chum Salmon (*Oncorhynchus keta*) ESUs			
Columbia River ESU	T - 70 FR 37160	70 FR 52630	-- --
Hood Canal Summer Run ESU	T - 70 FR 37160	70 FR 52630	72 FR 29121
Coho Salmon (*Oncorhynchus kisutch*) ESUs			
Lower Columbia River ESU	T - 70 FR 37160	-- --	*
Oregon Coast ESU	T – 76 FR 35755	73 FR 7816	-- --

Species	ESA Status	Critical Habitat	Recovery Plan
So. Oregon Northern California Coast ESU	T- 76 FR 50447	64 FR 24049	-- --
Central California Coast ESU	E- 76 FR 50447	64 FR 24049	-- --
Sockeye Salmon (*Oncorhynchus nerka*) ESUs			
Ozette Lake ESU	T - 70 FR 37160	70 FR 52630	74 FR 25706
Snake River ESU	E - 70 FR 37160	58 FR 68543	
Steelhead Trout (*Oncorhynchus mykiss*) Distinct Population Segments (DPS)			
Lower Columbia River DPS	T - 71 FR 834	70 FR 52630	-- --
Upper Columbia River DPS	T – 71 FR 834		72 FR 57303
Middle Columbia River DPS	T – 71 FR 834		
Puget Sound DPS	T - 72 FR 26722	-- --	-- --
Upper Willamette River DPS	T – 71 FR 834		76 FR 52317
Northern California DPS	T - 71 FR 834	70 FR 52488	-- --
Central California Coast DPS	T - 71 FR 834	70 FR 52488	-- --
Snake River Basin DPS	T – 71 FR 834	70 FR 52488	
California Central Valley DPS	T – 71 FR 834	70 FR 52488	
South-Central California DPS	T – 71 FR 834	70 FR 52488	*
Southern California DPS	E – 71 FR 5248	70 FR 52488	77 FR 1669

4.1 Species and Critical Habitat Not Considered Further in this Opinion

As described in the *Approach to the Assessment*, NMFS uses two criteria to identify those endangered or threatened species or critical habitat that are not likely to be adversely affected by the various activities. The first criterion was exposure or some reasonable expectation of a co-occurrence between one or more potential stressors associated with the Navy's activities and a particular listed species or designated critical habitat: if we conclude that a listed species or designated critical habitat is not likely to be exposed to the activities, we must also conclude that the species or critical habitat is not likely to be adversely affected by those activities. The second criterion is the probability of a response given exposure, which considers susceptibility: species that may be exposed to sound transmissions from active sonar, for example, but are likely to be unaffected by the sonar (at sound pressure levels they are likely to be exposed to) are also not likely to be adversely affected by the sonar. We applied these criteria to the species listed at the beginning of this section; this subsection summarizes the results of those evaluations.

4.1.1 North Pacific Right Whale

Historically, the endangered North Pacific right whale occurred in waters off the coast of British Columbia and the States of Washington, Oregon, and California (Clapham et al. 2004; Scarff 1986). However, the extremely low population numbers of this species in the North Pacific Ocean over the past five decades and the rarity of reports from these waters suggests that these right whales have probabilities of being exposed to ship and aircraft traffic and sonar

transmissions associated with the activities considered in this Opinion that are sufficiently small for us to conclude that North Pacific right whales are not likely to be exposed to the activities considered in this consultation. As a result, this species will not be considered in greater detail in the remainder of this Opinion.

In April 2008 (73 FR 19000), NMFS clarified that two areas previously designated as critical habitat for right whales in the North Pacific (71 FR 38277) also applied to the listed North Pacific right whale. The areas encompass about 36,750 square miles of marine habitat, which include feeding areas within the Gulf of Alaska and the Bering Sea that support the species. The Navy's military readiness activities would not occur in the designated critical habitat nor would the activities be expected to have any impacts to the critical habitat or the primary constituent elements. Therefore, the Navy's military readiness activities on the NWTRC are not likely to adversely affect the designated critical habitat for North Pacific right whales. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.2 Green Sea Turtle

Green sea turtles occur along the coasts of British Columbia and the States of Washington, Oregon, and northernmost California (Bowlby et al. 1994), but those occurrences are usually associated with mild or strong El Nino currents that push warmer water masses northward. When those water masses dissipate, as has happened at least twice over the past two years, green sea turtles become hypothermic in the colder, ambient temperatures. Because the Action Area occurs at the thermal limits of green sea turtles (primarily because of low sea surface temperatures), the probability of green sea turtles occurring in the Action Area is sufficiently small for us to conclude that green sea turtles are not likely to be exposed to the activities considered in this consultation. As a result, this species will not be considered in greater detail in the remainder of this Opinion.

Critical habitat was designated in 1998 for green turtles in coastal waters around Culebra Island, Puerto Rico. The action area does not overlap the critical habitat for green sea turtles. Therefore, the Navy's military readiness activities on the NWTRC are not likely to adversely affect the designated critical habitat for green sea turtles. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.3 Loggerhead Sea Turtle

Loggerhead sea turtles occur along the coasts of British Columbia and the States of Washington, Oregon, and northernmost California, but those occurrences are usually associated with mild or strong El Nino currents that push warmer water masses northward. When those water masses dissipate, as has happened at least twice over the past two years, loggerhead sea turtles become hypothermic in the colder, ambient temperatures. Because the Action Area occurs at the thermal limits of loggerhead sea turtles (primarily because of low sea surface temperatures), the

probability of loggerhead sea turtles occurring in the Action Area is sufficiently small for us to conclude that loggerhead sea turtles are not likely to be exposed to the activities considered in this consultation. As a result, this species will not be considered in greater detail in the remainder of this Opinion.

4.1.4 Olive Ridley Sea Turtle

Like green sea turtles, olive ridley sea turtles also occur along the coasts of British Columbia and the States of Washington, Oregon, and northernmost California, but those occurrences are usually associated with mild or strong El Nino currents that push warmer water masses northward. When those water masses dissipate, as has happened at least twice over the past two years, olive ridley sea turtles become hypothermic in the colder, ambient temperatures. Because the Action Area occurs at the thermal limits of olive ridley sea turtles (primarily because of low sea surface temperatures), the probability of olive ridley sea turtles occurring in the Action Area is sufficiently small for us to conclude that olive ridley sea turtles are not likely to be exposed to the activities considered in this consultation. As a result, this species will not be considered in greater detail in the remainder of this Opinion.

4.1.5 Guadalupe Fur Seal

Guadalupe fur seals are medium sized, sexually dimorphic otariids that are generally asocial with their conspecifics and other species (Belcher and T.E. Lee 2002; Reeves et al. 2002). Except for adult males, members of this species resemble California sea lions and northern fur seals. Distinguishing characteristics of the Guadalupe fur seal include the digits on their hind flippers (all of similar length), large, long foreflippers, unique vocalizations, and a characteristic behavior of floating vertically with their heads down in the water and their hind flippers exposed for cooling (Reeves et al. 2002).

Guadalupe fur seals' historic range included the Gulf of Farallones, California to the Revillagigedo Islands, Mexico (Belcher and T.E. Lee 2002; Rick et al. 2009). Currently, they breed mainly on Guadalupe Island, Mexico, 155 miles off of the Pacific Coast of Baja California. A smaller breeding colony, discovered in 1997, appears to have been established at Isla Benito del Este, Baja California, Mexico (Belcher and T.E. Lee 2002).

There are reports of individuals being sighted in the California Channel Islands, Farallone Islands, Monterey Bay, and other areas of coastal California and Mexico (Belcher and T.E. Lee 2002; Carretta et al. 2002; Reeves et al. 2002). A single female gave birth to a pup on the Channel Islands in 1997. No Guadalupe fur seals have been sighted during 2009-2013 Navy-funded surveys in the Hawaii-Southern California Training and Testing (HSTT) study area.

Before intensive hunting decreased their numbers, Guadalupe fur seals ranged from Monterey Bay, California, to the Revillagigedo Islands, Mexico (Aurioles-Gamboa and Camacho-Ríos 2007), but have occasionally been identified from strandings (Northwest Region Stranding

Database; Wilkinson 2013) or in archaeological contexts as far north as northern California, Oregon, and Washington (Etiner 2002; Rick et al. 2009). Between 1989 and 2011, a total of 118 dead stranded animals were found along the Washington and Oregon coastline (Northwest Region Stranding Database; Wilkinson 2013). Between 20 June and 1 November 2007, 19 Guadalupe fur seals stranded on the Washington and Oregon outer coasts, prompting NOAA to declare an Unusual Mortality Event on 19 October 2007 (Lambourn et al. 2012). The Unusual Mortality Event was officially closed on 11 December 2009. In 2012, approximately 58 Guadalupe fur seals stranded on the outer coasts of Washington and Oregon (Lambourn 2013 pers. comm.). This is three times the number of strandings that prompted the Unusual Mortality Event in 2007. Of all the strandings reported off Washington and Oregon (1989–2012), most occurred from mid-May through August with occasional reports between October and December (Lambourn et al. 2012; Northwest Region Stranding Database).Sightings of live animals off Washington and Oregon are more limited, although there is photo documentation of apparently healthy Guadalupe fur seals in offshore waters of Washington and British Columbia in recent years during summer and early autumn (Lambourn et al. 2012). Given the increased number of strandings in the Pacific Northwest, coupled with their increasing population, it is possible that Guadalupe fur seals are returning to their historic pelagic migration range suggested by the archaeological findings (Eitner 2002; Rick et al. 2009; Lambourn et al. 2012).

4.1.5.1 **Exclusion of Guadalupe fur seal from further analysis in NWTRC**

The Navy initially provided NMFS with estimated exposures derived from the Navy Acoustic Effects Model (NAEMO) for the no action alternative described in the NWTT DEIS/OEIS, January 2014, because the Navy considers NAEMO to be the best available information, and the training activities described in the NAA for NWTT are equivalent to the continuing training activities under consideration by NMFS for the NWTRC reinitiated consultation. NWTT encompasses the NWTRC, so references in the below discussion of the NWTT areas apply equally to the NWTRC.

During development of the Navy's NWTT DEIS/OEIS, the Navy was asked by NMFS to include an analysis of potential exposures to Guadalupe fur seals. Guadalupe fur seals are thought to be extralimital in distribution within the Pacific Northwest although there were historic and archeological records of presence in the past. While there are past and current reports of Guadalupe fur seal strandings in the Pacific Northwest, NMFS does not have at-sea Guadalupe fur seal sightings from which to derive a density estimate.

For the NWTT DEIS/OEIS, a single NWTT study area-wide layer (0.106 animals/km^2 winter and spring, and 0.082 animals/km^2 summer and fall) was derived to use in NAEMO from the northern fur seal at-sea densities described on pages 320-324 of Navy (2014b). The Navy then used a subset of northern fur seal exposures generated by NAEMO as a surrogate for Guadalupe fur seals (*see Attachment A*). Essentially, a fraction of the northern fur seal exposures (a

comparative ratio of possible Guadalupe fur seal occurrences offshore in NWTT based on NMFS' stranding records) were used to estimate Guadalupe fur seal exposures.

The estimated (not modeled) results for Guadalupe fur seals were incorporated directly into the NWTT DEIS; this equated to 11 exposures (page 3.4-151 in Navy 2014a) for the NAA, which was submitted to NMFS to support the reinitiated consultation of the NWTRC.

This initial analysis, however, was done without consideration of the likely differences in biological at-sea distributions of both northern fur seals and Guadalupe fur seals. Northern fur seals have a documented highly pelagic distribution through the offshore waters of NWTT where the majority of Navy training would occur (Davis et al. 2008, NMFS 2007, Lee et al. 2014, Sterling et al. 2014). This was the justification for the NWTT study area wide single density values by season (Navy 2014b).

Within the Pacific Northwest, Guadalupe fur seals are more likely to be coastally distributed given their extralimital at-sea occurrence and associated stranding records (Lambourn et al. 2012). Strandings by year as reported by Lambourn et al. (2012) are shown in Table 1.

Table 1. Guadalupe fur seal stranding in the Pacific Northwest 1992-2011.

Year	# Guadalupe fur seal strandings	Comments
1992	1	
2005	1	
2006	3	
2007	19 *	June 20, 2007 -November 1 2007. Unusual Mortality Event declared by NMFS
2008	5 *	
2009	5 *	Unusual Mortality Event declared over by NMFS December 2009
2010	10	
2011	16	

*Of the 29 strandings, there was one live stranded female with the rest deceased with both sexes of yearlings. Based on examination by NMFS stranding personnel of 14 collected carcasses, most of the animals were assessed as being "thin". The live stranded adult female was acting disoriented. This animal was held for ten days at Point Defiance Zoo and Aquarium. She was thin, anemic, blind in the right eye and an old healed scar over her right shoulder. Teeth were broken on the right side of her jaw.

During similar time period, only three at-sea sightings of Guadalupe fur seals were made <30 mile from shore (Lambourn et al. 2012)

Most Guadalupe fur seal strandings in the Pacific Northwest likely represent young individuals at the extreme limits of their preferred geographic foraging range as indicated by the poor health of examined carcasses to date (*see* Figure 7 from Lambourn et al. 2012). There is no current evidence to support normal population expansion into the Pacific Northwest (e.g., lack of

significant sightings of healthy individuals at-sea, lack of sightings of healthy individuals hauled-out on shore, lack of healthy individuals in the stranding record, etc.). During this same period, there were only three at-sea sightings of Guadalupe fur seals made <30 miles from shore (Lambourn et al. 2012).

The Navy has since modified the Guadalupe fur seal analysis for the NWTRC consultation to account for species-specific biological differences in at-sea distributions within NWTT operating areas. This limits Guadalupe fur seal exposures to that which can be derived from the present best available science regarding Guadalupe fur seal distribution and would more accurately reflect impacts from offshore Navy training events.

The first step in this reanalysis was the identification of the specific Navy training events modeled in NAEMO that generated exposures for northern fur seals. All exposures to northern fur seals in the NWTT No Action Alternative were generated from TRACKEX (Maritime patrol aircraft, sub, surface) the same training activities that are described in NWTRC. The Navy then analyzed the potential for co-occurrence of the activities resulting in exposures and the Guadalupe fur seal's distribution to determine if the currently predicted exposures should be modified.

Since TRACKEX events occur approximately >50 NM offshore, which is beyond the normal at-sea distribution for Guadalupe fur seals, the Navy asserts TRACKEX training events under the NWTT NAA (similar to NWTRC events), has no co-occurrence with Guadalupe fur seals and would not result in exposures to the species. Therefore, all of the current exposures were eliminated from the Navy's analysis of training activities under the NAA for NWTT, and likewise, in this consultation on NWTRC.

The Navy will make changes to the no action alternative in the NWTT Final EIS/OEIS. This analysis will be repeated for the exposures predicted for Guadalupe fur seals for Alternative 1 and 2 in the NWTT Final EIS/OEIS and the exposure numbers for those alternatives will be adjusted accordingly. Additionally, the appropriate revisions will be made to the Navy's take request for NWTT in an addendum to the MMPA LOA application and the ESA consultation package for the NWTT preferred alternative.

Therefore, based on the evidence available, we conclude that impulsive and non-impulsive acoustic stressors resulting from training activities the U.S. Navy plans to conduct in the NWTRC Action Area on an annual basis, or cumulatively over the remainder of the five year period through November 2015, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline that further reduce ability for survival and recovery of species), would not affect population

dynamics, behavioral ecology, and social dynamics of individual Guadalupe fur seals. Guadalupe fur seal is not discussed further in this Opinion.

4.1.5.2 **Critical Habitat**

NMFS has not designated critical habitat for Guadalupe fur seals.

4.1.6 ESA-listed Rockfish

4.1.6.1 **Georgia Basin Bocaccio**

The bocaccio that occur in the Georgia Basin are listed as an endangered "species," which, in this case, refers to a distinct segment of a vertebrate population (75 FR 22276). The listing includes bocaccio throughout Puget Sound, which encompasses all waters south of a line connecting Point Wilson on the Olympic Peninsula and Partridge on Whidbey Island; West Point on Whidbey Island, Deception Island, and Rosario Head on Fidalgo Island; and the southern end of Swinomish Channel between Fidalgo Island and McGlinn Island (U.S. Geological Survey 1979), and the Strait of Georgia, which encompasses the waters inland of Vancouver Island, the Gulf Islands, and the mainland coast of British Columbia.

Bocaccio are threatened as a result of the effect of directed fisheries and incidental capture as bycatch in other fisheries, including salmon fisheries. They are also adversely affected by land use practices that have increased oxygen demands within their range and the loss of kelp habitat necessary for juvenile recruitment.

The hearing sensitivities of Georgia Basin bocaccio have not been studied. However, they produce low frequency sounds (lower than 900 Hz) (Sirovic and Demer 2009) and are believed to be low-frequency hearing generalists (Croll et al. 1999b).

All fish have two sensory systems that are used to detect sound in the water including the inner ear, which functions very much like the inner ear found in other vertebrates, and the lateral line, which consists of a series of receptors along the body of the fish (Popper 2008). The inner ear generally detects higher frequency sounds while the lateral line detects water motion at low frequencies (below a few hundred Hz) (Hastings et al. 1996). A sound source produces both a pressure wave and motion of the medium particles (water molecules in this case), both of which may be important to fish. Fish detect particle motion with the inner ear. Pressure signals are initially detected by the gas-filled swim bladder or other air pockets in the body, which then re-radiate the signal to the inner ear (Popper 2008). Because particle motion attenuates relatively quickly, the pressure component of sound usually dominates as distance from the source increases.

The lateral line system of a fish allows for sensitivity to sound (Hastings and Popper 2005). This system is a series of receptors along the body of the fish that detects water motion relative to the

fish that arise from sources within a few body lengths of the animal. The sensitivity of the lateral line system is generally from below 1 Hz to a few hundred Hz (Coombs and Montgomery 1999; Popper and Schilt 2009). The only study on the effect of exposure to sound on the lateral line system (conducted on one freshwater species) suggests no effect on these sensory cells by intense pure tone signals (Hastings et al. 1996).

While studies on the effect of sound on the lateral line are limited, the work of Hasting et al. (1996) showing limited sensitivity to within a few body lengths and to sounds below a few hundred Hz, make the effect of the mid-frequency sonar of the action unlikely to affect a fish's lateral line system. Therefore, further discussion of the lateral line in this analysis in unwarranted. Broadly, fish can be categorized as either hearing specialists or hearing generalists (Scholik and Yan 2002). Fish in the hearing specialist category have a broad frequency range with a low auditory threshold due to a mechanical connection between an air filled cavity, such as a swim bladder, and the inner ear.

Specialists detect both the particle motion and pressure components of sound and can hear at levels above 1 kilohertz (kHz). Generalists are limited to detection of the particle motion component of low-frequency sounds at relatively high sound intensities (Amoser and Ladich 2005). It is possible that a species will exhibit characteristics of generalists and specialists and will sometimes be referred to as an "intermediate" hearing specialist. For example, most damselfish are typically categorized as generalists, but because some larger damselfish have demonstrated the ability to hear higher frequencies expected of specialists, they are sometimes categorized as intermediate. Of the fish species with distributions occurring in the NWTRC for which hearing sensitivities are known, most are hearing generalists, including salmonid species. The hearing capability of Atlantic salmon (*Samo salar*), a hearing generalist, indicates a rather low sensitivity to sound (Hawkins and Johnstone 1978). Laboratory experiments yielded responses only to 0.58 kHz and only at high sound levels. The salmon's poor hearing is likely due to the lack of a link between the swim bladder and inner ear (Jørgensen et al. 2004).

4.1.6.2 **Georgia Basin Canary Rockfish**

Georgia Basin canary rockfish occur throughout Puget Sound, which encompasses all waters south of a line connecting Point Wilson on the Olympic Peninsula and Partridge on Whidbey Island; West Point on Whidbey Island, Deception Island, and Rosario Head on Fidalgo Island; and the southern end of Swinomish Channel between Fidalgo Island and McGlinn Island and the Strait of Georgia, which encompasses the waters inland of Vancouver Island, the Gulf Islands, and the mainland coast of British Columbia.

Predators of adult canary rockfish include yelloweye rockfish, lingcod, salmon, sharks, dolphins, seals (Antonelis and Fiscus 1980; Merkel 1957; Morejohn et al. 1978; Rosenthal et al. 1982) and possibly river otters (Stevens and Miller 1983). In addition, studies of the effect of climate

variability on rockfish are rare, but all the studies performed to date suggest that climate plays an extremely important role in population dynamics (Drake and Griffen 2010). Although the mechanism by which climate influences the population dynamics of rockfish remains unknown, several authors have reported negative correlations between the warm water conditions associated with El Nino and the population dynamics of rockfish (Moser et al. 2000). Field and Ralston (2005) reported that recruitment in all species of rockfish appeared to be correlated at large scales and hypothesized that such synchrony was the result of large-scale climatic phenomena. Tolimieri and Levin (2005) reported that bocaccio recruitment off of California is correlated with specific sets of climate patterns. These phenomena are also believed to affect the population dynamics of Georgia Basin canary rockfish and are assumed to have led to recruitment failures in the early- to mid-1990s.

Georgia Basin canary rockfish are threatened as a result of the effect of directed fisheries and incidental capture as bycatch in other fisheries, including salmon fisheries. The frequency of canary rockfish in Puget Sound appears to have been highly variable; frequencies were less than one percent in the 1960s and 1980s and about three percent in the 1970s and 1990s. In North Puget Sound, however, the frequency of canary rockfish has been estimated to have declined from a high of greater than two percent in the 1970s to about 0.76 percent by the late 1990s. This decline combined with their low intrinsic growth potential, threats from bycatch in commercial and recreational fisheries, loss of nearshore rearing habitat, chemical contamination, and the proportion of coastal areas with low dissolved oxygen levels led to this species' listing as threatened.

The hearing sensitivities of Georgia Basin canary rockfish have not been studied. However, they produce low frequency sounds (lower than 900 Hz) (Sirovic and Demer 2009) and are believed to be low-frequency hearing generalists (Croll et al. 1999b).

4.1.6.3 **Georgia Basin Yelloweye Rockfish**

Georgia Basin yelloweye rockfish occur through Puget Sound, which encompasses all waters south of a line connecting Point Wilson on the Olympic Peninsula and Partridge on Whidbey Island; West Point on Whidbey Island, Deception Island, and Rosario Head on Fidalgo Island; and the southern end of Swinomish Channel between Fidalgo Island and McGlinn Island, and the Strait of Georgia, which encompasses the waters inland of Vancouver Island, the Gulf Islands, and the mainland coast of British Columbia.

Predators of yelloweye rockfish include salmon and orcas (Ford et al. 1998a; Love et al. 2002). Direct studies on the effect of climate variability on rockfish are rare, but all the studies performed to date suggest that climate plays an extremely important role in population dynamics (Drake and Griffen 2010). Although the mechanism by which climate influences the population dynamics of rockfish remains unknown, several authors have reported negative correlations

between the warm water conditions associated with El Nino and the population dynamics of rockfish (Moser et al. 2000). Field and Ralston (2005) reported that recruitment in all species of rockfish appeared to be correlated at large scales and hypothesized that such synchrony was the result of large-scale climatic phenomena. Tolimieri and Levin (2005) reported that bocaccio recruitment off of California is correlated with specific sets of climate patterns. These phenomena are also believed to affect the population dynamics of Georgia Basin yelloweye rockfish.

Georgia Basin yelloweye rockfish are threatened as a result of the effect of directed fisheries and incidental capture as bycatch in other fisheries, including salmon fisheries. The frequency of yelloweye rockfish in collections from Puget Sound appears to have been highly variable; frequencies were less than one percent in the 1960s and 1980s and about three percent in the 1970s and 1990s. In North Puget Sound, however, the frequency of yelloweye rockfish has been estimated to have declined from a high of greater than three percent in the 1970s to about 0.65 percent in more recent samples. This decline combined with their low intrinsic growth potential, threats from bycatch in commercial and recreational fisheries, loss of nearshore rearing habitat, chemical contamination, and the proportion of coastal areas with low dissolved oxygen levels led to this species' listing as threatened.

The hearing sensitivities of Georgia Basin yelloweye rockfish have not been studied. However, they produce low frequency sounds (lower than 900 Hz) (Sirovic and Demer 2009) and are believed to be low-frequency hearing generalists (Croll et al. 1999b).

4.1.6.4 **Exclusion of Rockfish from Further Consideration in this Opinion**

The ESA-listed DPSs of rockfish species (bocaccio, canary rockfish, yelloweye rockfish) spend their lives in the waters of Puget Sound. The juveniles and subadults of these species tend to favor shallow water habitats associated with kelp forests and rocky reefs, and the adults favor rocky bottoms in deeper waters. The Navy does not conduct sonar activities within the shallow waters of Puget Sound; therefore juveniles of these species have a very low potential to be exposed to non-impulsive sound stressors associated with training. The number of larvae or juveniles that are potentially affected would represent an immeasurably small fraction of the individuals in the larval and juvenile life stages (for example, individual female canary rockfish produce between 260,000 to 1.9 million eggs). Therefore, the death of small numbers of individual larvae or juveniles is not likely to result in a measurable reduction in the viability of the populations those fish represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations).

The distribution of adult Georgia Basin bocaccio, canary rockfish, and yelloweye rockfish overlaps with the locations of the U.S. Navy's underwater detonation sites in Puget Sound. However, the U.S. Navy generally conducts underwater detonations during training exercises at

depths of 15.24 to 24.38 meters (50 to 80 feet) while bocaccio are most common at depths between 50 and 250 meters (160 and 820 feet); Georgia Basin yelloweye rockfish are most common at depths between 91 and 180 meters (300 to 580 feet), although they may occur in waters 50 to 475 meters (160 and 1,400 feet) deep; and canary rockfish are most common at depths between 50 and 250 meters (160 and 820 feet), although they may occur at depths of 425 meters (1,400 feet). At those depths, adult Georgia Basin bocaccio, Georgia Basin canary rockfish, and Georgia Basin yelloweye rockfish are not likely to be exposed to sound fields or pressure waves produced 1-lb., 1.5-lb or 2.5-pound charges the U.S. Navy proposes to use during mine countermeasures training. As a result, the adult stages of these species are not likely to be exposed to the activities considered in this Opinion. The distribution of adult ESA-listed DPSs of rockfish species (bocaccio, canary rockfish, yelloweye rockfish) are likely to be exposed to sound fields and pressure waves associated with active sonar training activities on the NWTRC. However, since the majority of sonar and other active acoustic sources that are outside the hearing range of most fish species including rock fish only minor behavioral impacts would be anticipated. Long-term consequences for bocaccio, canary rockfish, yelloweye rockfish fish populations are not expected and therefore the survival and recovery of these species would not be adversely affected by training in the NWTRC.

4.1.6.5 **Proposed Critical Habitat for ESA-listed Rockfish**

On 6 August 2013, NMFS proposed to designate critical habitat for three species of rockfish listed under the Endangered Species Act (ESA), including the threatened Distinct Population Segment (DPS) of yelloweye rockfish (*Sebastes ruberrimus*), the threatened DPS of canary rockfish (*S. pinniger*), and the endangered DPS of bocaccio (*S. paucispinus*) (listed rockfish). The final designation is anticipated in August 2014. Potential effects to designated critical habitat for rockfish will be addressed in the pending consultation[8] on *Northwest Training and Testing* activities. A synopsis of the proposed designation is provided below.

The specific areas proposed for designation for canary rockfish and bocaccio include approximately 1,184.75 sq mi (3,068.5 sq km) of marine habitat in Puget Sound, Washington. The specific areas proposed for designation for yelloweye rockfish include approximately 574.75 sq mi (1,488.6 sq km) of marine habitat in Puget Sound, Washington.

Physical or biological features essential to the conservation of rock fish include benthic habitats or sites deeper than 30m (98ft) that possess or are adjacent to areas of complex bathymetry consisting of rock and or highly rugose habitat are essential to conservation because these

[8] NMFS has proposed designation of critical habitat for these three species, but the Navy did not request a conference opinion on impacts to the proposed habitat. A determination as to whether reinitiation is required will be made upon final designation.

features support growth, survival, reproduction, and feeding opportunities by providing the structure for rockfish to avoid predation, seek food and persist for decades. Juvenile settlement habitats located in the nearshore with substrates such as sand, rock and/or cobble compositions that also support kelp (families Chordaceae, Alariaceae, Lessoniacea, Costariaceae, and Laminaricea) are essential for conservation because these features enable forage opportunities and refuge from predators and enable behavioral and physiological changes needed for juveniles to occupy deeper adult habitats.

Many forms of human activities have the potential to affect the essential features of listed rockfish species: (1) Nearshore development and in-water construction (e.g., beach armoring, pier construction, jetty or harbor construction, pile driving construction, residential and commercial construction); (2) dredging and disposal of dredged material; (3) pollution and runoff; (4) underwater construction and operation of alternative energy hydrokinetic projects (tidal or wave energy projects) and cable laying; (5) kelp harvest; (6) fisheries; (7) non-indigenous species introduction and management; (8) artificial habitats; (9) research activities; and (10) aquaculture.

Section 4(a)(3) of the ESA precludes the Secretary from designating military lands as critical habitat if those lands are subject to an Integrated Natural Resource Management Plan (INRMP) under the Sikes Act that the Secretary certifies in writing benefits the listed species. NMFS consulted with the DOD and determined that there are several installations with INRMPs which overlap with marine habitats occupied by listed rockfish: (1) Joint base Lewis-McCord: (2) Manchester Fuel Department, (3) Naval Air Station Whidbey Island, (4) Naval Station Everett, and (5) Naval Station Kitsap.

4.1.7 Green Sturgeon

Green sturgeon are long-lived, slow-growing fish and the most marine-oriented of the sturgeon species. Mature males range from 4.5-6.5 feet (1.4-2 m) in "fork length" and do not mature until they are at least 15 years old, while mature females range from 5-7 feet (1.6-2.2 m) fork length and do not mature until they are at least 17 years old. Maximum ages of adult green sturgeon are likely to range from 60-70 years (Moyle 2002). This species is found along the west coast of Mexico, the United States, and Canada.

Although they are members of the class of bony fishes, the skeleton of sturgeons is composed mostly of cartilage. Sturgeon lack scales; however, they have five rows of characteristic bony plates on their body called "scutes". The backbone of the sturgeon curves upward into the caudal fin, forming their shark-like tail. On the ventral, or underside, of their flattened snouts are sensory barbels and a siphon-shaped, protrusible, toothless mouth. Recent genetic information suggests that green sturgeon in North America are taxonomically distinct from morphologically similar forms in Asia.

Green sturgeon are believed to spend the majority of their lives in nearshore oceanic waters, bays, and estuaries. Early life-history stages reside in fresh water, with adults returning to freshwater to spawn when they are more than 15 years of age and more than 4 feet (1.3 m) in size. Spawning is believed to occur every 2-5 years (Moyle 2002). Adults typically migrate into fresh water beginning in late February; spawning occurs from March-July, with peak activity from April-June (Moyle et al. 1995). Females produce 60,000-140,000 eggs (Moyle et al. 1992). Juvenile green sturgeon spend 1-4 years in fresh and estuarine waters before dispersal to saltwater (Beamesderfer and Webb 2002). They disperse widely in the ocean after their out-migration from freshwater (Moyle et al. 1992). The only feeding data we have on adult green sturgeon shows that they are eating "benthic" invertebrates including shrimp, mollusks, amphipods, and even small fish (Moyle et al. 1992). The green sturgeon, *Acipenser medirostris*, is an anadromous species inhabiting Asian and American shorelines of the northern Pacific Ocean (Moyle 2002). In North America, green sturgeon occur from the Bering Sea to Ensenada, Mexico.

We do not have specific information on hearing in green sturgeon. However, Meyer and Popper (Meyer and Popper 2002) recorded auditory evoked potentials to pure tone stimuli of varying frequency and intensity in lake sturgeon and reported that lake sturgeon detect pure tones from 100 to 2000 Hz, with best sensitivity from 100 to 400 Hz. They also compared these sturgeon data with comparable data for oscar (*Astronotus ocellatus*) and goldfish (*Carassius auratus*) and reported that the auditory brainstem responses for the lake sturgeon are more similar to the goldfish (which is considered a hearing specialist that can hear up to 5000 Hz) than to the oscar (which is a non-specialist that can only detect sound up to 400 Hz); these authors, however, felt additional data were necessary before lake sturgeon could be considered specialized for hearing.

Lovell et al. (Lovell et al. 2005) also studied sound reception in and the hearing abilities of paddlefish (*Polyodon spathula*) and lake sturgeon (*Acipenser fulvescens*). They concluded that both species were responsive to sounds ranging in frequency from 100 to 500 Hz with lowest hearing thresholds from frequencies in bandwidths between 200 and 300 Hz and higher thresholds at 100 and 500 Hz. We assume that the hearing sensitivities reported for these other species of sturgeon are representative of the hearing sensitivities of southern green sturgeon.

4.1.8 Critical Habitat For Southern Resident Killer Whales

Critical habitat that has been designated for southern resident killer whales includes the summer core area in Haro Strait and waters around the San Juan Islands, the Puget Sound area, and the Strait of Juan de Fuca, which together comprise about 2,560 square miles of marine and coastal habitat (71 FR 69054). The designated critical habitat includes three specific marine areas of Puget Sound in Clallam, Jefferson, King, Kitsap, Island, Mason, Pierce, San Juan, Skagit,

Snohomish, Thurston, and Whatcom Counties in the State of Washington. The critical habitat designation includes all waters relative to a contiguous shoreline delimited by the line at a depth of 20 feet (6.1 m) relative to extreme high water in (see 50 CFR § 226.206 for complete latitude and longitude references to all points contained in the following narratives):

1. The summer core areas, which includes all U.S. marine waters in Whatcom and San Juan counties; and all marine waters in Skagit County west and north of the Deception Pass Bridge (Highway 20);
2. Puget Sound, which includes (a) all marine waters in Island County east and south of the Deception Pass Bridge (Highway 20) and east of a line connecting the Point Wilson Lighthouse and a point on Whidbey Island located at 48°12′30″N latitude and 122°44′26″W longitude; (b) all marine waters in Skagit County east of the Deception Pass Bridge (Highway 20); (c) all marine waters of Jefferson County east of a line connecting the Point Wilson Lighthouse and a point on Whidbey Island located at latitude 48°12′3″″N latitude and 122°44′26″W longitude, and north of the Hood Canal Bridge (Highway 104); (d) all marine waters in eastern Kitsap County east of the Hood Canal Bridge (Highway 104); (e) all marine waters (excluding Hood Canal) in Mason County; and (f) all marine waters in King, Pierce, Snohomish, and Thurston counties
3. Strait of Juan de Fuca Area: All U.S. marine waters in Clallam County east of a line connecting Cape Flattery, Washington, Tatoosh Island, Washington, and Bonilla Point, British Columbia; all marine waters in Jefferson and Island counties west of the Deception Pass Bridge (Highway 20), and west of a line connecting the Point Wilson Lighthouse and a point on Whidbey Island located at 48°12′30″N. latitude and 122o44′26″W. longitude.

4.1.8.1 Physical or Biological Features Essential for Conservation (Primary Constituent Elements)

Killer whale habitat utilization is dynamic, and specific breeding, calving or resting areas are not currently documented. Births occur largely from October to March, but may take place in any month (Olesiuk et al. 1990) and therefore potentially in any part of the whale's range. Southern Residents are highly mobile and can travel up to 160km in a 24 hour period (Baird 2000), allowing rapid movements between areas. The three primary concerns raised as potential factors in the decline of Southern Residents are; prey availability, contaminants/pollution, and vessel effects. There are habitat components for each of these concerns for killer whales which relate to the essential features necessary for killer whale conservation.

Fish are the major dietary component of resident killer whales in the northeastern Pacific, with 22 species of fish and one species of squid (Gonatopsis borealis) known to be eaten (Scheffer and Slipp 1948, Ford et al. 1998, 2000, Ford and Ellis 2005, Saulitis et al. 2000). Observations from this region indicate that salmon are the preferred prey (Ford

et al. 1998, Ford and Ellis 2005). Foraging areas are dependent on variable temporal and spatial patterns of prey species, particularly migratory salmon. These characteristics present challenges in identifying critical habitat for Southern Resident killer whales. However, several studies are currently underway to fill important data gaps by quantifying habitat use on a finer scale and determining if certain behaviors are more frequently observed in particular habitat areas (NWFSC unpbul. data).
In consideration of the natural history of the Southern Resident killer whales and their habitat needs, the physical or biological features of Southern Resident killer whale habitat proposed in the Federal Register (69 FR 76673, December 22, 2004) the PCEs 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.

Critical habitat that has been designated for southern resident killer whales would not be affected by the training activities the U.S. Navy conducts on the NWTRC. Except for some air combat maneuvers, harm exercises, electronic combat exercises, mine countermeasures, insertion/extraction, and research, development, test and evaluations of unmanned aerial systems, all of the training activities the U.S. Navy plans to conduct on the NWTRC would occur on offshore areas of the complex.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude southern resident killer whales from designated critical habitat, so those activities are not likely to adversely affect the designated critical habitat for southern resident killer whales. As described below in Section 7 of this Opinion, we determined that the Navy's NWTRC training activities are not likely to jeopardize listed fish species and that incidental take of these species is anticipated to be limited. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.9 Critical Habitat for Leatherback Sea Turtle

In 1979, NMFS designated critical habitat for leatherback turtles to include the coastal waters adjacent to Sandy Point, St. Croix, U.S. Virgin Islands (44 FR 17710).

In 2007, NMFS received a petition to revise the leatherback critical habitat designation to include waters off the U.S. West Coast. NMFS published a 90-day finding on the petition in December 2007. Then, on January 5, 2010, NMFS published a proposed rule to revise the critical habitat designation (75 FR 319), which proposed designating additional areas within the Pacific Ocean. NMFS announced the designation of additional critical habitat to provide protection for endangered leatherback sea turtles along the U.S. West Coast on January 20, 2012, per a court settlement agreement, and the regulation formally published in the Federal Register on January 26, 2012 (77 FR 4170). Specific areas in the designation include two adjacent marine areas totaling approximately 46,100 square miles (119,400 square km) stretching along the California coast from Point Arena to Point Vincente; and one 24,500 square mile (63,455 square km) marine area stretching from Cape Flattery, Washington to the Umpqua River (Winchester Bay), Oregon east of a line approximating the 2,000 meter depth contour.

The Critical Habitat Review Team (CHRT) identified two primary constituent elements essential for the conservation of leatherbacks in marine waters off the U.S. West Coast: (1) occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (Chrysaora, Aurelia, Phacellophora, and Cyanea) of sufficient condition, distribution, diversity, and abundance to support individual as well as population growth, reproduction, and development; (2) migratory pathway conditions to allow for safe and timely passage and access to/from/within high use foraging areas.

The military readiness activities would not be expected to alter or reduce the occurrence of prey species of the leatherback sea turtle and the CHRT determined that only permanent or long-term structures that alter the habitat would be considered as having potential effects on passage. Given this determination, the CHRT did not consider fishing gear or vessel traffic as potential threats to passage. Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC. These stressors are not likely to exclude leatherback sea turtles from designated critical habitat or alter the primary constituent elements of the critical habitat, so the activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for leatherback sea turtles. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.10 Critical Habitat for the Southern Population of Green Sturgeon

On October 9, 2009, NMFS designated critical habitat for southern green sturgeon (74 FR 52300). The area identified as critical habitat is the entire range of the biological species, green sturgeon, from the Bering Sea, Alaska, to Ensenada, Mexico. Specific freshwater areas include the Sacramento River, Feather River, Yuba River, and the Sacramento-San Joaquin Delta.

Specific coastal bays and estuaries include estuaries from Elkhorn Slough, California, to Puget Sound, Washington. Coastal marine areas include waters along the entire biological species range within a depth of 60 fathoms. The principle biological or physical constituent elements essential for the conservation of southern green sturgeon in freshwater include: food resources; substrate of sufficient type and size to support viable egg and larval development; water flow, water quality such that the chemical characteristics support normal behavior, growth and viability; migratory corridors; water depth; and sediment quality. Primary constituent elements of estuarine habitat include food resources, water flow, water quality, migratory corridors, water depth, and sediment quality. The specific primary constituent elements of marine habitat include food resources, water quality, and migratory corridors.

Critical habitat of southern green sturgeon is threatened by several anthropogenic factors. Four dams and several other structures currently are impassible for green sturgeon to pass on the Sacramento, Feather, and San Joaquin rivers, preventing movement into spawning habitat. Threats to these riverine habitats also include increasing temperature, insufficient flow that may impair recruitment, the introduction of striped bass that may eat young sturgeon and compete for prey, and the presence of heavy metals and contaminants in the river.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude green sturgeon from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for southern green sturgeon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.11 Critical Habitat for Pacific Eulachon

On 20 October, 2011, NMFS designated critical habitat for the southern DPS of Pacific eulachon, including streams and rivers in Washington State (Grays, Elochoman, Cowlitz, Kalama, Lewis, Quinault, and Elwa rivers), Oregon (Columbia River), and California (Mad, Klamath, Umpqua, and Sandy rivers as well as Tenmile Creek). These areas contain physical or biological features essential to the conservation of the DPS, including (1) freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, (2) freshwater and estuarine migration corridors free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted, and (3) nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude Pacific eulachon from designated critical habitat, so the activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for Pacific eulachon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.12 Critical Habitat for Puget Sound Chinook Salmon

NMFS designated critical habitat for Puget Sound Chinook salmon on 2 September 2005 (70 FR 52630). The specific geographic area includes portions of the Nooksack River, Skagit River, Sauk River, Stillaguamish River, Skykomish River, Snoqualmie River, Lake Washington, Green River, Puyallup River, White River, Nisqually River, Hamma Hamma River and other Hood Canal watersheds, the Dungeness/ Elwha Watersheds, and nearshore marine areas of the Strait of Georgia, Puget Sound, Hood Canal and the Strait of Juan de Fuca. This designation includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high water line. In areas where the ordinary high-water line is not defined the lateral extent is defined as the bank full elevation.

The designation for this species includes sites necessary to support one or more Chinook salmon life stages. These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding. Specific primary constituent elements include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat, and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude Puget Sound Chinook salmon from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for Puget Sound Chinook salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.13 Critical Habitat for Upper Columbia River Spring Chinook Salmon

NMFS designated critical habitat for Upper Columbia River Spring Chinook salmon on September 2, 2005 (70 FR 52630). Designated critical habitat includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood Rivers as

well as specific stream reaches in a number of tributary subbasins. These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding. The critical habitat designation for this species identifies primary constituent elements that include sites necessary to support one or more Chinook salmon life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation are not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude Upper Columbia River Spring Chinook salmon from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for Upper Columbia River Chinook salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.14 Critical Habitat for Lower Columbia River Chinook Salmon

NMFS designated critical habitat for Lower Columbia River Chinook salmon on September 2, 2005 (70 FR 52630). Designated critical habitat includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood Rivers as well as specific stream reaches in a number of tributary subbasins. These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding. The critical habitat designation for this species identifies primary constituent elements that include sites necessary to support one or more Chinook salmon life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation are not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude Lower Columbia River Chinook salmon from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for Lower Columbia River Chinook salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.15 Critical Habitat for Willamette River Chinook Salmon

NMFS designated critical habitat for Willamette River Chinook salmon on September 2, 2005 (70 FR 52630). Designated critical habitat includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood Rivers as well as specific stream reaches in a number of tributary subbasins. These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding. The critical habitat designation for this species identifies primary constituent elements that include sites necessary to support one or more Chinook salmon life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation are not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude Willamette River Chinook salmon from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for Willamette River Chinook salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.16 Critical Habitat for California Coast Chinook Salmon

NMFS designated critical habitat for California Coast Chinook salmon on September 2, 2005 (70 FR 52488). Specific geographic areas designated include the following CALWATER hydrological units: Redwood Creek, Trinidad, Mad River, Eureka Plain, Eel River, Cape Mendocino, Mendocino Coast, and the Russian River. These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding. The critical habitat designation for this ESU identifies primary constituent elements that include sites necessary to support one or more Chinook salmon life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. The critical habitat designation (70 FR 52488) contains additional details on the sub-areas that are included as part of this designation, and the areas that were excluded from designation.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation are not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude California Coast Chinook salmon from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for California Coast Chinook salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.17 Critical Habitat for Central Valley Chinook Salmon

NMFS issued a final rule on September 2, 2005, designating critical habitat for two Evolutionarily Significant Units (ESUs) of chinook salmon (Oncorhynchus tshawytscha) and five ESUs of steelhead (O. mykiss) listed as of the date of this designation under the Endangered Species Act of 1973, as amended (ESA). The specific areas designated in the rule include approximately 8,935 net mi (14,269 km) of riverine habitat and 470 mi 2 (1,212 km 2) of estuarine habitat (primarily in San Francisco-San Pablo-Suisun Bays) in California. Some of the areas designated are occupied by two or more ESUs. There are 37 occupied HSA watersheds within the freshwater and estuarine range of this ESU. Seven watersheds received a low rating, 3 received a medium rating, and 27 received a high rating of conservation value to the ESU (NMFS, 2005a). Four of these HSA watersheds comprise portions of the San Francisco-San Pablo-Suisun Bay estuarine complex which provides rearing and migratory habitat for this ESU HSA watershed habitat areas for this ESU include approximately 1,373 mi (2,197 km) of occupied stream habitat and approximately 427 mi ^{2} (1,102 km ^{2}) of estuarine habitat in the San Francisco-San Pablo-Suisun Bay complex.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation are not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude Central Valley Chinook salmon from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for Central Valley Chinook salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.18 Critical Habitat for Oregon Coast Coho Salmon

NMFS designated critical habitat for Oregon Coast Coho on February 11, 2008 (73 FR 7816). The designation includes 72 of 80 watersheds occupied by Oregon Coast Coho salmon, and totals about 6,600 stream miles including all or portions of the Nehalem, Nestucca/Trask,

Yaguina, Alsea, Umpqua and Coquille basins. These areas are essential for feeding, migration, spawning, and rearing. The specific primary constituent elements include: spawning sites with water and substrate quantity to support spawning, incubation, and larval development; freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth, foraging, behavioral development (e.g., predator avoidance, competition), and mobility; freshwater migratory corridors free of obstruction with adequate water quantity and quality conditions; and estuarine, nearshore and offshore areas free of obstruction with adequate water quantity, quality and salinity conditions that support physiological transitions between fresh- and saltwater, predator avoidance, foraging and other life history behaviors.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude Oregon Coast coho salmon from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for Oregon Coast coho salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.19 Critical Habitat for SONC Coast Coho Salmon

NMFS designated critical habitat for Southern Oregon/Northern California (SONC) Coast coho salmon on May 5, 1999 (64 FR 24049). Critical habitat for this species encompasses all accessible river reaches between Cape Blanco, Oregon, and Punta Gorda, California. Critical habitat consists of the water, substrate, and river reaches (including off-channel habitats) in specified areas. Accessible reaches are those within the historical range of the species that can still be occupied by any life stage of coho salmon.

Of 155 historical streams for which data are available, 63 percent likely still support coho salmon. These river habitats are important for a variety of reasons, such as supporting the feeding and growth of juveniles and serving as spawning habitat for adults. Limiting factors identified for this species include: loss of channel complexity, connectivity and sinuosity, loss of floodplain and estuarine habitats, loss of riparian habitats and large in-river wood, reduced stream flow, poor water quality, temperature and excessive sedimentation, and unscreened diversions and fish passage structures.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not

likely to exclude Southern Oregon/Northern California Coast coho salmon from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for Southern Oregon/Northern California Coast coho salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.20 Critical Habitat for Central California Coast Coho Salmon

NMFS designated critical habitat for central California coast coho salmon on May 5, 1999 (64 FR 24049). The designation encompasses accessible reaches of all rivers (including estuarine areas and riverine reaches) between Punta Gorda and the San Lorenzo River (inclusive) in California, including two streams entering San Francisco Bay: Arroyo Corte Madera Del Presidio and Corte Madera Creek. This critical habitat designation includes all waterways, substrate, and adjacent riparian zones of estuarine and riverine reaches (including off-channel habitats) below longstanding naturally impassable barriers (i.e. natural waterfalls in existence for at least several hundred years). These areas are important for the species' overall conservation by protecting growth, reproduction, and feeding.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude central California coast coho salmon from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for central California coast coho salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.21 Critical Habitat for Columbia River Chum Salmon

NMFS designated critical habitat for Columbia River chum salmon on September 2, 2005 (70 FR 52630). The designation includes defined areas in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy, Lewis, Lower Columbia/Clatskanie, Lower Cowlitz, Lower Columbia subbasin and river corridor. This designation includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high water line. In areas where the ordinary high-water line is not defined the lateral extent is defined as the bank full elevation.

The critical habitat designation for this species identifies primary constituent elements that include sites necessary to support one or more chum salmon life stages. These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding and are rated as having high conservation value to the species. Columbia River chum salmon have primary constituent elements of freshwater spawning, freshwater rearing,

freshwater migration, estuarine areas free of obstruction, nearshore marine areas free of obstructions, and offshore marine areas with good water quality. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity.

The critical habitat for Columbia River chum salmon does not overlap or occur in proximity to the NWTRC, so the military readiness activities the U.S. Navy conducts on the NWTRC will not affect the designated critical habitat for Columbia River chum salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.22 Critical Habitat for Hood Canal Summer Run Chum Salmon

NMFS designated critical habitat for Hood Canal summer-run chum salmon on September 2, 2005 (70 FR 52630). The specific geographic area includes the Skokomish River, Hood Canal subbasin, which includes the Hamma Hamma and Dosewallips rivers and others, the Puget Sound subbasin, Dungeness/Elwha subbasin, and nearshore marine areas of Hood Canal and the Strait of Juan de Fuca from the line of extreme high tide to a depth of 30 meters. This includes a narrow nearshore zone from the extreme high-tide to mean lower low tide within several Navy security/restricted zones. Additionally, about 8 miles of habitat was unoccupied at the time it was designated, including Finch, Anderson and Chimacum creeks (69 FR 74572; 70 FR 52630), but has recently been re-seeded. The designation for Hood Canal summer-run chum, like others made at this time, includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high water line. In areas where the ordinary high-water line is not defined the lateral extent is defined as the bank full elevation.

The specific primary constituent elements identified for Hood Canal summer-run chum salmon are areas for spawning, freshwater rearing and migration, estuarine areas free of obstruction, nearshore marine areas free of obstructions, and offshore marine areas with good water quality. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity.

Of 17 subbasins reviewed in NMFS's assessment of critical habitat for the Hood Canal chum salmon, 14 subbasins were rated as having a high conservation value, while only three were rated as having a medium value to the conservation. These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding. Limiting factors identified for this species include degraded floodplain and mainstem river channel structure, degraded estuarine conditions and loss of estuarine habitat, riparian area degradation and loss of in-river wood in mainstem, excessive sediment in spawning gravels, and reduced stream flow in migration areas.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude Hood Canal chum salmon from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for Hood Canal chum salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.23 Critical Habitat for Ozette Lake Sockeye Salmon

NMFS designated critical habitat for Ozette Lake sockeye salmon on September 2, 2005 (70 FR 52630). The specific geographic area includes: Ozette Lake and the Ozette Lake watershed, including the Ozette River upstream to endpoints in: Big River; Coal Creek; the East Branch of Umbrella Creek; North Fork Crooked Creek; Ozette River; South Fork Crooked Creek; Umbrella Creek (48.2127, -124.5787); and three unnamed Ozette Lake tributaries ("Hatchery Creek," tributary to Umbrella Creek, and "Stony Creek").

The designation for Ozette Lake sockeye salmon, like others made at this time, includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high water line. In areas where the ordinary high-water line is not defined the lateral extent is defined as the bank full elevation.

The specific primary constituent elements identified for Ozette Lake sockeye salmon are areas for spawning, freshwater rearing and migration, estuarine areas free of obstruction, nearshore marine areas free of obstructions, and offshore marine areas with good water quality. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity.

There is one watershed supporting the Ozette Lake sockeye ESU and it was rated as having a high conservation value. These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding. Limiting factors identified for this species include degraded water quality, predation in the lake, reduced quality and quantity of beach spawning habitat, changes in lake level that dewater redds decreasing egg-to-fry survival, variability in marine survival, and reduced stream flow in migration areas.

The critical habitat for Ozette Lake sockeye salmon does not overlap or occur in proximity to the NWTRC, so the military readiness activities the U.S. Navy conducts on the NWTRC will not affect the designated critical habitat for Ozette Lake sockeye salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.24 Critical Habitat for Snake River Sockeye Salmon

NMFS designated critical habitat for Ozette Lake sockeye salmon on September 2, 2005 (70 FR 52630). This evolutionarily significant unit, or ESU, includes naturally spawned anadromous and residual sockeye salmon originating from the Snake River basin, and also sockeye salmon from one artificial propagation program: Redfish Lake Captive Broodstock Program. The designation for Snake River sockeye salmon, like others made at this time, includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high water line. In areas where the ordinary high-water line is not defined the lateral extent is defined as the bank full elevation.

The specific primary constituent elements identified for Snake River sockeye salmon are areas for spawning, freshwater rearing and migration, estuarine areas free of obstruction, nearshore marine areas free of obstructions, and offshore marine areas with good water quality. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity.

These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding. Limiting factors identified for this species include degraded water quality, predation in the lake, reduced quality and quantity of beach spawning habitat, changes in lake level that dewater redds decreasing egg-to-fry survival, variability in marine survival, and reduced stream flow in migration areas.

The critical habitat for Snake River sockeye salmon does not overlap or occur in proximity to the NWTRC, so the military readiness activities the U.S. Navy conducts on the NWTRC will not affect the designated critical habitat for Snake River sockeye salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.25 Critical Habitat for Lower Columbia River Steelhead

NMFS designated critical habitat for Lower Columbia River steelhead on September 2, 2005 (70 FR 52630). Designated critical habitat includes the following subbasins: Middle Columbia/Hood subbasin, Lower Columbia/Sandy subbasin, Lewis subbasin, Lower Columbia/Clatskanie subbasin, Upper Cowlitz subbasin, Cowlitz subbasin, Clackamas subbasin, Lower Willamette subbasin, and the Lower Columbia River corridor. These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding. The critical habitat designation for this species identifies primary constituent elements that include sites necessary to support one or more steelhead life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. The

critical habitat designation (70 FR 52630) contains additional description of the watersheds that are included as part of this designation, and any areas specifically excluded from the designation.

The critical habitat for Lower Columbia River steelhead does not overlap or occur in proximity to the NWTRC, so the military readiness activities the U.S. Navy conducts on the NWTRC will not affect the designated critical habitat for Lower Columbia River steelhead. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.26 Critical Habitat for Northern California Steelhead

NMFS designated critical habitat for Northern California steelhead on September 2, 2005 (70 FR 52488). Specific geographic areas designated include the following hydrological units: Redwood Creek, Trinidad, Mad River, Eureka Plain, Eel River, Cape Mendocino, and the Mendocino Coast. These areas are important for the species overall conservation by protecting quality growth, reproduction, and feeding.

The critical habitat designation for this species identifies primary constituent elements that include sites necessary to support one or more steelhead life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. The critical habitat designation (70 FR 52488) contains additional details on the sub-areas that are included as part of this designation, and the areas that were excluded from designation.

In total, Northern California steelhead occupy 50 watersheds (freshwater and estuarine). The total area of habitat designated as critical includes about 3,000 miles of stream habitat and about 25 square miles of estuarine habitat, mostly within Humboldt Bay. This designation includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high water line. In areas where the ordinary high-water line is not defined the lateral extent is defined as the bankfull elevation. In estuarine areas the lateral extent is defined by the extreme high water because extreme high tide areas encompass those areas typically inundated by water and regularly occupied by juvenile salmon during the spring and summer, when they are migrating in the nearshore zone and relying on cover and refuge qualities provided by these habitats, and while they are foraging. Of the 50 watersheds reviewed in NMFS's assessment of critical habitat for Northern California steelhead, nine watersheds received a low rating of conservation value, 14 received a medium rating, and 27 received a high rating of conservation value for the species. Two estuarine areas used for rearing and migration (Humboldt Bay and the Eel River estuary) also received a rating of high conservation value.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude northern California steelhead from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for northern California steelhead. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.27 Critical Habitat for Central California Coast Steelhead

NMFS designated critical habitat for the Central California Coast steelhead on September 2, 2005 (70 FR 52488), and includes areas within the following hydrologic units: Russian River, Bodega, Marin Coastal, San Mateo, Bay Bridge, Santa Clara, San Pablo, and Big Basin. These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding. The critical habitat designation for this species identifies primary constituent elements that include sites necessary to support one or more steelhead life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. The critical habitat designation (70 FR 52488) contains additional details on the sub-areas that are included as part of this designation, and the areas that were excluded from designation.

In total, Central California Coast steelhead occupy 46 watersheds (freshwater and estuarine). The total area of habitat designated as critical includes about 1,500 miles of stream habitat and about 400 square miles of estuarine habitat (principally Humboldt Bay). This designation includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high water line. In areas where the ordinary high-water line is not defined the lateral extent is defined as the bankfull elevation. In estuarine areas the lateral extent is defined by the extreme high water because extreme high tide areas encompass those areas typically inundated by water and regularly occupied by juvenile salmon during the spring and summer, when they are migrating in the nearshore zone and relying on cover and refuge qualities provided by these habitats, and while they are foraging. Of the 46 occupied watersheds reviewed in NMFS's assessment of critical habitat for Central California Coast steelhead, 14 watersheds received a low rating of conservation value, 13 received a medium rating, and 19 received a high rating of conservation value for the species. Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude Central California Coast steelhead from designated

critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for Central California Coast steelhead. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.28 Critical Habitat for Snake River Basin Steelhead Trout

NMFS designated critical habitat for the Snake River Basin steelhead on September 2, 2005 (70 FR 52488). These areas are important for the species‘ overall conservation by protecting quality growth, reproduction, and feeding. The critical habitat designation for this species identifies primary constituent elements that include sites necessary to support one or more steelhead life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. The critical habitat designation (70 FR 52488) contains additional details on the sub-areas that are included as part of this designation, and the areas that were excluded from designation.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude Snake River Basin steelhead from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for Snake River Basin steelhead. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.29 Critical Habitat for California Central Valley Steelhead Trout

NMFS designated critical habitat for the California Central Valley steelhead on September 2, 2005 (70 FR 52488). These areas are important for the species overall conservation by protecting quality growth, reproduction, and feeding. The critical habitat designation for this species identifies primary constituent elements that include sites necessary to support one or more steelhead life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. The critical habitat designation (70 FR 52488) contains additional details on the sub-areas that are included as part of this designation, and the areas that were excluded from designation.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat

designation is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude California Central Valley steelhead from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for California Central Valley steelhead. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.30 Critical Habitat for South-Central California Steelhead Trout

NMFS designated critical habitat for the South-Central California steelhead on September 2, 2005 (70 FR 52488). These areas are important for the species‘ overall conservation by protecting quality growth, reproduction, and feeding. The critical habitat designation for this species identifies primary constituent elements that include sites necessary to support one or more steelhead life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. The critical habitat designation (70 FR 52488) contains additional details on the sub-areas that are included as part of this designation, and the areas that were excluded from designation.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude South-Central California steelhead from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for South-Central California steelhead. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.31 Critical Habitat for Southern California Steelhead Trout

NMFS designated critical habitat for the Southern California steelhead on September 2, 2005 (70 FR 52488). These areas are important for the species‘ overall conservation by protecting quality growth, reproduction, and feeding. The critical habitat designation for this species identifies primary constituent elements that include sites necessary to support one or more steelhead life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. The critical habitat designation (70 FR 52488) contains additional details on the sub-areas that are included as part of this designation, and the areas that were excluded from designation.

Based on our analyses of the evidence available, the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources of this critical habitat designation is not likely to decline as a result of being exposed to stressors associated with the military readiness activities the U.S. Navy conducts on the NWTRC and these stressors are not likely to exclude Southern California steelhead from designated critical habitat, so the military readiness activities the U.S. Navy conducts on the NWTRC are not likely to adversely affect the designated critical habitat for Southern California steelhead. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.2 Species Considered Further in this Biological Opinion

The rest of this section of our Opinion consists of narratives for each of the threatened and endangered species that occur in the action area and that may be adversely affected by the readiness activities the U.S. Navy conducts in waters on the NWTRC. In each narrative, we present a summary of information on the distribution and population structure of each species to provide a foundation for the exposure analyses that appear later in this Opinion. Then we summarize information on the threats to the species and the species' status given those threats to provide points of reference for the jeopardy determinations we make later in this Opinion. That is, we rely on a species' status and trend to determine whether or not an action's direct or indirect effects are likely to increase the species' probability of becoming extinct or decrease its probability of recovery [or could put "likely to reduce the species' likelihood of survival and recovery."].

After the *Status* subsection of each narrative, we present information on the diving and social behavior of the different species because that behavior helps determine whether aerial and ship board surveys are likely to detect each species. We also summarize information on the vocalizations and hearing of the different species because that background information lays the foundation for our assessment of how the different species are likely to respond to sounds produced by sonar and detonations.

More detailed background information on the status of these species and critical habitat can be found in a number of published documents including status reviews, recovery plans for the blue whale (NMFS 1998b), fin whales (NMFS 2010b), fin and sei whale (NMFS 1998a), humpback whale (NMFS 1991), sperm whale (NMFS 2010c), a status report on large whales prepared by Perry et al. (1999a) and the status review and recovery plan for the leatherback sea turtle (NMFS and USFWS 1998; NMFS and USFWS 2007). Richardson et al. (1995b) and Tyack (2000) provide detailed analyses of the functional aspects of cetacean communication and their responses to active sonar. Finally, Croll et al. (1999), NRC (2005; 2000; 2003a), and Richardson and Wursig (1995) provide information on the potential and probable effects of active sonar on the marine animals considered in this Opinion.

4.2.1 Blue Whale

The blue whale, *Balaenoptera musculus* (Linnæus 1758), is a cosmopolitan species of baleen whale. It is the largest animal ever known to have lived on Earth: adults in the Antarctic have reached a maximum body length of about 33 m and can weigh more than 150,000 kg. The largest blue whales reported from the North Pacific are a female that measured 26.8 m (88 ft) taken at Port Hobron in 1932 (Reeves et al. 1985) and a 27.1 m (89 ft) female taken by Japanese pelagic whaling operations in 1959 (NMFS 1998b).

As is true of other baleen whale species, female blue whales are somewhat larger than males. Blue whales are identified by the following characteristics: a long-body and comparatively slender shape; a broad, flat "rostrum" when viewed from above; a proportionately smaller dorsal fin than other baleen whales; and a mottled gray color pattern that appears light blue when seen through the water.

4.2.1.1 **Distribution**

Blue whales are found along the coastal shelves of North America and South America (Clarke 1980; Donovan 1984; Rice 1998). In the western North Atlantic Ocean, blue whales are found from the Arctic to at least the mid-latitude waters of the North Atlantic (CETAP 1982; Gagnon and Clark 1993; Wenzel et al. 1988; Yochem and Leatherwood 1985). Blue whales have been observed frequently off eastern Canada, particularly in waters off Newfoundland, during the winter. In the summer months, they have been observed in Davis Strait (Mansfield 1985), the Gulf of St. Lawrence (from the north shore of the St. Lawrence River estuary to the Strait of Belle Isle), and off eastern Nova Scotia (Sears 1987a). In the eastern North Atlantic Ocean, blue whales have been observed off the Azores Islands, although Reiner et al. (1996) do not consider them common in that area.

In 1992, the Navy conducted an extensive acoustic survey of the North Atlantic Ocean using the Integrated Underwater Surveillance System's fixed acoustic array system (Clark 1995). Concentrations of blue whale sounds were detected in the Grand Banks off Newfoundland and west of the British Isles. In the lower latitudes, one blue whale was tracked acoustically for 43 days, during which time the animal traveled 1400 nautical miles around the western North Atlantic from waters northeast of Bermuda to the southwest and west of Bermuda (Gagnon and Clark 1993).

In the North Pacific Ocean, blue whales have been recorded off the island of Oahu in the main Hawaiian Islands and off Midway Island in the western edge of the Hawaiian Archipelago (Barlow 2006; Northrop et al. 1971; Thompson and Friedl 1982), although blue whales are rarely sighted in Hawaiian waters and have not been reported to strand in the Hawaiian Islands.

In the eastern tropical Pacific Ocean, the Costa Rica Dome appears to be important for blue whales based on the high density of prey (euphausiids) available in the Dome and the number of blue whales that appear to reside there (Reilly and Thayer 1990). Blue whales have been sighted in the Dome area in every season of the year, although their numbers appear to be highest from June through November. Blue whales have also been reported year-round in the northern Indian Ocean, with sightings in the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca (Mizroch et al. 1984). The migratory movements of these whales are unknown.

Blue whales in the eastern Pacific winter from California south; in the western Pacific, they winter from the Sea of Japan, the East China and Yellow Seas, and the Philippine Sea. Blue whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska. Nishiwaki (1966) reported that blue whales occur in the Aleutian Islands and in the Gulf of Alaska. An array of hydrophones, deployed in October 1999, detected two blue whale call types in the Gulf of Alaska (Stafford 2003). Fifteen blue whale sightings off British Columbia and in the Gulf of Alaska have been made since 1997 (Calambokidis et al. 2009b). Three of these photographically verified sightings were in the northern Gulf of Alaska within 71 nm of each other and were less than 100 nm offshore (Calambokidis et al. 2009b).

Blue whales appear to migrate to waters offshore of Washington, Oregon, and northern California to forage. Thus far, blue whales are associated with deeper, pelagic waters in the action area; they have not been reported to occur proximate to the coast or in Puget Sound itself. Širović et al. (Širović et al. 2012; Širović et al. 2011) reported detection of blue whale vocalizations in the offshore waters of Washington from late fall through February. Oelson et al (Oleson and Hildebrand 2011) also reported visual blue whale sightings in these areas. Although a resident population of blue whales might occur off the coast of Vancouver Island throughout the year (Burtenshaw et al. 2004), most blue whales that occur in the action area for this consultation appear to migrate between summer, foraging areas and winter rearing areas along the Pacific Coast of the United States. That seasonal migration brings them to waters off the NWTRC (with some individuals continuing north to the Gulf of Alaska) during the warm, summer season with a southward migration to waters off California, south to Central America, during the winter season (Calambokidis et al. 2009b; Gregr et al. 2000; Mate et al. 1998).

4.2.1.2 **Population Structure**

For this and all subsequent species, the term "population" refers to groups of individuals whose patterns of increase or decrease in abundance over time are determined by internal dynamics (births resulting from sexual interactions between individuals in the group and deaths of those individuals) rather than external dynamics (immigration or emigration). This definition is a reformulation of definitions articulated by Futuymda (1986) and Wells and Richmond (1995)

and is more restrictive than those uses of 'population' that refer to groups of individuals that co-occur in space and time but do not have internal dynamics that determine whether the size of the group increases or decreases over time (see review by Wells and Richmond 1995). The definition we apply is important to section 7 consultations because such concepts as 'population decline,' 'population collapse,' 'population extinction,' and 'population recovery' apply to the restrictive definition of 'population' but do not explicitly apply to alternative definitions. As a result, we do not treat the different whale "stocks" recognized by the International Whaling Commission or other authorities as populations unless those distinctions were clearly based on demographic criteria. We do, however, acknowledge those "stock" distinctions in these narratives.

At least three subspecies of blue whales have been identified based on body size and geographic distribution (*B. musculus intermedia*, which occurs in the higher latitudes of the Southern Oceans, *B. m. musculus*, which occurs in the Northern Hemisphere, and *B. m. brevicauda* which occurs in the mid-latitude waters of the southern Indian Ocean and north of the Antarctic convergence), but this consultation will treat them as a single entity. Readers who are interested in these subspecies will find more information in Gilpatrick et al. (1997), Kato et al. (1995), Omura et al. (1970), and Ichihara (1966).

In addition to these subspecies, the International Whaling Commission's Scientific Committee has formally recognized one blue whale population in the North Pacific (Donovan 1991), although there is increasing evidence that there may be more than one blue whale population in the Pacific Ocean (Gilpatrick et al. (1997), Barlow et al. (1995), Mizroch et al. (1984), Ohsumi and Wada (1972)). For example, studies of the blue whales that winter off Baja California and in the Gulf of California suggest that these whales are morphologically distinct from blue whales of the western and central North Pacific (Gilpatrick et al. 1997), although these differences might result from differences in the productivity of their foraging areas more than genetic differences (Barlow et al. 1997; Calambokidis et al. 1990; Sears 1987b). A population of blue whales that has distinct vocalizations inhabits the northeast Pacific from the Gulf of Alaska to waters off Central America (Gregr et al. 2000; Mate et al. 1998; Stafford 2003). We assume that this population is the one affected by the activities considered in this Opinion.

4.2.1.3 **Natural Threats**

Natural causes of mortality in blue whales are largely unknown, but probably include predation and disease (not necessarily in their order of importance). Blue whales are known to become infected with the nematode *Carricauda boopis* (Baylis 1928), which are believed to have caused fin whales to die as a result of renal failure (Lambertsen 1986); see additional discussion under Fin whales). Killer whales and sharks are also known to attack, injure, and kill very young or sick fin and humpback whales and probably hunt blue whales as well (Perry et al. 1999a).

4.2.1.4 **Anthropogenic Threats**

Two human activities are known to threaten blue whales; whaling and shipping. Historically, whaling represented the greatest threat to every population of blue whales and was ultimately responsible for listing blue whales as an endangered species. As early as the mid-seventeenth century, the Japanese were capturing blue, fin, and other large whales using a fairly primitive open-water netting technique (Tonnessen and Johnsen 1982). In 1864, explosive harpoons and steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species.

From 1889 to 1965, whalers killed about 5,761 blue whales in the North Pacific Ocean (Hill et al. 1999). From 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). Evidence of a population decline was seen in the catch data from Japan. In 1912, whalers captured 236 blue whales; in 1913, 58 blue whales; in 194, 123 blue whales; from 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). In the eastern North Pacific, whalers killed 239 blue whales off the California coast in 1926. And, in the late 1950s and early 1960s, Japanese whalers killed 70 blue whales per year off the Aleutian Islands (Mizroch et al. 1984).

Although the International Whaling Commission banned commercial whaling in the North Pacific in 1966, Soviet whaling fleets continued to hunt blue whales in the North Pacific for several years after the ban. Surveys conducted in these former-whaling areas in the 1980s and 1990s failed to find any blue whales (Forney and Brownell Jr. 1996). By 1967, Soviet scientists wrote that blue whales in the North Pacific Ocean (including the eastern Bering Sea and Prince William Sound) had been so overharvested by Soviet whaling fleets that some scientists concluded that any additional harvests were certain to cause the species to become extinct in the North Pacific (Latishev 2007). As its legacy, whaling has reduced blue whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push blue whales closer to extinction. Otherwise, whaling currently does not threaten blue whale populations.

In 1980, 1986, 1987, and 1993, ship strikes have been implicated in the deaths of blue whales off California (Barlow 1997). More recently, Berman-Kowalewski et al. (2010) reported that between 1988 and 2007, 21 blue whale deaths were reported along the California coast, typically one or two cases annually. In addition, several photo-identified blue whales from California waters were observed with large scars on their dorsal areas that may have been caused by ship strikes. Studies have shown that blue whales respond to approaching ships in a variety of ways, depending on the behavior of the animals at the time of approach, and speed and direction of the approaching vessel. While feeding, blue whales react less rapidly and with less obvious avoidance behavior than whales that are not feeding (Sears 1983). Within the St. Lawrence Estuary, blue whales are believed to be affected by large amounts of recreational and commercial

vessel traffic. Blue whales in the St. Lawrence appeared more likely to react to these vessels when boats made fast, erratic approaches or sudden changes in direction or speed (Edds and Macfarlane 1987).

Although commercial fisheries using large gill nets or other large set gears poses some entanglement risk to marine mammals, there is little direct evidence of blue whale mortality from fishing gears. Therefore it is difficult to estimate the numbers of blue whales killed or injured by gear entanglements. The offshore drift gillnet fishery is the only fishery that is likely to "take" blue whales from this stock, but no fishery mortalities or serious injuries have been observed. 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 becoming entangled and cause little damage to nets (Carretta et al. 2008).

4.2.1.5 **Status and Trends**

Blue whales (including all subspecies) were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973. Blue whales are listed as endangered on the IUCN Red List of Threatened Animals (IUCN 2010). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for blue whales.

It is difficult to assess the current status of blue whales globally because (1) there is no general agreement on the size of the blue whale population prior to whaling and (2) estimates of the current size of the different blue whale populations vary widely. We may never know the size of the blue whale population in the North Pacific prior to whaling, although some authors have concluded that their population numbers about 200,000 animals before whaling. Similarly, estimates of the global abundance of blue whales are uncertain. Since the cessation of whaling, the global population of blue whales has been estimated to range from 11,200 to 13,000 animals (Maser et al. 1981). These estimates, however, are more than 20 years old.

The current best available abundance estimate for the Eastern North Pacific stock of blue whales that occur off California, Oregon, and Washington is 2,497 (coefficient of variation = 0.24) (Fallis et al. 1983). There was a documented increase in the blue whale population size between 1979 and 1994, but there has not been evidence to suggest an increase in the population since then (Barlow 1994; Barlow and Taylor 2001a; Carretta et al. 2010) . In 2008, Cascadia Research conducted photographic identification surveys to make abundance estimates of blue whales along the U.S. West Coast. The results reflect an upward trend in abundance of blue whales along the U.S. West Coast, although their numbers are highly variable off California, most likely due to the variability of its use as a feeding area (Calambokidis et al. 2009c).

There currently is no estimate of abundance for the Central North Pacific stock of blue whales due to a lack of sighting information (Fallis et al. 1983). The information available on the status and trend of blue whales do not allow us to reach any conclusions about the extinction risks facing blue whales as a species, or particular populations of blue whales. With the limited data available on blue whales, we do not know whether these whales exist at population sizes large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself) or if blue whales are threatened more by exogenous threats such as anthropogenic activities (primarily whaling and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate).

4.2.1.6 **Diving and Social Behavior**

Blue whales spend more than 94 percent of their time underwater (Lagerquist et al. 2000). Generally, blue whales dive 5-20 times at 12-20 sec intervals before a deep dive of 3-30 min (Croll et al. 1999a; Leatherwood et al. 1976; Maser et al. 1981; Yochem and Leatherwood 1985). Average foraging dives are 140 m deep and last for 7.8 min (Croll et al. 2001a). Non-foraging dives are shallower and shorter, averaging 68 m and 4.9 min (Croll et al. 2001a). However, dives of up to 300 m are known (Calambokidis et al. 2003). Nighttime dives are generally shallower (50 m).

Blue whales occur singly or in groups of two or three (Aguayo 1974; Mackintosh 1965; Nemoto 1964; Pike and Macaskie 1969; Ruud 1956; Slijper 1962). However, larger foraging aggregations, even with other species such as fin whales, are regularly reported (Fiedler et al. 1998; Schoenherr 1991). Little is known of the mating behavior of blue whales.

4.2.1.7 **Vocalization and Hearing**

Blue whales produce prolonged low-frequency vocalizations that include moans in the range from 12.5-400 Hz, with dominant frequencies from 16-25 Hz, and songs that span frequencies from 16-60 Hz that last up to 36 sec repeated every 1 to 2 min (see McDonald et al. 1995). Berchok et al. (2006) examined vocalizations of St. Lawrence blue whales and found mean peak frequencies ranging from 17.0-78.7 Hz. Reported source levels are 180-188 dB re 1µPa, but may reach 195 dB re 1µPa (Aburto et al. 1997; Clark and Gagnon 2004; Ketten 1998; McDonald et al. 2001). Samaran et al. (2010) estimated Antarctic blue whale calls in the Indian Ocean at 179 ± 5 dB re 1 μPa_{rms} -1 m in the 17-30 Hz range and pygmy blue whale calls at 175± 1 dB re 1 μPa_{rms} -1 m in the 17-50 Hz range.

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization,

navigation, contextual information transmission, and location of prey resources) (Edds-Walton 1997; Payne and Webb. 1971; Thompson et al. 1992). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while in summer high-latitude feeding areas. Short, rapid sequences of 30-90 Hz calls are associated with socialization and may be displays by males based upon call seasonality and structure. The low-frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long-distance communication occurs (Edds-Walton 1997; Payne and Webb. 1971). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999).

Cetaceans have an auditory anatomy that follows the basic mammalian pattern, with some modifications to adapt to the demands of hearing in the sea. The typical mammalian ear is divided into the outer ear, middle ear, and inner ear. The outer ear is separated from the inner ear by the tympanic membrane, or eardrum. In terrestrial mammals, the outer ear, eardrum, and middle ear function to transmit airborne sound to the inner ear, where the sound is detected in a fluid. Since cetaceans already live in a fluid medium, they do not require this matching, and thus do not have an air-filled external ear canal. The inner ear is where sound energy is converted into neural signals that are transmitted to the central nervous system via the auditory nerve. Acoustic energy causes the basilar membrane in the cochlea to vibrate. Sensory cells at different positions along the basilar membrane are excited by different frequencies of sound (Tyack 1999). Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low-frequency) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995b). Nevertheless, data reported by Melcón et al. (Melcon et al. 2012b) demonstrates that blue whales hear, respond to and change their behavior in response to sounds in the mid-frequency range at received levels below 120 dB SPL (re: 1 µPa). For this outcome to have occurred, it was necessary for the blue whales to hear and devote attentional resources to the sonar, despite its high frequency (relative to their putative hearing sensitivity) and its low received level.

4.2.1.8 **Critical Habitat**

NMFS has not designated critical habitat for blue whales.

4.2.2 Fin Whale

The fin whale, *Balaenoptera physalus* (Linnæus 1758), is a well-defined, cosmopolitan species of baleen whale (Gambell 1985a). Fin whales are the second-largest whale species by length. Fin whales are long-bodied and slender, with a prominent dorsal fin set about two-thirds of the way

back on the body. The streamlined appearance can change during feeding when the pleated throat and chest area becomes distended by the influx of prey and seawater, giving the animal a tadpole-like appearance. The basic body color of the fin whale is dark gray dorsally and white ventrally, but the pigmentation pattern is complex. The lower jaw is gray or black on the left side and creamy white on the right side. This asymmetrical coloration extends to the baleen plates as well, and is reversed on the tongue. Individually distinctive features of pigmentation, along with dorsal fin shapes and body scars, have been used in photo-identification studies (Agler et al. 1990). Fin whales live 70-80 years (Kjeld 1982).

4.2.2.1 **Distribution**

Fin whales are distributed widely in every ocean except the Arctic Ocean. In the North Atlantic Ocean, fin whales occur in summer foraging areas from the coast of North America to the Arctic, around Greenland, Iceland, northern Norway, Jan Meyers, Spitsbergen, and the Barents Sea. In the western Atlantic, they winter from the edge of sea ice south to the Gulf of Mexico and the West Indies. In the eastern Atlantic, they winter from southern Norway, the Bay of Biscay, and Spain with some whales migrating into the Mediterranean Sea (Gambell 1985a).

In the Southern Hemisphere, fin whales are distributed broadly south of 50° S in the summer and migrate into the Atlantic, Indian, and Pacific Oceans in the winter, along the coast of South America (as far north as Peru and Brazil), Africa, and the islands in Oceania north of Australia and New Zealand (Gambell 1985a).

Fin whales are common off the Atlantic coast of the United States in waters immediately off the coast seaward to the continental shelf (about the 1,000-fathom contour). In this region, they tend to occur north of Cape Hatteras where they accounted for about 46 percent of the large whales observed in surveys conducted between 1978 and 1982. During the summer months, fin whales in this region tend to congregate in feeding areas between 41°20'N and 51°00'N, from shore seaward to the 1,000-fathom contour. This species preys opportunistically on both invertebrates and fish (Watkins et al. 1984). They feed by filtering large volumes of water for the associated prey.

In the North Pacific Ocean, fin whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska; in the eastern Pacific, they occur south to California; in the western Pacific, they occur south to Japan. Fin whales in the eastern Pacific winter from California south; in the western Pacific, they winter from the Sea of Japan, the East China and Yellow Seas, and the Philippine Sea (Gambell 1985a). The overall distribution may be based on prey availability. Fin whales are larger and faster than humpback and right whales and are less concentrated in nearshore environments.

4.2.2.2 **Population Structure**

Fin whales have two recognized subspecies: *Balaenoptera physalus physalus* occurs in the North Atlantic Ocean while *B. p. quoyi* (Fischer 1829) occurs in the Southern Ocean. Globally, fin whales are sub-divided into three major groups: Atlantic, Pacific, and Antarctic. Within these major areas, different organizations use different population structure.

In the North Atlantic Ocean, the International Whaling Commission recognizes seven management units or "stocks" of fin whales: (1) Nova Scotia, (2) Newfoundland-Labrador, (3) West Greenland, (4) East Greenland-Iceland, (5) North Norway, (6) West Norway-Faroe Islands, and (7) British Isles-Spain-Portugal. In addition, the population of fin whales that resides in the Ligurian Sea, in the northwestern Mediterranean Sea, is believed to be genetically distinct from other fin whale populations.

In the North Pacific Ocean, the International Whaling Commission recognizes two "stocks": (1) East China Sea and (2) rest of the North Pacific (Donovan 1991). However, Mizroch et al. (1984) concluded that there were five possible "stocks" of fin whales within the North Pacific based on histological analyses and tagging experiments: (1) East and West Pacific that intermingle around the Aleutian Islands; (2) East China Sea; (3) British Columbia; (4) Southern-Central California to Gulf of Alaska; and (5) Gulf of California. Based on genetic analyses, Berube et al. (1998) concluded that fin whales in the Sea of Cortez represent an isolated population that has very little genetic exchange with other populations in the North Pacific Ocean (although the geographic distribution of this population and other populations can overlap seasonally). They also concluded that fin whales in the Gulf of St. Lawrence and Gulf of Maine are distinct from fin whales found off Spain and in the Mediterranean Sea.

Regardless of how different authors structure the fin whale population, mark-recapture studies have demonstrated that individual fin whales migrate between management units (Mitchell 1974; Sigurjonsson et al. 1989), which suggests that these management units are not geographically isolated populations.

Mizroch et al. (1984) identified five fin whale "feeding aggregations" in the Pacific Ocean: (1) an eastern group that move along the Aleutians, (2) a western group that move along the Aleutians (Berzin and Rovnin 1966; Nasu 1974); (3) an East China Sea group; (4) a group that moves north and south along the west coast of North America between California and the Gulf of Alaska (Rice 1974); and (5) a group centered in the Sea of Cortez (Gulf of California).

Hatch (2004) reported that fin whale vocalizations among five regions of the eastern North Pacific were heterogeneous: the Gulf of Alaska, the northeast North Pacific (Washington and British Columbia), the southeast North Pacific (California and northern Baja California), the Gulf of California, and the eastern tropical Pacific.

Sighting data show no evidence of migration between the Sea of Cortez and adjacent areas in the Pacific, but seasonal changes in abundance in the Sea of Cortez suggests that these fin whales might not be isolated (Tershy et al. 1993). Nevertheless, Bérubé et al. (2002) concluded that the Sea of Cortez fin whale population is genetically distinct from the oceanic population and have lower genetic diversity, which suggests that these fin whales might represent an isolated population.

Fin whales also appear to migrate to waters offshore of Washington, Oregon, and northern California to forage. Most fin whales that occur in the action area for this consultation appear to migrate between summer, foraging areas and winter rearing areas along the Pacific Coast of the United States. Širović et al. (Širović et al. 2012; Širović et al. 2011) reported fin whale vocalizations off Washington from July through April with calls not detected from May to July. Moore et al. (1998) recorded fin whale vocalizations in waters off Washington and Oregon throughout the year, with concentrations between September and February, which demonstrates that fin whales are likely to occur in the action area throughout the year.

4.2.2.3 **Natural Threats**

Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggested annual natural mortality rates might range from 0.04 to 0.06 for northeast Atlantic fin whales. The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure and may be preventing some fin whale populations from recovering (Lambertsen 1983). Adult fin whales engage in flight responses (up to 40 km/h) to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Killer whale or shark attacks may also result in serious injury or death in very young and sick individuals (Perry et al. 1999a).

4.2.2.4 **Anthropogenic Threats**

Fin whales have undergone significant exploitation, but are currently protected under the IWC. Fin whales are still hunted in subsistence fisheries off West Greenland. In 2004, five males and six females were killed, and two other fin whales were struck and lost. In 2003, two males and four females were landed and two others were struck and lost (IWC 2005). Between 2003 and 2007, the IWC set a catch limit of up to 19 fin whales in this subsistence fishery. However, the scientific recommendation was to limit the number killed to four individuals until accurate populations could be produced (IWC 2005).

Fin whales experience significant injury and mortality from fishing gear and ship strikes (Carretta et al. 2007; Douglas et al. 2008; Lien 1994; Perkins and Beamish 1979; Waring et al. 2007). Between 1969 and 1990, 14 fin whales were captured in coastal fisheries off Newfoundland and Labrador; of these seven are known to have died because of capture (Lien 1994; Perkins and Beamish 1979). In 1999, one fin whale was reported killed in the Gulf of

Alaska pollock trawl fishery and one was killed the same year in the offshore drift gillnet fishery (Angliss and Outlaw 2005; Carretta and Chivers. 2004). According to Waring et al. (2007), four fin whales in the western North Atlantic died or were seriously injured in fishing gear, while another five were killed or injured as a result of ship strikes between January 2000 and December 2004.

Jensen and Silber (2004) review of the NMFS's ship strike database revealed fin whales as the most frequently confirmed victims of ship strikes (26 percent of the recorded ship strikes [n = 75/292 records]), with most collisions occurring off the east coast, followed by the west coast of the U.S. and Alaska/Hawai′i. Between 1999-2005, there were 15 reports of fin whales strikes by vessels along the U.S. and Canadian Atlantic coasts (Cole et al. 2005; Nelson et al. 2007). Of these, 13 were confirmed, resulting in the deaths of 11 individuals. Five of seven fin whales stranded along Washington State and Oregon showed evidence of ship strike with incidence increasing since 2002 (Douglas et al. 2008). Similarly, 2.4 percent of living fin whales from the Mediterranean show ship strike injury and 16 percent of stranded individuals were killed by vessel collision (Panigada et al. 2006). There are also numerous reports of ship strikes off the Atlantic coasts of France and England (Jensen and Silber 2004).

Management measures aimed at reducing the risk of ships hitting right whales should also reduce the risk of collisions with fin whales. In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship strike appear to be largely ignored (Vanderlaan et al. 2008). However, new rules for seasonal (June through December) slowing of vessel traffic to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are predicted to be capable of reducing ship strike mortality by 27 percent in the Bay of Fundy region.

The organochlorines DDE, DDT, and PCBs have been identified from fin whale blubber, but levels are lower than in toothed whales due to the lower level in the food chain that fin whales feed at (Aguilar and Borrell 1988; Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983; Marsili and Focardi 1996). Females contained lower burdens than males, likely due to mobilization of contaminants during pregnancy and lactation (Aguilar and Borrell 1988; Gauthier et al. 1997). Contaminant levels increase steadily with age until sexual maturity, at which time levels begin to drop in females and continue to increase in males (Aguilar and Borrell 1988).

Climate change also presents a potential threat to fin whales, particularly in the Mediterranean Sea, where fin whales appear to rely exclusively upon northern krill as a prey source. These krill occupy the southern extent of their range and increases in water temperature could result in their decline and that of fin whales in the Mediterranean Sea (Gambaiani et al. 2009).

4.2.2.5 **Status and Trends**

Fin whales were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973. Although fin whale population structure remains unclear, various abundance estimates are available. Pre-exploitation fin whale abundance is estimated at 464,000 individuals worldwide; the estimate for 1991 was roughly 25 percent of this (Braham 1991). Historically, worldwide populations were severely depleted by commercial whaling, with more than 700,000 whales harvested in the twentieth century (Cherfas 1989).

The status and trend of fin whale populations is largely unknown. Over 26,000 fin whales were harvested between 1914-1975 (Braham 1991 as cited in Perry et al. 1999a). NMFS estimates roughly 3,000 individuals occur off California, Oregon, and Washington based on ship surveys in summer/autumn of 1996, 2001, and 2005, of which estimates of 283 and 380 have been made for Oregon and Washington alone (Barlow 2003; Barlow and Taylor 2001b; Forney 2007). Barlow (2003) noted densities of up to 0.0012 individuals/km^2 off Oregon and Washington and up to 0.004 individuals/km^2 off California.

Fin whales were extensively hunted in coastal waters of Alaska as they congregated at feeding areas in the spring and summer (Mizroch et al. 2009). There has been little effort in the Gulf of Alaska since the cessation of whaling activities to assess abundance of large whale stocks. Fin whale calls have been recorded year-round in the Gulf of Alaska, but are most prevalent from August-February (Moore et al. 1998; Moore et al. 2006).

Regardless of which of these estimates, if any, have the closest correspondence to the actual size and trend of the fin whale population, all of these estimates suggest that the global population of fin whales consists of tens of thousands of individuals.

The current best available abundance estimate for the Hawaiian stock of fin whales is 174 (coefficient of variation = 0.72) (Barlow 2003). The current best available abundance estimate of fin whales in California, Oregon, and Washington waters is 3,044 (coefficient of variation = 0.18) (Carretta et al. 2011). Survey estimate numbers for both stocks are considered to be an underestimate because large whales that could not be identified in the field (due to distance, bad sighting conditions, etc.) were recorded in these and other surveys as "unidentified rorqual" or "unidentified large whale" (Carretta et al. 2010). A recent study indicates that the abundance of fin whales in waters off the U.S. west coast has increased during the 1991–2008 survey period, most likely from *in situ* population growth combined with distribution shifts (Moore and Barlow 2011).

Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, fin whales appear to exist at population sizes that are large enough to avoid demographic phenomena that are known to increase the extinction probability of species

that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that fin whales are likely to be threatened more by exogenous threats such as anthropogenic activities (primarily whaling, entanglement, and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) than endogenous threats caused by the small size of their population.

Nevertheless, based on the evidence available, the number of fin whales that are recorded to have been killed or injured in the past 20 years by human activities or natural phenomena, does not appear to be increasing the extinction probability of fin whales, although it may slow the rate at which they recover from population declines that were caused by commercial whaling.

4.2.2.6 **Diving and Social Behavior**

The amount of time fin whales spend at the surface varies. Some authors have reported that fin whales make 5-20 shallow dives, each of 13-20 s duration, followed by a deep dive of 1.5-15 min (Gambell 1985a; Lafortuna et al. 2003; Stone et al. 1992). Other authors have reported that the fin whale's most common dives last 2-6 min (Hain et al. 1992; Watkins 1981b). The most recent data support average dives of 98 m and 6.3 min for foraging fin whales, while non-foraging dives are 59 m and 4.2 min (Croll et al. 2001a). However, Lafortuna et al. (1999) found that foraging fin whales have a higher blow rate than when traveling. Foraging dives in excess of 150 m are known (Panigada et al. 1999). In waters off the U.S. Atlantic Coast, individuals or duos represented about 75 percent of sightings during the Cetacean and Turtle Assessment Program (Hain et al. 1992).

Individuals or groups of less than five individuals represented about 90 percent of the observations. Barlow (2003) reported mean group sizes of 1.1–4.0 during surveys off California, Oregon, and Washington.

4.2.2.7 **Vocalization and Hearing**

Fin whales produce a variety of low-frequency sounds in the 10-200 Hz range (Edds 1988; Thompson et al. 1992; Watkins 1981a; Watkins et al. 1987). Typical vocalizations are long, patterned pulses of short duration (0.5-2 s) in the 18-35 Hz range, but only males are known to produce these (Clark et al. 2002; Patterson and Hamilton 1964). Richardson et al. (1995b) reported the most common sound as a 1 s vocalization of about 20 Hz, occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. Au (2000a) reported moans of 14-118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34-150 Hz, and songs of 17-25 Hz (Cummings and Thompson 1994; Edds 1988; Watkins 1981a). Source levels for fin whale vocalizations are 140-200 dB re 1μPa-m (see also Clark and Gagnon

2004; as compiled by Erbe 2002b). The source depth of calling fin whales has been reported to be about 50 m (Watkins et al. 1987).

Although their function is still in doubt, low-frequency fin whale vocalizations travel over long distances and may aid in long-distance communication (Edds-Walton 1997; Payne and Webb. 1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpbacks (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999).

A general description of the anatomy of the ear for cetaceans is provided in the description of the blue whale.

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995b).

4.2.2.8 **Critical Habitat**

NMFS has not designated critical habitat for fin whales.

4.2.3 Humpback Whale

Humpback whales (*Megaptera novaeangliae*) are distinguished from other whales in the same Family (Balaenopteridae) by extraordinarily long flippers (up to 5 m or about 1/3 total body length), a more robust body, fewer throat grooves (14-35), more variable dorsal fin, and utilization of very long (up to 30 min.), complex, repetitive vocalizations (songs) (Payne and McVay 1971) during courtship. Their grayish-black baleen plates, approximately 270-440 on each side of the jaw, are intermediate in length (6570 cm) to those of other baleen whales. Humpbacks in different geographical areas vary somewhat in body length, but maximum recorded size is 18m (Winn and Reichley 1985).

The whales are generally dark on the back, but the flippers, sides and ventral surface of the body and flukes may have substantial areas of natural white pigmentation plus acquired scars (white or black). Researchers distinguish individual humpbacks by the apparently unique black and white patterns on the underside of the flukes as well as other individually variable features (Glockner and Venus 1983; Katona and Whitehead 1981; Kaufman and Osmond 1987).

4.2.3.1 **Distribution**

Humpback whales are a cosmopolitan species that occur in the Atlantic, Indian, Pacific, and Southern oceans. Humpback whales migrate seasonally between warmer, tropical or sub-tropical waters in winter months (where they breed and give birth to calves, although feeding occasionally occurs) and cooler, temperate or sub-Arctic waters in summer months (where they

feed). In both regions, humpback whales tend to occupy shallow, coastal waters. However, migrations are undertaken through deep, pelagic waters (Winn and Reichley 1985).

In the North Pacific Ocean, the summer range of humpback whales includes coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Tomlin 1967, Nemoto 1957, Johnson and Wolman 1984 as cited in NMFS 1991). These whales migrate to Hawai'i, southern Japan, the Mariana Islands, and Mexico during the winter.

4.2.3.2 **Population Structure**

Descriptions of the population structure of humpback whales differ depending on whether an author focuses on where humpback whales winter or where they feed. During winter months in northern or southern hemispheres, adult humpback whales migrate to specific areas in warmer, tropical waters to reproduce and give birth to calves. During summer months, humpback whales migrate to specific areas in northern temperate or sub-arctic waters to forage. In summer months, humpback whales from different "reproductive areas" will congregate to feed; in the winter months, whales will migrate from different foraging areas to a single wintering area. In either case, humpback whales appear to form "open" populations; that is, populations that are connected through the movement of individual animals.

North Pacific. Based on genetic and photo-identification studies, the NMFS currently recognizes four stocks, likely corresponding to populations, of humpback whales in the North Pacific Ocean: two in the eastern North Pacific, one in the central North Pacific, and one in the western Pacific (Hill and DeMaster 1998). However, gene flow between them may exist. Humpback whales summer in coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Johnson and Wolman 1984; Nemoto 1957; Tomilin 1967). These whales migrate to Hawai′i, southern Japan, the Mariana Islands, and Mexico during winter. However, more northerly penetrations in Arctic waters occur on occasion (Hashagen et al. 2009). The central North Pacific population winters in the waters around Hawai′i while the eastern North Pacific population (also called the California-Oregon-Washington-Mexico stock) winters along Central America and Mexico. However, Calambokidis et al. (1997) identified individuals from several populations wintering (and potentially breeding) in the areas of other populations, highlighting the potential fluidity of population structure. Herman (1979) presented extensive evidence that humpback whales associated with the main Hawaiian Islands immigrated there only in the past 200 years. Winn and Reichley (1985) identified genetic exchange between the humpback whales that winter off Hawai′i and Mexico (with further mixing on feeding areas in Alaska) and suggested that humpback whales that winter in Hawai′i may have emigrated from Mexican wintering areas. A "population" of humpback whales winters in the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall

Islands, with occurrence in the Mariana Islands, at Guam, Rota, and Saipan from January-March (Darling and Cerchio 1993; Eldredge 1991; Eldredge 2003; Rice 1998). During summer, whales from this population migrate to the Kuril Islands, Bering Sea, Aleutian Islands, Kodiak, Southeast Alaska, and British Columbia to feed (Angliss and Outlaw 2008; Calambokidis 1997; Calambokidis et al. 2001).

Separate feeding groups of humpback whales are thought to inhabit western U.S. and Canadian waters, with the boundary between them located roughly at the U.S./Canadian border. The southern feeding ground ranges between 32°-48°N, with limited interchange with areas north of Washington State (Calambokidis et al. 2004; Calambokidis et al. 1996). Humpback whales feed along the coasts of Oregon and Washington from May-November, with peak numbers reported May-September, when they are the most commonly reported large cetacean in the region (Calambokidis and Chandler. 2000; Calambokidis et al. 2004; Dohl 1983; Green et al. 1992b). Off Washington State, humpback whales 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, in the Blanco upwelling zone, and near Swiftsure Bank (Calambokidis et al. 2004). Humpback whales also tend to congregate near Heceta Bank off the coast of Oregon (Green et al. 1992b). Additional data suggest that further subdivisions in feeding groups may exist, with up to six feeding groups present between Kamchatka and southern California (Witteveen et al. 2009).

Humpback whales primarily feed along the shelf break and continental slope (Green et al. 1992b; Tynan et al. 2005). Although humpback whales were common in inland Washington State waters in the early 1900s, severe hunting throughout the eastern North Pacific has diminished their numbers and few recent inshore sightings have been made (Calambokidis et al. 1990; Scheffer and Slipp 1948).

Historically, humpback whales occurred in Puget Sound. Since the 1970s, however, humpback whales have become rare within Puget Sound, although at least five humpback whales have been observed in Puget Sound since 1976 (Calambokidis et al. 1990; Calambokidis et al. 2004; Osborne et al. 1988). Because of their contemporary rarity in Puget Sound, we assume that humpback whales would not be exposed to Navy training activities within the Sound itself, but would be exposed in waters offshore of Washington.

Although humpback whales no longer appear to occur regularly in Puget Sound, they have consistently been more common than any other large cetacean observed off the coast of Washington State for more than a decade (Calambokidis et al. 2009b; Calambokidis et al. 2004; Forney 2007). Humpback whales occur in those waters seasonally from May through November, becoming fairly common beginning in July, and reaching peak densities from August to September with density declining substantially from September onward (Calambokidis 1997; Calambokidis and Chandler. 2000; Calambokidis et al. 2001; Calambokidis et al. 1997; Green et

al. 1992b). During that time interval, humpback whales have been reported in coastal waters, on the continental shelf, and the continental slope, with concentrations occurring in steep slope water near Grays, Astoria, and Nitinat canyons (Forney 2007; Green et al. 1992b).

Several authors have reported that humpback whales do not occur off the coasts of Washington and Oregon in the winter (Green et al. 1992b). However, Shelden et al. (Shelden et al. 2000) reported observations of humpback whales north and south of Juan de Fuca canyon (off northern Washington) in late December. These authors also reported that humpback whales were common in Georgia Strait during the winter in the early 1900s and they suggested that, as their population increases, humpback whales might be re-occupying areas they had previously abandoned after their populations were decimated by whalers; these authors also allowed that humpback whales might remain in waters off Washington when their prey is abundant late in the year.

4.2.3.3 **Natural Threats**

Natural sources and rates of mortality of humpback whales are not well known. Based upon prevalence of tooth marks, attacks by killer whales appear to be highest among humpback whales migrating between Mexico and California, although populations throughout the Pacific Ocean appear to be targeted to some degree (Steiger et al. 2008). Juveniles appear to be the primary age group targeted. Humpback whales engage in grouping behavior, flailing tails, and rolling extensively to fight off attacks. Calves remain protected near mothers or within a group and lone calves have been known to be protected by presumably unrelated adults when confronted with attack (Ford and Reeves 2008).

Parasites and biotoxins from red-tide blooms are other potential causes of mortality (Perry et al. 1999a). The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in humpback whales and may be preventing some populations from recovering (Lambertsen 1992). Studies of 14 humpback whales that stranded along Cape Cod between November 1987 and January 1988 indicate they apparently died from a toxin produced by dinoflagellates during this period.

4.2.3.4 **Anthropogenic Threats**

Three human activities are known to threaten humpback whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of whales and was ultimately responsible for listing several species as endangered.

Humpback whales are also killed or injured during interactions with commercial fishing gear. Like fin whales, humpback whales have been entangled by fishing gear off Newfoundland and Labrador, Canada. A total of 595 humpback whales were reported captured in coastal fisheries in those two provinces between 1969 and 1990, of which 94 died (Lien 1994; Perkins and Beamish 1979). Along the Atlantic coast of the U.S. and the Maritime Provinces of Canada, there were

160 reports of humpback whales being entangled in fishing gear between 1999 and 2005 (Cole et al. 2005; Nelson et al. 2007). Of these, 95 entangled humpback whales were confirmed, with 11 whales sustaining injuries and nine dying of their wounds. NMFS estimates that between 2002 and 2006, there were incidental serious injuries to 0.2 humpback annually in the Bering Sea/Aleutian Islands sablefish longline fishery. However, NMFS does not consider this estimation reliable because observers have not been assigned to a number of fisheries known to interact with the Central and Western North Pacific stocks of humpback whale. In addition, the Canadian observation program is also limited and uncertain (Angliss and Allen 2009).

More humpback whales are killed in collisions with ships than any other whale species except fin whales (Jensen and Silber 2003). Along the Pacific coast, a humpback whale is known to be killed about every other year by ship strikes (Barlow et al. 1997). Of 123 humpback whales that stranded along the Atlantic coast of the U.S. between 1975 and 1996, 10 (8.1 percent) showed evidence of collisions with ships (Laist et al. 2001). Between 1999 and 2005, there were 18 reports of humpback whales being struck by vessels along the Atlantic coast of the U.S. and the Maritime Provinces of Canada (Cole et al. 2005; Nelson et al. 2007). Of these reports, 13 were confirmed as ship strikes and in seven cases, ship strike was determined to be the cause of death. In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship strike appear to be largely ignored (Vanderlaan et al. 2008). However, new rules for seasonal (June through December) slowing of vessel traffic to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are expected to reduce the chance of humpback whales being hit by ships by 9 percent.

Organochlorines, including PCB and DDT, have been identified from humpback whale blubber (Gauthier et al. 1997). Higher PCB levels have been observed in Atlantic waters versus Pacific waters along the United States and levels tend to increase with individual age (Elfes et al. 2010). Although humpback whales in the Gulf of Maine and off Southern California tend to have the highest PCB concentrations, overall levels are on par with other baleen whales, which are generally lower than odontocete cetaceans (Elfes et al. 2010). As with blue whales, these contaminants are transferred to young through the placenta, leaving newborns with contaminant loads equal to that of mothers before bioaccumulating additional contaminants during life and passing the additional burden to the next generation (Metcalfe et al. 2004). Contaminant levels are relatively high in humpback whales as compared to blue whales. Humpback whales feed higher on the food chain, where prey carry higher contaminant loads than the krill that blue whales feed on.

4.2.3.5 **Status and Trends**

Humpback whales were originally listed as endangered in 1970 (35 FR 18319), and this status remains under the ESA.

In the North Pacific the pre-exploitation population size may have been as many as 15,000 humpback whales, and current estimates are 6,000-8,000 whales (Calambokidis et al. 2009b; Rice 1978). It is estimated that 15,000 humpback whales resided in the North Pacific in 1905 (Rice 1978). However, from 1905 to 1965, nearly 28,000 humpback whales were harvested in whaling operations, reducing the number of all North Pacific humpback whale to roughly 1,000 (Perry et al. 1999a). Population estimates have risen over time from 1,407-2,100 in the 1980s to 6,010 in 1997 (Baker 1985; Baker and Herman 1987; Calambokidis et al. 1997; Darling and Morowitz 1986). Based on surveys between 2004 and 2006, Calambokidis et al. (2008a) estimated that the number of humpback whales in the North Pacific consisted of about 18,300 whales, not counting calves. Because estimates vary by methodology, they are not directly comparable and it is not clear which of these estimates is more accurate or if the change from 1,407 to 18,300 is the result of a real increase or an artifact of model assumptions. Tentative estimates of the eastern North Pacific stock suggest an increase of 6-7 percent annually, but fluctuations have included negative growth in the recent past (Angliss and Outlaw 2005).

4.2.3.6 **Diving**

Maximum diving depths are approximately 170 m, with a very deep dive (240 m) recorded off Bermuda (Hamilton et al. 1997). Dives can last for up to 21 min, although feeding dives ranged from 2.1-5.1 min in the north Atlantic (Dolphin 1987). In southeast Alaska, average dive times were 2.8 min for feeding whales, 3.0 min for non-feeding whales, and 4.3 min for resting whales (Dolphin 1987). Because most humpback prey is likely found within 300 m of the surface, most humpback dives are probably relatively shallow. In Alaska, capelin are the primary prey of humpback and are found primarily between 92 and 120 m; depths to which humpbacks apparently dive for foraging (Witteveen et al. 2008).

4.2.3.7 **Social Behavior**

During the feeding season, humpback whales form small groups that occasionally aggregate on concentrations of food that may be stable for long-periods of times. Humpbacks use a wide variety of behaviors to feed on various small, schooling prey including krill and fish (Hain et al. 1982; Hain et al. 1995; Jurasz and Jurasz 1979; Weinrich et al. 1992). There is good evidence of some territoriality on feeding and calving areas (Clapham 1994; Clapham 1996; Tyack 1981). Humpback whales are generally believed to fast while migrating and on breeding grounds, but some individuals apparently feed while in low-latitude waters normally believed to be used exclusively for reproduction and calf-rearing (Danilewicz et al. 2009; Pinto De Sa Alves et al. 2009). Some individuals, such as juveniles, may not undertake migrations at all (Findlay and Best 1995).

Humpback whales feed on pelagic schooling euphausiids and small fish including capelin, herring and mackerel. Like other large mysticetes, they are a "lunge feeder" taking advantage of dense prey patches and engulfing as much food as possible in a single gulp. They also blow nets,

or curtains, of bubbles around or below prey patches to concentrate the prey in one area, then lunge with open mouths through the middle. Dives appear to be closely correlated with the depths of prey patches, which vary from location to location. In the north Pacific (southeast Alaska), most dives were of fairly short duration (<4 min) with the deepest dive to 148 m (Dolphin 1987), while whales observed feeding on Stellwagen Bank in the North Atlantic dove to <40 m (Hain et al. 1995). Hamilton et al. (1997) tracked one possibly feeding whale near Bermuda to 240 m depth.

4.2.3.8 **Vocalization and Hearing**

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz to 4 kHz with estimated source levels from 144-174 dB (Au et al. 2006; Au et al. 2000; Frazer and Mercado III 2000; Richardson et al. 1995b; Winn et al. 1970). Males also produce sounds associated with aggression, which are generally characterized as frequencies between 50 Hz to 10 kHz and having most energy below 3 kHz (Silber 1986; Tyack 1983a). Such sounds can be heard up to 9 km away (Tyack 1983a). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also produced in breeding areas (Richardson et al. 1995b; Tyack 1983a). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25-89 Hz), and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz) which can be very loud (175-192 dB re 1 μPa at 1 m; (Au et al. 2000; Erbe 2002a; Payne 1985; Richardson et al. 1995b; Thompson et al. 1986). However, humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995b).

4.2.3.9 **Critical Habitat**

NMFS has not designated critical habitat for humpback whales.

4.2.4 Sei Whale

Sei whales (pronounced "say" or "sigh"; *Balaenoptera borealis*) are members of the baleen whale family and are considered one of the "great whales" or rorquals. Two subspecies of sei whales are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere.

These large animals can reach lengths of about 40-60 ft (12-18 m) and weigh 100,000 lbs (45,000 kg). Females may be slightly longer than males. Sei whales have a long, sleek body that is dark bluish-gray to black in color and pale underneath. The body is often covered in oval-shaped scars (probably caused from cookie-cutter shark and lamprey bites) and sometimes has subtle "mottling". This species has an erect "falcate", "dorsal" fin located far down (about two-thirds) the animals back. They often look similar in appearance to Bryde's whales, but can be distinguished by the presence of a single ridge located on the animal's "rostrum". Bryde's whales,

unlike other rorquals, have three distinct prominent longitudinal ridges on their rostrum. Sei whales have 219-410 baleen plates that are dark in color with gray/white fine inner fringes in their enormous mouths. They also have 30-65 relatively short ventral pleats that extend from below the mouth to the naval area. The number of throat grooves and baleen plates may differ depending on geographic population.

The Sei is regarded as the fastest swimmer among the great whales, reaching bursts of speed in excess of 20 knots. When a sei whale begins a dive it usually submerges by sinking quietly below the surface, often remaining only a few meters deep, leaving a series of swirls or tracks as it move its flukes. When at the water's surface, sei whales can be sighted by a columnar or bushy blow that is about 10-13 feet (3-4 m) in height. The dorsal fin usually appears at the same time as the blowhole, when the animal surfaces to breathe. This species usually does not arch its back or raise its flukes when diving.

Sei whales become sexually mature at 6-12 years of age when they reach about 45 ft (13 m) in length, and generally mate and give birth during the winter in lower latitudes. Females breed every 2-3 years, with a gestation period of 11-13 months. Females give birth to a single calf that is about 15 ft (4.6 m) long and weighs about 1,500 lbs (680 kg). Calves are usually nursed for 6-9 months before being weaned on the preferred feeding grounds. Sei whales have an estimated lifespan of 50-70 years.

4.2.4.1 **Distribution**

The sei whale occurs in all oceans of the world except the Arctic. The migratory pattern of this species is thought to encompass long distances from high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999a). Sei whales are often associated with deeper waters and areas along continental shelf edges (Hain et al. 1985). This general offshore pattern is disrupted during occasional incursions into shallower inshore waters (Waring et al. 2004). The species appears to lack a well-defined social structure and individuals are usually found alone or in small groups of up to six whales (Perry et al. 1999a). When on feeding grounds, larger groupings have been observed (Gambell 1985b).

In the western Atlantic Ocean, sei whales occur from Nova Scotia and Labrador in the summer months and migrate south to Florida, the Gulf of Mexico, and the northern Caribbean (Gambell 1985b). In the eastern Atlantic Ocean, sei whales occur in the Norwegian Sea (as far north as Finnmark in northeastern Norway), occasionally occurring as far north as Spitsbergen Island, and migrate south to Spain, Portugal, and northwest Africa (Gambell 1985b).

In the North Pacific Ocean, sei whales occur from the Bering Sea south to California (on the east) and the coasts of Japan and Korea (on the west). During the winter, sei whales are found from 20°-23°N (Gambell 1985b; Masaki 1977).

Sei whales occur throughout the Southern Ocean during the summer months, although they do not migrate as far south to feed as blue or fin whales. During the austral winter, sei whales occur off Brazil and the western and eastern coasts of Southern Africa and Australia.

4.2.4.2 **Population Structure**

The population structure of sei whales is not well defined, but presumed to be discrete by ocean basin (north and south), except for sei whales in the Southern Ocean, which may form a ubiquitous population or several discrete ones.

North Pacific. Some mark-recapture, catch distribution, and morphological research indicate more than one population may exist – one between 155°-175° W, and another east of 155° W (Masaki 1976; Masaki 1977). Sei whales have been reported primarily south of the Aleutian Islands, in Shelikof Strait and waters surrounding Kodiak Island, in the Gulf of Alaska, and inside waters of southeast Alaska and south to California to the east and Japan and Korea to the west (Leatherwood et al. 1982b; Nasu 1974). Sightings have also occurred in Hawaiian waters (Smultea et al. 2010). Sei whales have been occasionally reported from the Bering Sea and in low numbers on the central Bering Sea shelf (Hill and DeMaster 1998). Whaling data suggest that sei whales do not venture north of about 55°N (Gregr et al. 2000). Masaki (1977) reported sei whales concentrating in the northern and western Bering Sea from July-September, although other researchers question these observations because no other surveys have reported sei whales in the northern and western Bering Sea. Harwood (1987) evaluated Japanese sighting data and concluded that sei whales rarely occur in the Bering Sea. Harwood (1987) reported that 75-85 percent of the North Pacific population resides east of 180°. During winter, sei whales are found from 20°-23° N (Gambell 1985b; Masaki 1977). Considering the many British Columbia whaling catches in the early to mid-1900s, sei whales have clearly utilized this area in the past (Gregr et al. 2000; Pike and Macaskie 1969).

Sei whales appear to prefer to forage in regions of steep bathymetric relief, such as continental shelf breaks, canyons, or basins situated between banks and ledges (Best and Lockyer 2002; Gregr and Trites 2001; Kenney and Winn 1987), where local hydrographic features appear to help concentrate zooplankton, especially copepods. In their foraging areas, sei whales appear to associate with oceanic frontal systems (Horwood 1987). In the north Pacific, sei whales are found feeding particularly along the cold eastern currents (Perry et al. 1999a).

In the early to mid-1900s, sei whales were hunted off the coast of British Columbia (Gregr et al. 2000; Pike and Macaskie 1969). Masaki (1977) presented sightings data on sei whales in the

North Pacific from the mid-1960s to the early 1970s. Over that time interval sei whales did not appear to occur in waters of Washington State and southern British Columbia in May or June, their densities increased in those waters in July and August (1.9 - 2.4 and 0.7 - 0.9 whales per 100 miles of distance for July and August, respectively), then declined again in September. More recently, sei whales have become known for an irruptive migratory habit in which they appear in an area then disappear for time periods that can extend to decades. Based on a sei whale that stranded near Port Angeles and the sei whales observed by Forney and her co-workers (Forney 2007), we know that these whales still occur in waters off Washington, Oregon, and northern California.

4.2.4.3 **Natural Threats**

The foraging areas of right and sei whales in the western North Atlantic Ocean overlap and both whales feed preferentially on copepods (Mitchell 1975).

Andrews (1916) suggested that killer whales attacked sei whales less frequently than fin and blue whales in the same areas. Sei whales engage in a flight responses to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Endoparasitic helminths (worms) are commonly found in sei whales and can result in pathogenic effects when infestations occur in the liver and kidneys (Rice 1977).

4.2.4.4 **Anthropogenic Threats**

Human activities known to threaten sei whales include whaling, commercial fishing, and maritime vessel traffic. Historically, whaling represented the greatest threat to every population of sei whales and was ultimately responsible for listing sei whales as an endangered species. Sei whales are thought to not be widely hunted, although harvest for scientific whaling or illegal harvesting may occur in some areas.

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-U.S. 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 1980s. 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).

The offshore drift gillnet fishery is the only fishery that is likely to "take" sei whales from this stock, but no fishery mortalities or serious injuries to sei whales have been observed. 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.

Sei whales are occasionally killed in collisions with vessels. Of three sei whales that stranded along the U.S. Atlantic coast between 1975 and 1996, two showed evidence of collisions (Laist et al. 2001). Between 1999 and 2005, there were three reports of sei whales being struck by vessels along the U.S. Atlantic coast and Canada's Maritime Provinces (Cole et al. 2005; Nelson et al. 2007). Two of these ship strikes were reported as having resulted in death. One sei whale was killed in a collision with a vessel off the coast of Washington in 2003 (Waring et al. 2009). New rules for seasonal (June through December) slowing of vessel traffic in the Bay of Fundy to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are predicted to reduce sei whale ship strike mortality by 17 percent.

Sei whales are known to accumulate DDT, DDE, and PCBs (Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983). Males carry larger burdens than females, as gestation and lactation transfer these toxins from mother to offspring.

4.2.4.5 **Status and Trends**

The sei whale was originally listed as endangered in 1970 (35 FR 18319), and this status remained since the inception of the ESA in 1973.

Ohsumi and Fukuda (1975) estimated that sei whales in the North Pacific numbered about 49,000 whales in 1963, had been reduced to 37,000-38,000 whales by 1967, and reduced again to 20,600-23,700 whales by 1973. From 1910-1975, approximately 74,215 sei whales were caught in the entire North Pacific Ocean (Harwood and Hembree. 1987; Perry et al. 1999a). From the early 1900s, Japanese whaling operations consisted of a large proportion of sei whales: 300-600 sei whales were killed per year from 1911-1955. The sei whale catch peaked in 1959, when 1,340 sei whales were killed. In 1971, after a decade of high sei whale catch numbers, sei whales were scarce in Japanese waters. Japanese and Soviet catches of sei whales in the North Pacific and Bering Sea increased from 260 whales in 1962 to over 4,500 in 1968-1969, after which the sei whale population declined rapidly (Mizroch et al. 1984). When commercial whaling for sei whales ended in 1974, the population in the North Pacific had been reduced to 7,260-12,620 animals (Tillman 1977). There have been no direct estimates of sei whale populations for the eastern Pacific Ocean (or the entire Pacific). Between 1991 and 2001, during aerial surveys, there were two confirmed sightings of sei whales along the U.S. Pacific coast.

Sei whales are known to occur in the Gulf of Alaska and as far north as the Bering Sea in the north Pacific. However, their distribution is poorly understood. The only stock estimate for U.S. waters is for the eastern north Pacific stock offshore California, Oregon and Washington (Carretta et al. 2009); abundance in Alaskan waters is unknown and they have not been sighted during recent surveys (Rone et al. 2010; Waite et al. 2003).

4.2.4.6 **Diving**

Generally, sei whales make 5-20 shallow dives of 20-30 sec duration followed by a deep dive of up to 15 min (Gambell 1985b). The depths of sei whale dives have not been studied; however the composition of their diet suggests that they do not perform dives in excess of 300 meters. Sei whales are usually found in small groups of up to 6 individuals, but they commonly form larger groupings when they are on feeding grounds (Gambell 1985b).

4.2.4.7 **Social Behavior**

Sei whales are primarily planktivorous, feeding mainly on euphausiids and copepods, although they are also known to consume fish (Waring et al. 2007). In the Northern Hemisphere, sei whales consume small schooling fish such as anchovies, sardines, and mackerel when locally abundant (Mizroch et al. 1984; Rice 1977). Sei whales in the North Pacific feed on euphausiids and copepods, which make up about 95 percent of their diets (Calkins 1986). The dominant food for sei whales off California during June-August is northern anchovy, while in September-October whales feed primarily on krill (Rice 1977). The balance of their diet consists of squid and schooling fish, including smelt, sand lance, Arctic cod, rockfish, pollack, capelin, and Atka mackerel (Nemoto and Kawamura 1977). In the Southern Ocean, analysis of stomach contents indicates sei whales consume Calanus spp. and small-sized euphasiids with prey composition showing latitudinal trends (Kawamura 1974). Evidence indicates that sei whales in the Southern Hemisphere reduce direct interspecific competition with blue and fin whales by consuming a wider variety of prey and by arriving later to feeding grounds (Kirkwood 1992). Rice (1977) suggested that the diverse diet of sei whales may allow them greater opportunity to take advantage of variable prey resources, but may also increase their potential for competition with commercial fisheries.

Little is known about the actual social system of these animals. Groups of 2-5 individuals are typically observed, but sometimes thousands may gather if food is abundant. However, these large aggregations may not be dependent on food supply alone, as they often occur during times of migration. Norwegian workers call the times of great sei whale abundance "invasion years." During mating season, males and females may form a social unit, but strong data on this issue are lacking.

4.2.4.8 **Vocalization and Hearing**

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100-600 Hz range with 1.5 s duration and tonal and upsweep calls in the 200-600 Hz range of 1-3 s durations (McDonald et al. 2005). Differences may exist in vocalizations between ocean basins (Rankin et al. 2009). Vocalizations from the North Atlantic consisted of paired sequences (0.5-0.8 sec, separated by 0.4-1.0 sec) of 10-20 short (4 msec) FM sweeps between 1.5-3.5 kHz (Richardson et al. 1995b).

A general description of the anatomy of the ear for cetaceans is provided in the description of the blue whale.

4.2.4.9 **Critical Habitat**

The NMFS has not designated critical habitat for sei whales.

4.2.5 Sperm Whale

Sperm whales (*Physeter macrocephalus*) are the largest of the odontocetes (toothed whales) and the most sexually dimorphic cetaceans, with males considerably larger than females. Adult females may grow to lengths of 36 feet (11 m) and weigh 15 tons (13,607 kg). Adult males, however, reach about 52 feet (16 m) and may weigh as much as 45 tons (40,823 kg).

The sperm whale is distinguished by its extremely large head, which takes up to 25 to 35 percent of its total body length. It is the only living cetacean that has a single blowhole asymmetrically situated on the left side of the head near the tip. Sperm whales have the largest brain of any animal (on average 17 pounds (7.8 kg) in mature males), however, compared to their large body size, the brain is not exceptional in size.

There are between 20-26 large conical teeth in each side of the lower jaw. The teeth in the upper jaw rarely erupt and are often considered to be vestigial. It appears that teeth may not be necessary for feeding, since they do not break through the gums until puberty, if at all, and healthy sperm whales have been caught that have no teeth.

Sperm whales are mostly dark gray, but oftentimes the interior of the mouth is bright white, and some whales have white patches on the belly. Their flippers are paddle-shaped and small compared to the size of the body, and their flukes are very triangular in shape. They have small dorsal fins that are low, thick, and usually rounded.

4.2.5.1 **Distribution**

Sperm whales are distributed in all of the world's oceans, from equatorial to polar waters, and are highly migratory. Mature males range between 70º N in the North Atlantic and 70º S in the Southern Ocean (Perry et al. 1999a; Reeves and Whitehead 1997), whereas mature females and immature individuals of both sexes are seldom found higher than 50º N or S (Reeves and

Whitehead 1997). In winter, sperm whales migrate closer to equatorial waters (Kasuya and Miyashita 1988; Waring 1993) where adult males join them to breed.

4.2.5.2 **Population Structure**

There is no clear understanding of the global population structure of sperm whales (Dufault et al. 1999). Recent ocean-wide genetic studies indicate low, but statistically significant, genetic diversity and no clear geographic structure, but strong differentiation between social groups (Lyrholm and Gyllensten 1998; Lyrholm et al. 1996; Lyrholm et al. 1999). The IWC currently recognizes four sperm whale stocks: North Atlantic, North Pacific, northern Indian Ocean, and Southern Hemisphere (Dufault et al. 1999; Reeves and Whitehead 1997). The NMFS recognizes six stocks under the MMPA- three in the Atlantic/Gulf of Mexico and three in the Pacific (Alaska, California-Oregon-Washington, and Hawai′i; (Perry et al. 1999b; Waring et al. 2004). Genetic studies indicate that movements of both sexes through expanses of ocean basins are common, and that males, but not females, often breed in different ocean basins than the ones in which they were born (Whitehead 2003). Sperm whale populations appear to be structured socially, at the level of the clan, rather than geographically (Whitehead 2003; Whitehead 2008).

Sperm whales are found throughout the North Pacific and are distributed broadly in tropical and temperate waters to the Bering Sea as far north as Cape Navarin in summer, and occur south of 40° N in winter (Gosho et al. 1984; Miyashita et al. 1995 as cited in Carretta et al. 2005; Rice 1974). Sperm whales are found year-round in Californian and Hawaiian waters (Barlow 1995; Dohl 1983; Forney et al. 1995; Shallenberger 1981). They are seen in every season except winter (December-February) in Washington and Oregon (Green et al. 1992b). Summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993). Summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993).

Sperm whales are seasonal migrants to waters off the coast of Washington and Oregon where their densities are highest during spring and summer; they do not appear to occur in these waters during the winter. Sperm whales also tend to occur in the deeper water at the western edge of the action area. In surveys of waters off Oregon and Washington conducted by Green et al. (1992b), no sperm whales were encountered in waters less than 200 meters deep, 12 percent of the sperm whales were encountered in waters 200 to 2000 meters deep (the continental slope), and the remaining 88 percent of the sperm whales were encountered in waters greater than 2,000 meters deep. In surveys conducted by Forney and her co-workers (Forney 2007), sperm whales were reported from the Olympic Coast Slope transects (west of the Olympic Coast National Marine Sanctuary), but not from surveys conducted over the National Marine Sanctuary or the area immediately west of Cape Flattery.

4.2.5.3 **Natural Threats**

Sperm whales are known to be occasionally predated upon by killer whales (Jefferson et al. 1991; Pitman et al. 2001) by pilot whales (Arnbom et al. 1987; Palacios and Mate 1996; Rice 1989; Weller et al. 1996; Whitehead et al. 1997) and large sharks (Best et al. 1984) and harassed by pilot whales (Arnbom et al. 1987; Palacios and Mate 1996; Rice 1989; Weller et al. 1996; Whitehead et al. 1997). Strandings are also relatively common events, with one to dozens of individuals generally beaching themselves and dying during any single event. Although several hypotheses, such as navigation errors, illness, and anthropogenic stressors, have been proposed (Goold et al. 2002; Wright 2005), direct widespread causes remain unclear. Calcivirus and papillomavirus are known pathogens of this species (Lambertsen et al. 1987; Smith and Latham 1978).

4.2.5.4 **Anthropogenic Threats**

Sperm whales historically faced severe depletion from commercial whaling operations. From 1800 to 1900, the IWC estimated that nearly 250,000 sperm whales were killed by whalers, with another 700,000 from 1910 to 1982 (IWC Statistics 1959-1983). However, other estimates have included 436,000 individuals killed between 1800-1987 (Carretta et al. 2005). However, all of these estimates are likely underestimates due to illegal killings and inaccurate reporting by Soviet whaling fleets between 1947 and 1973. In the Southern Hemisphere, these whalers killed an estimated 100,000 whales that they did not report to the IWC (Yablokov et al. 1998), with smaller harvests in the Northern Hemisphere, primarily the North Pacific, that extirpated sperm whales from large areas (Yablokov 2000). Additionally, Soviet whalers disproportionately killed adult females in any reproductive condition (pregnant or lactating) as well as immature sperm whales of either gender.

Following a moratorium on whaling by the IWC, significant whaling pressures on sperm whales were eliminated. However, sperm whales are known to have become entangled in commercial fishing gear and 17 individuals are known to have been struck by vessels (Jensen and Silber 2004). Whale-watching vessels are known to influence sperm whale behavior (Richter et al. 2006).

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).

Interactions between sperm whales and longline fisheries in the Gulf of Alaska have been reported since 1995 and are increasing in frequency (Hill and DeMaster 1998; Hill et al. 1999; Rice 1989). Between 2002 and 2006, there were three observed serious injuries (considered mortalities) to sperm whales in the Gulf of Alaska from the sablefish longline fishery (Angliss and Outlaw 2008). Sperm whales have also been observed in Gulf of Alaska feeding off longline

gear (for sablefish and halibut) at 38 of the surveyed stations (Angliss and Outlaw 2008). Recent findings suggest sperm whales in Alaska may have learned that fishing vessel propeller cavitation (as gear is retrieved) are an indicator that longline gear with fish is present as a predation opportunity (Thode et al. 2007).

Contaminants have been identified in sperm whales, but vary widely in concentration based upon life history and geographic location, with northern hemisphere individuals generally carrying higher burdens (Evans et al. 2004). Contaminants include dieldrin, chlordane, DDT, DDE, PCBs, HCB and HCHs in a variety of body tissues (Aguilar 1983; Evans et al. 2004), as well as several heavy metals (Law et al. 1996). However, unlike other marine mammals, females appear to bioaccumulate toxins at greater levels than males, which may be related to possible dietary differences between females who remain at relatively low latitudes compared to more migratory males (Aguilar 1983; Wise et al. 2009). Chromium levels from sperm whales skin samples worldwide have varied from undetectable to 122.6 µg Cr/g tissue, with the mean (8.8 µg Cr/g tissue) resembling levels found in human lung tissue with chromium-induced cancer (Wise et al. 2009). Older or larger individuals did not appear to accumulate chromium at higher levels.

4.2.5.5 **Status and Trends**

Sperm whales were originally listed as endangered in 1970 (35 FR 18319), and this status remained with the inception of the ESA in 1973. Although population structure of sperm whales is unknown, several studies and estimates of abundance are available. Sperm whale populations probably are undergoing the dynamics of small population sizes, which is a threat in and of itself. In particular, the loss of sperm whales to directed Soviet whaling likely inhibits recovery due to the loss of adult females and their calves, leaving sizeable gaps in demographic and age structuring (Whitehead and Mesnick 2003).

There are approximately 76,803 sperm whales in the eastern tropical Pacific, eastern North Pacific, Hawai′i, and western North Pacific (Whitehead 2002a). Minimum estimates in the eastern North Pacific are 1,719 individuals and 5,531 in the Hawaiian Islands (Carretta et al. 2007). The tropical Pacific is home to approximately 26,053 sperm whales and the western North Pacific has approximately 29,674 (Whitehead 2002a). There was a dramatic decline in the number of females around the Galapagos Islands during 1985-1999 versus 1978-1992 levels, likely due to migration to nearshore waters of South and Central America (Whitehead and Mesnick 2003).

Hill and DeMaster (1999) concluded that about 258,000 sperm whales were harvested in the North Pacific between 1947-1987. Although the IWC protected sperm whales from commercial harvest in 1981, Japanese whalers continued to hunt sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). In 2000, the Japanese Whaling Association announced plans to kill 10 sperm whales in the Pacific Ocean for research. Although consequences of these deaths

are unclear, the paucity of population data, uncertainty regarding recovery from whaling, and re-establishment of active programs for whale harvesting pose risks for the recovery and survival of this species. Sperm whales are also hunted for subsistence purposes by whalers from Lamalera, Indonesia, where a traditional whaling industry has been reported to kill up to 56 sperm whales per year.

4.2.5.6 **Diving**

Sperm whales are probably the deepest and longest diving mammalian species, with dives to 3 km down and durations in excess of 2 hours (Clarke 1976; Watkins 1985; Watkins et al. 1993). However, dives are generally shorter (25- 45 min) and shallower (400-1,000 m). Dives are separated by 8-11 min rests at the surface (Gordon 1987; Watwood et al. 2006) (Jochens et al. 2006; Papastavrou et al. 1989). Sperm whales typically travel ~3 km horizontally and 0.5 km vertically during a foraging dive (Whitehead 2003). Differences in night and day diving patterns are not known for this species, but, like most diving air-breathers for which there are data (rorquals, fur seals, and chinstrap penguins), sperm whales probably make relatively shallow dives at night when prey are closer to the surface.

Unlike other cetaceans, there is a preponderance of dive information for this species, most likely because it is the deepest diver of all cetacean species so generates a lot of interest. Sperm whales feed on large and medium-sized squid, octopus, rays and sharks, on or near the ocean floor (Clarke 1986; Whitehead 2002b). Some evidence suggests that they do not always dive to the bottom of the sea floor (likely if food is elsewhere in the water column), but that they do generally feed at the bottom of the dive. Davis et al. (2007) report that dive-depths (100-500 m) of sperm whales in the Gulf of California overlapped with depth distributions (200-400 m) of jumbo squid, based on data from satellite-linked dive recorders placed on both species, particularly during daytime hours. Their research also showed that sperm whales foraged throughout a 24-hour period, and that they rarely dove to the sea floor bottom (>1000 m). The most consistent sperm whale dive type is U-shaped, during which the whale makes a rapid descent to the bottom of the dive, forages at various velocities while at depth (likely while chasing prey) and then ascends rapidly to the surface. There is some evidence that male sperm whales, feeding at higher latitudes during summer months, may forage at several depths including <200 m, and utilize different strategies depending on position in the water column (Teloni et al. 2007).

4.2.5.7 **Social Behavior**

Movement patterns of Pacific female and immature male groups appear to follow prey distribution and, although not random, movements are difficult to anticipate and are likely associated with feeding success, perception of the environment, and memory of optimal foraging areas (Whitehead 2008). However, no sperm whale in the Pacific has been known to travel to points over 5,000 km apart and only rarely have been known to move over 4,000 km within a

time frame of several years. This means that although sperm whales do not appear to cross from eastern to western sides of the Pacific (or vice-versa), significant mixing occurs that can maintain genetic exchange. Movements of several hundred miles are common, (i.e. between the Galapagos Islands and the Pacific coastal Americas). Movements appear to be group or clan specific, with some groups traveling straighter courses than others over the course of several days. However, general transit speed averages about 4 km/h. Sperm whales in the Caribbean region appear to be much more restricted in their movements, with individuals repeatedly sighted within less than 160 km of previous sightings.

Gaskin (1973) proposed a northward population shift of sperm whales off New Zealand in the austral autumn based on reduction of available food species and probable temperature tolerances of calves.

Sperm whales have a strong preference for waters deeper than 1,000 m (Reeves and Whitehead 1997; Watkins and Schevill 1977), although Berzin (1971) reported that they are restricted to waters deeper than 300 m. While deep water is their typical habitat, sperm whales are rarely found in waters less than 300 m in depth (Clarke 1956; Rice 1989). Sperm whales have been observed near Long Island, New York, in water between 40-55 m deep (Scott and Sadove 1997). When they are found relatively close to shore, sperm whales are usually associated with sharp increases in topography where upwelling occurs and biological production is high, implying the presence of a good food supply (Clarke 1956). Such areas include oceanic islands and along the outer continental shelf.

Sperm whales are frequently found in locations of high productivity due to upwelling or steep underwater topography, such as continental slopes, seamounts, or canyon features (Jaquet 1996; Jaquet and Whitehead 1996). Cold-core eddy features are also attractive to sperm whales in the Gulf of Mexico, likely because of the large numbers of squid that are drawn to the high concentrations of plankton associated with these features (Biggs et al. 2000; Davis et al. 2000; Davis et al. 2002). Surface waters with sharp horizontal thermal gradients, such as along the Gulf Stream in the Atlantic, may also be temporary feeding areas for sperm whales (Griffin 1999; Jaquet and Whitehead 1996; Waring et al. 1993). Sperm whales over George's Bank were associated with surface temperatures of 23.2-24.9°C (Waring et al. 2004).

Local information is inconsistent regarding sperm whale tendencies. Gregr and Trites (2001) reported that female sperm whales off British Columbia were relatively unaffected by the surrounding oceanography. However, Tynan et al. (2005) reported increased sperm whales densities with strong turbulence associated topographic features along the continental slope near Heceta Bank. Two noteworthy strandings in the region include an infamous incident (well publicized by the media) of attempts to dispose of a decomposed sperm whale carcass on an

Oregon beach by using explosives. In addition, a mass stranding of 47 individuals in Oregon occurred during June 1979 (Norman et al. 2004a; Rice et al. 1986).

Stable, long-term associations among females form the core of sperm whale societies (Christal et al. 1998). Up to about a dozen females usually live in such groups, accompanied by their female and young male offspring. Young individuals are subject to alloparental care by members of either sex and may be suckled by non-maternal individuals (Gero et al. 2009). Group sizes may be smaller overall in the Caribbean Sea (6-12 individuals) versus the Pacific (25-30 individuals) (Jaquet and Gendron 2009). Males start leaving these family groups at about 6 years of age, after which they live in "bachelor schools," but this may occur more than a decade later (Pinela et al. 2009). The cohesion among males within a bachelor school declines with age. During their breeding prime and old age, male sperm whales are essentially solitary (Christal and Whitehead 1997).

4.2.5.8 **Vocalization and Hearing**

Sound production and reception by sperm whales are better understood than in most cetaceans. Sperm whales produce broad-band clicks in the frequency range of 100 Hz to 20 kHz that can be extremely loud for a biological source (200-236 dB re 1μPa), although lower source level energy has been suggested at around 171 dB re 1 μPa (Goold and Jones 1995; Madsen et al. 2003; Weilgart and Whitehead 1997; Weilgart et al. 1993). Most of the energy in sperm whale clicks is concentrated at around 2-4 kHz and 10-16 kHz (Goold and Jones 1995; NMFS 2006a; Weilgart et al. 1993). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Cranford 1992; Norris and Harvey 1972). These long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). However, clicks are also used in short patterns (codas) during social behavior and intra-group interactions (Weilgart et al. 1993). They may also aid in intra-specific communication. Another class of sound, "squeals", are produced with frequencies of 100 Hz to 20 kHz (e.g., Weir et al. 2007).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway. 1990). From this whale, responses support a hearing range of 2.5-60 kHz. However, behavioral responses of adult, free-ranging individuals also provide insight into hearing range; sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low-frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999b).

4.2.5.9 **Critical Habitat**

NMFS has not designated critical habitat for sperm whales.

4.2.6 Southern Resident Killer Whale

Killer whales (*Orcinus orca*) are the most widely distributed cetacean (e.g., whales, dolphins, and porpoises) species in the world and likely represent the most widely distributed mammal species in the world. Killer whales have a distinctive color pattern, with black dorsal and white ventral portions. They also have a conspicuous white patch above and behind the eye and a highly variable gray or white saddle behind the dorsal fin.

The species shows considerable size "dimorphism". Adult males develop larger pectoral flippers, dorsal fins, tail flukes, and girths than females. Male adult killer whales can reach up to 32 feet (9.8 m) in length and can weigh nearly 22,000 pounds (10,000 kg); females can reach 28 feet (8.5 m) in length and can weigh up to 16,500 pounds (7,500 kg).

Most information on killer whale life history and biology is from long-term studies of several populations in the eastern North Pacific. Sexual maturity of female killer whales is achieved when the whales reach lengths of approximately 15-18 feet (4.6 m-5.4 m), depending on geographic region. The gestation period for killer whales varies from 15-18 months, and birth may take place in any month. Calves are nursed for at least 1 year, and may be weaned between 1 and 2 years of age. The birth rate for killer whales is not well understood, but, in some populations, is estimated as every 5 years for an average period of 25 years.

Life expectancy for wild female killer whales is approximately 50 years, with maximum longevity estimated at 80-90 years. Male killer whales typically live for about 30 years, with maximum longevity estimated at 50-60 years.

4.2.6.1 **Distribution**

Three kinds of killer whales occur along the Pacific Coast of the United States: Eastern North Pacific (ENP) southern resident killer whales, ENP offshore killer whales, and ENP transient killer whales. Of these only the southern resident killer whales are listed as endangered or threatened under the ESA. Southern resident killer whales primarily occur in the inland waters of Washington State and southern Vancouver Island, although individuals from this population have been observed off the Queen Charlotte Islands (north of their traditional range) and off coastal California in Monterey Bay, near the Farallon Islands, and off Point Reyes (NMFS 2005a).

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, when all three pods regularly occur in the Georgia Strait, San Juan Islands, and Strait of Juan de Fuca (Felleman et al. 1991; Heimlich-Boran 1988; Olson 1998; Osborne 1999).

The K and L pods typically arrive in May or June and remain in this core area until October or November, although both pods make frequent trips lasting a few days to the outer coasts of Washington and southern Vancouver Island (Ford et al. 2000). The J pod will occur intermittently in the Georgia Basin and Puget Sound during late fall, winter and early spring. During the warmer months, all of the pods concentrate their activities in Haro Strait, Boundary Passage, the southern Gulf Islands, the eastern end of the Strait of Juan de Fuca, and several localities in the southern Georgia Strait (Felleman et al. 1991; Ford et al. 2000; Heimlich-Boran 1988; Olson 1998).

The local movement of southern resident killer whales usually follows the distribution of salmon, which are their preferred prey (Heimlich-Boran 1988; Heimlich-Boran 1986; Nichol and Shackleton 1996). Areas that are major corridors for migrating salmon, and therefore, for southern resident killer whales, include Haro Strait and Boundary Passage, the southern tip of Vancouver Island, Swanson Channel off North Pender Island, and the mouth of the Fraser River delta, which is visited by all three pods in September and October (Felleman et al. 1991; Ford et al. 2000).

4.2.6.2 **Population Structure**

Southern resident killer whales are the only marine mammal that begin and end their lives almost entirely within the action area. Southern resident killer whales consist of three pods, or stable familial groups: the J pod, K pod, and L pod. The J pod is seen most frequently along the western shore of San Juan Island and is the only pod observed regularly in Puget Sound throughout winter (Heimlich-Boran 1988; Osborne 1999). The K pod is most frequently observed during May and June when they occur along the western shore of San Juan Island while searching for salmon. The L pod is the largest of the three pods (Ford et al. 1994) and frequently breaks off into separate subgroups. During the months of July, August, and September, all three pods of southern resident killer whales remain in the inland waterways of Puget Sound, Strait of Juan de Fuca, and southern Georgia Strait. Since the late 1970s, K and L pods typically arrived in this area in May or June and remained there until October or November and appeared to have left these waters by December (Osborne 1999). Since the late 1990s, however, all three pods have tended to remain in this area through December and K and L pods have remained in inland waters until January or February for several years (NMFS 2008). While they tend to spend most of their time in inland waters, both of these pods would, however, travel to the outer coasts of Washington and southern Vancouver Island (Ford et al. 2000).

Less is known about the distribution and movements of southern resident killer whales from late fall, through winter, and into early spring. Over this time interval, the J pod has been observed periodically in the Georgia Basin and Puget Sound, but their movement at other times is uncertain (Osborne 1999); although this pod was sighted once off Cape Flattery, Washington, in March 2004 (NMFS 2008). The K and L pods have been sighted as they passed through the

Strait of Juan de Fuca in late fall, which led Krahn et al. (Krahn et al. 2002) to conclude that these pods might travel to the outer coasts of Vancouver Island and Washington, although they may continue to other areas from there. Based on sighting information and stranding data collected from 1975 through 2007, southern resident killer whales travel to Vancouver Island and the Queen Charlotte Islands, coastal Washington, coastal Oregon, and California (NMFS 2008).

4.2.6.3 **Natural Threats**

Southern resident killer whales, like many wild animal populations, experience highest mortality in the first year age class (Krahn et al. 2002; Olesiuk et al. 1990), although the reasons for these mortalities are still uncertain. The causes could include poor mothering, infectious or non-infectious diseases, and infanticide (Gaydos et al. 2004).

Gaydos et al. (2004) identified 16 infectious agents in free-ranging and captive southern resident killer whales, but concluded that none of these pathogens were known to have high potential to cause epizootics. They did, however, identify pathogens in sympatric odontocete species that could threaten the long-term viability of the small southern resident population.

4.2.6.4 **Anthropogenic Threats**

Several human activities appeared to contribute to the decline of southern resident killer whales. Southern resident killer whales were once shot deliberately in Washington and British Columbia (Baird 2001; Olesiuk et al. 1990). However, between 1967 and 1973, 43 to 47 killer whales were removed from the population for displays in oceanaria; because of those removals, the southern resident killer whale population declined by about 30 percent. By 1971, the population had declined to about 67 individuals. Since then, the population has fluctuated between highs of about 90 individuals and lows of about 75 individuals.

Over the same time interval, southern resident killer whales have been exposed to changes in the distribution and abundance of their prey base (primarily Pacific salmon) which has reduced their potential forage base, potential competition with salmon fisheries, which reduces their realized forage base, disturbance from vessels, and persistent toxic chemicals in their environment.

Salmon, which are the primary prey species for southern resident killer whales, have declined because of land alteration throughout the Pacific Northwest associated with agriculture, timber harvest practices, the construction of dams, and urbanization, fishery harvest practices, and hatchery operations. Many of the salmon populations that were once abundant historically have declined to the point where they have been listed as endangered or threatened with extinction. Since the late 1800s, salmon populations throughout the Columbia River basin have declined (Krahn et al. 2002). Two recent studies have examined the relationships between salmon abundance and population dynamics of resident killer whales and support the belief that Chinook and chum salmon are most important to the Southern Residents. Both studies, however, are

limited by incomplete data on salmon occurrence and year-round range use by the whales (NMFS 2008).

Since the 1970s commercial shipping, whale watching, ferry operations, and recreational boat traffic have increased in Puget Sound and the coastal islands of southern British Columbia. This traffic exposes southern resident killer whales to several threats that have consequences for the species' likelihood of avoiding extinction and recovering if it manages to avoid extinction. First, these vessels increase the risks of southern resident killer whales being struck, injured, or killed by ships. In 2005, a southern resident killer whale was injured in a collision with a commercial whale watch vessel although the whale subsequently recovered from those injuries. However, in 2006, an adult male southern resident killer whale, L98, was killed in a collision with a tug boat; given the gender imbalances in the southern resident killer whale population, we assume that the death of this adult male would have reduced the demographic health of this population.

Second, the number and proximity of vessels, particularly whale-watch vessels in the areas occupied by southern resident killer whales, represents a source of chronic disturbance for this population. Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Goodwin and Cotton 2004; Lusseau 2006). However, several authors suggest that the noise generated during motion is probably an important factor (Evans et al. 1992; Evans et al. 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

Several investigators have studied the effects of whale watch vessels on marine mammals (Amaral and Carlson 2005; Au and Green 2000a; Corkeron 1995; Erbe 2002b; Felix 2001; Magalhaes et al. 2002; Richter et al. 2006; Scheidat et al. 2004; Simmonds 2005a; Watkins 1986; Williams et al. 2002a). The whale's behavioral responses to whale watching vessels depended on the distance of the vessel from the whale, vessel speed, vessel direction, vessel noise, and the number of vessels. The whales' responses changed with these different variables and, in some circumstances, the whales did not respond to the vessels. 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 disturbance associated with the presence of vessel, the vessel traffic affects the acoustic ecology of southern resident killer whales, which would affect their social ecology. Foote et al. (2004) compared recordings of southern resident killer whales that were made in the presence or absence of boat noise in Puget Sound during three time periods between 1977 and 2003. They concluded that the duration of primary calls in the presence of boats increased by

about 15 percent during the last of the three time periods (2001 to 2003). At the same time, Holt et al. (2009) reported that southern resident killer whales in Haro Strait off the San Juan Islands in Puget Sound, Washington, increased the amplitude of their social calls in the face of increased sounds levels of background noise. Although the costs of these vocal adjustments remains unknown, Foote et al. (2004) suggested that the amount of boat noise may have reached a threshold above which the killer whales need to increase the duration of their vocalization to avoid masking by the boat noise.

Exposure to contaminants may also harm southern resident killer whales. The presence of high levels of persistent organic pollutants, such as PCB, DDT, and flame –retardants has been documented in southern resident killer whales (Krahn et al. 2007; Ross et al. 2000). Although the consequences of these pollutants on the fitness of individual killer whales and the population itself remain unknown, in other species these pollutants have been reported to suppress immune responses (Wright et al. 2007), impair reproduction, and exacerbate the energetic consequences of physiological stress responses when they interact with other compounds in an animal's tissues (Martineau 2007). Because of their long life span, position at the top of the food chain, and their blubber stores, killer whales would be capable of accumulating high concentrations of contaminants.

4.2.6.5 **Status**

Southern resident killer whales were listed as endangered under the ESA in 2005 (70 FR 69903). In the mid- to late-1800s, southern resident killer whales were estimated to have numbered around 200 individuals. By the mid-1960s, they had declined to about 100 individuals. As discussed in the preceding section, between 1967 and 1973, 43 to 47 killer whales were removed from the population to provide animals for displays in oceanaria and the population declined by about 30 percent as a result of those removals. By 1971, the population had declined to about 67 individuals. Since then, the population has fluctuated between highs of about 90 individuals and lows of about 75 individuals.

At population sizes between 75 and 90 individuals, we would expect southern resident killer whales to have higher probabilities of becoming extinct because of demographic stochasticity, demographic heterogeneity (Coulson et al. 2006; Fox 2007) —including stochastic sex determination (Lande et al. 2003) — and the effects of these phenomena interacting with environmental variability. Demographic stochasticity refers to the randomness in the birth or death of an individual in a population, which results in random variation on how many young that individuals produce during their lifetime and when they die. Demographic heterogeneity refers to variation in lifetime reproductive success of individuals in a population (generally, the number of reproductive adults an individual produces over their reproductive lifespan), such that the deaths of different individuals have different effects on the growth or decline of a population (Coulson et al. 2006). Stochastic sex determination refers to the randomness in the sex of

offspring such that sexual ratios in population fluctuate over time (Melbourne and Hastings 2008). For example, the small number of adult male southern resident killer whales might represent a stable condition for this species or it might reflect the effects of stochastic sex determination. Regardless, a high mortality rates among adult males in a population with a smaller percentage of males would increase the imbalance of male-to-female gender ratios in this population and increase the importance of the few adult males that remain.

At these population sizes, populations experience higher extinction probabilities because stochastic sexual determination leaves them with harmful imbalances between the number of male or female animals in the population (which occurred to the heath hen and dusky seaside sparrow just before they became extinct), or because the loss of individuals with high reproductive success has a disproportionate effect on the rate at which the population declines (Coulson et al. 2006). In general, an individual's contribution to the growth (or decline) of the population it represents depends, in part, on the number of individuals in the population: the smaller the population, the more the performance of a single individual is likely to affect the population's growth or decline (Coulson et al. 2006). Given the small size of the southern resident killer whale population, the performance (= "fitness," measured as the longevity of individuals and their reproductive success over their lifespan) of individual whales would be expected to have appreciable consequences for the growth or decline of the southern resident killer whale population.

These phenomena would increase the extinction probability of southern resident killer whales and amplify the potential consequences of human-related activities on this species. Based on their population size and population ecology (that is, slow-growing mammals that give birth to single calves with several years between births), we assume that southern resident killer whales would have elevated extinction probabilities because of exogenous threats caused by anthropogenic activities that result in the death or injury of individual whales (for example, ship strikes or entanglement) and natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) as well as endogenous threats resulting from the small size of their population. Based on the number of other species in similar circumstances that have become extinct (and the small number of species that have avoided extinction in similar circumstances), the longer southern resident killer whales remain in these circumstances, the greater their extinction probability becomes.

4.2.6.6 **Diving and Social Behavior**

Killer whales are highly social animals that occur primarily in groups or pods of up to 40-50 animals (Baird 2000; Dahlheim and Heyning 1999). Larger aggregations of up to several hundred individuals occasionally form, but are usually considered temporary groupings of smaller social units that probably congregate near seasonal concentrations of prey, for social interaction, or breeding (Baird 2000; Dahlheim and Heyning 1999; Ford et al. 2000). The basic

social units are matrilines, which usually consist of an adult female, her sons and daughters, the offspring of her daughters, and might extend to include 3 to five generations of killer whales (Baird 2000; Ford 2002; Ford et al. 2000). The members of matrilines maintain such strong social connections that individuals rarely separate from these groups for more than a few hours. Groups of related matrilines are known as pods — for example, L Pod of southern resident killer whales consists of 12 matrilines — which are less cohesive than matrilines (matrilines within a pod might travel separately for weeks or months). Clans are the next level of social structure in resident killer whales and consist of pods with similar vocal dialects and common, but older, maternal heritage.

In terms of gender and age composition, southern and northern resident killer whales social groups consisted of 19 percent adult males, 31 percent adult females, and 50 percent immature whales of either sex in 1987 (Olesiuk et al. 1990). This composition is comparable with the composition of southern Alaska resident killer whales and killer whale populations in the Southern Ocean (Matkin et al. 2003; Miyazaki 1989).

4.2.6.7 **Vocalizations and Hearing**

Killer whales produce a wide variety of clicks, whistles, and pulsed calls (Ford 1989; Schevill and Watkins 1966; Thomsen et al. 2001). Their clicks are relatively broadband, short (0.1–25 milliseconds), and range in frequency from 8 to 80 kHz with an average center frequency of 50 kHz and an average bandwidth of 40 kHz (Au et al. 2004). Killer whales apparently use these signals to sense objects in their environment, such as prey; whales foraging on salmon produce these signals at peak-to-peak source levels ranging from 195 to 225 dB re 1 µPa at 1 m (Au et al. 2004).

Killer whale whistles are tonal signals that have longer duration (0.06–18 seconds) and frequencies ranging from 0.5–10.2 kHz (Thomsen et al. 2001). Killer whales are reported to whistle most often while they have been engaged in social interactions rather than during foraging and traveling (Thomsen et al. 2002). Northern resident killer whales whistles have source levels ranging from 133 to 147 dB re 1 µPa at 1 m (Miller 2006).

Killer whale pulsed calls are the most commonly observed type of signal associated with killer whales (Ford 1989). With both northern and southern resident killer whales, these signals are relatively long (600–2,000 ms) and range in frequency between 1 and 10 kHz; but may contain harmonics up to 30 kHz (Ford 1989). The variable calls of killer whales have source levels ranging from 133 to 165 dB while stereotyped calls have source levels ranging from 135 to 168 dB re 1 µPa at 1 m (Miller 2006). Killer whales use these calls when foraging and traveling (Ford 1989).

4.2.7 Leatherback Sea Turtle

The leatherback sea turtle is the largest turtle and the largest living reptile in the world. Mature turtles can be as long as six and a half feet (2 m) and weigh almost 2000 lbs. (900 kg). The leatherback is the only sea turtle that lacks a hard, bony shell. A leatherback's carapace is approximately 1.5 inches (4 cm) thick and consists of leathery, oil saturated connective tissue overlaying loosely interlocking dermal bones. The carapace has seven longitudinal ridges and tapers to a blunt point. Adult leatherbacks are primarily black with a pinkish white mottled ventral surface and pale white and pink spotting on the top of the head. The front flippers lack claws and scales and are proportionally longer than in other sea turtles; back flippers are paddle-shaped. The ridged carapace and large flippers are characteristics that make the leatherback uniquely equipped for long distance foraging migrations.

Female leatherback sea turtles lay clutches of approximately 100 eggs on sandy, tropical beaches. Females nest several times during a nesting season, typically at 8-12 day intervals. After 60-65 days, leatherback hatchlings with white striping along the ridges of their backs and on the margins of the flippers emerge from the nest. Leatherback hatchlings are approximately 50-77 cm (2-3 inches) in length, with fore flippers as long as their bodies, and weigh approximately 40-50 grams (1.4-1.8 ounces).

Leatherback sea turtles lack the crushing chewing plates characteristic of sea turtles that feed on hard-bodied prey (Pritchard 1971). Instead, they have pointed tooth-like cusps and sharp edged jaws that are perfectly adapted for a diet of soft-bodied pelagic (open ocean) prey, such as jellyfish and salps. A leatherback's mouth and throat also have backward-pointing spines that help retain such gelatinous prey.

4.2.7.1 **Distribution**

Leatherback sea turtles are widely distributed throughout the oceans of the world. The species is found in four main regions of the world: the Pacific, Atlantic, and Indian Oceans, and the Caribbean Sea. Leatherbacks also occur in the Mediterranean Sea, although they are not known to nest there. The four main regional areas may further be divided into nesting aggregations. Leatherback turtles are found on the western and eastern coasts of the Pacific Ocean, with nesting aggregations in Mexico and Costa Rica (eastern Pacific) and Malaysia, Indonesia, Australia, the Solomon Islands, Papua New Guinea, Thailand, and Fiji (western Pacific). In the Atlantic Ocean, leatherback nesting aggregations have been documented in Gabon, Sao Tome and Principe, French Guiana, Suriname, and Florida. In the Caribbean, leatherbacks nest in the U.S. Virgin Islands and Puerto Rico. In the Indian Ocean, leatherback nesting aggregations are reported in India and Sri Lanka and KwaZulu Natal, South Africa.

Leatherback sea turtles have been documented in Alaska waters as far north as approximately 60º latitude (approximately 50 miles north of the northern edge of the TMAA) and as far west in

the Gulf of Alaska as the Aleutian Islands (Eckert 1993). In contrast with other sea turtles, leatherback sea turtles have physiological traits that allow for the conservation of body heat which enable them to maintain body core temperatures well above the ambient water temperatures (Eckert 1993; Greer et al. 1973; Pritchard 1971). Shells, or carapaces, of adult leatherbacks are 4 cm (1.5 inches) thick on average, contributing to the leatherback's thermal tolerance that enables this species to forage in water temperatures far lower than the leatherback's core body temperature (Bostrom et al. 2010). In an analysis of available sightings (Eckert 2002), researchers found that leatherback turtles with carapace lengths smaller than 100 cm (39 inches) were sighted only in waters 79 ºF or warmer, while adults were found in waters as cold as 32ºF to 59ºF off Newfoundland (Goff and Lien 1988). As a result, they are more capable of surviving for extended periods of time in cooler waters than the hard-shelled sea turtles (Bleakney 1965; Lazell Jr. 1980).

4.2.7.2 **Population Structure**

Leatherback turtles are widely distributed throughout the oceans of the world. The species is divided into four main populations in the Pacific, Atlantic, and Indian Oceans, and the Caribbean Sea. Leatherbacks also occur in the Mediterranean Sea, although they are not known to nest there. The four main populations are further divided into nesting aggregations. Leatherback turtles are found on the western and eastern coasts of the Pacific Ocean, with nesting aggregations in Mexico and Costa Rica (eastern Pacific) and Malaysia, Indonesia, Australia, the Solomon Islands, Papua New Guinea, Thailand, and Fiji (western Pacific). In the Atlantic Ocean, leatherback nesting aggregations have been documented in Gabon, Sao Tome and Principe, French Guiana, Suriname, and Florida. In the Caribbean, leatherbacks nest in the U.S. Virgin Islands and Puerto Rico. In the Indian Ocean, leatherback nesting aggregations are reported in India, Sri Lanka, and the Andaman and Nicobar Islands.

4.2.7.3 **Natural Threats**

The various habitat types leatherback sea turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural threats. The beaches on which leatherback sea turtles nest and the nests themselves are threatened by hurricanes and tropical storms as well as the storm surges, sand accretion, and rainfall that are associated with hurricanes. Hatchlings are hunted by predators like herons, gulls, dogfish, and sharks. Larger leatherback sea turtles, including adults, are also killed by sharks and other large, marine predators.

4.2.7.4 **Anthropomorphic Threats**

Leatherback sea turtles are endangered by several human activities, including fisheries interactions, entanglement in fishing gear (e.g., gillnets, longlines, lobster pots, weirs), direct harvest, egg collection, the destruction and degradation of nesting and coastal habitat, boat collisions, and ingestion of marine debris.

The foremost threat is the number of leatherback turtles killed or injured in fisheries. Spotila (2004) concluded that a conservative estimate of annual leatherback fishery-related mortality (from longlines, trawls and gillnets) in the Pacific Ocean during the 1990s is 1,500 animals. He estimates that this represented about a 23 percent mortality rate (or 33 percent if most mortality was focused on the East Pacific population). Spotila (2000) asserts that most of the mortality associated with the Playa Grande nesting site was fishery related.

Leatherback sea turtles are exposed to commercial fisheries in many areas of the Atlantic Ocean. For example, leatherback entanglements in fishing gear are common in Canadian waters where Goff and Lien (Goff and Lien 1988) reported that 14 of 20 leatherbacks encountered off the coast of Newfoundland and Labrador were entangled in fishing gear including salmon net, herring net, gillnet, trawl line and crab pot line. Leatherbacks are reported taken by the many other nations that participate in Atlantic pelagic longline fisheries (see NMFS 2001, for a complete description of take records), including Taiwan, Brazil, Trinidad, Morocco, Cyprus, Venezuela, Korea, Mexico, Cuba, U.K., Bermuda, People's Republic of China, Grenada, Canada, Belize, France, and Ireland.

In the Pacific Ocean, between 1,000 and 1,300 leatherback sea turtles are estimated to have been captured and killed in longline fisheries in 2000 (Lewison et al. 2004). Shallow-set longline fisheries based out of Hawai'i are estimated to have captured and killed several hundred leatherback sea turtles before they were closed in 2001. When they were re-opened in 2004, with substantial modifications to protect sea turtles, these fisheries were estimated to have captured and killed about 1 or 2 leatherback sea turtles each year. Between 2004 and 2008, shallow-set fisheries based out of Hawai'i are estimated to have captured about 19 leatherback sea turtles, killing about 5 of these sea turtles. A recent biological opinion on these fisheries expected this rate of interaction and deaths to continue into the foreseeable future. Leatherback sea turtles have also been and are expected to continue to be captured and killed in the deep-set based longline fisheries based out of Hawai'i and American Samoa.

Shrimp trawls in the Gulf of Mexico capture the largest number of leatherback sea turtles: each year, they have been estimated to capture about 3,000 leatherback sea turtles with 80 of those sea turtles dying as a result. Along the Atlantic coast of the U.S., NMFS estimated that about 800 leatherback sea turtles are captured in pelagic longline fisheries, bottom longline and drift gillnet fisheries for sharks as well as lobster, deep-sea red crab, Jonah crab, dolphin fish and wahoo, and Pamlico Sound gillnet fisheries. Although most of these turtles are released alive, these fisheries combine to kill about 300 leatherback sea turtles each year; the health effects of being captured on the sea turtles that survive remain unknown.

Leatherback sea turtles are known to drown in fish nets set in coastal waters of Sao Tome, West Africa (Tomás et al. 2000). Gillnets are one of the suspected causes for the decline in the

leatherback turtle population in French Guiana (Chevalier et al. 1999), and gillnets targeting green and hawksbill turtles in the waters of coastal Nicaragua also incidentally catch leatherback turtles (Lagueux 1998). Observers on shrimp trawlers operating in the northeastern region of Venezuela documented the capture of six leatherbacks from 13,600 trawls (Marcano and Alió-M 2000). An estimated 1,000 mature female leatherback turtles are caught annually off of Trinidad and Tobago with mortality estimated to be between 50-95 percent (Eckert et al. 2007). However, many of the turtles do not die as a result of drowning, but rather because the fishermen butcher them in order to get them out of their nets. There are known to be many sizeable populations of leatherbacks nesting in West Africa, possibly as many as 20,000 females nesting annually (Fretey 2001). In Ghana, nearly two thirds of the leatherback turtles that come up to nest on the beach are killed by local fishermen.

On some beaches, nearly 100 percent of the eggs laid have been harvested. Spotila et al. (1996) and Eckert et al. (2007) note that adult mortality has also increased significantly, particularly as a result of driftnet and longline fisheries. Like green and hawksbill sea turtles, leatherback sea turtles are threatened by domestic or domesticated animals that prey on their nests; artificial lighting that disorients adult female and hatchling sea turtles, which can dramatically increase the mortality rates of hatchling sea turtles; beach replenishment; ingestion and entanglement in marine debris; and environmental contaminants.

Oil spills are a risk for all sea turtles. Several aspects of sea turtles life histories put them at risk, including the lack of avoidance behavior of oiled waters and indiscriminate feeding in convergence zones. Sea turtles are air breathers and all must come to the surface frequently to take a breath of air. In a large oil spill, these animals may be exposed to volatile chemicals during inhalation (NMFS 2010d).

Additionally, sea turtles may experience oiling impacts on nesting beaches when they come ashore to lay their eggs, and their eggs may be exposed during incubation potentially resulting in increased egg mortality and/or possibly developmental defects in hatchlings. Hatchlings emerging from their nests may encounter oil on the beach and in the water as they begin their lives at sea (NMFS 2010d).

External Effects: Oil and other chemicals on skin and body may result in skin and eye irritation, burns to mucous membranes of eyes and mouth, and increased susceptibility to infection (NMFS 2010d).

Internal Effects: Inhalation of volatile organics from oil or dispersants may result in respiratory irritation, tissue injury, and pneumonia. Ingestion of oil or dispersants may result in gastrointestinal inflammation, ulcers, bleeding, diarrhea, and maldigestion. Absorption of inhaled

and ingested chemicals may damage organs such as the liver or kidney, result in anemia and immune suppression, or lead to reproductive failure or death (NMFS 2010d).

4.2.7.5 **Status and Trends**

The leatherback turtle was listed under the Endangered Species Act as endangered throughout its range in 1970. There is a recovery plan for this species (NMFS and USFWS 1998).

Leatherback turtles are considered critically endangered by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2010) and are protected by the Convention on International Trade in Endangered Species (CITES).

The Pacific Ocean leatherback population is generally smaller in size than that in the Atlantic Ocean. Because adult female leatherbacks frequently nest on different beaches, nesting population estimates and trends are especially difficult to monitor. In the Pacific, the IUCN notes that most leatherback nesting populations have declined more than 80 percent. In other areas of the leatherback's range, observed declines in nesting populations are not as severe, and some population trends are increasing or stable. In the Atlantic, available information indicates that the largest leatherback nesting population occurs in French Guyana, but the trends are unclear. Some Caribbean nesting populations appear to be increasing, but these populations are very small when compared to those that nested in the Pacific less than 10 years ago. Nesting trends on U.S. beaches have been increasing in recent years.

4.2.7.6 **Diving**

The leatherback sea turtle is one of the deepest divers in the ocean, with dives as deep as 3,937 ft (1,200 m), although it spends most of its time feeding at a depth of less than 328 ft (100 m). Leatherback turtles primarily feed on gelatinous zooplankton such as cnidarians (jellyfish and siphonophores) and tunicates (salps and pyrosomas) (Bjorndal 1997; NMFS and USFWS 1998). The leatherback dives continually and spends short periods of time on the surface between dives (Eckert et al. 1989; Southwood et al. 1999). Typical dive durations averaged 6.9 to 14.5 minutes (min) per dive, with a maximum of 42 min (Eckert et al. 1996). Sea turtles typically remain submerged for several minutes to several hours depending upon their activity state (Standora et al. 1984). Long periods of submergence hamper detection and confound census efforts. During migrations or long distance movements, leatherbacks maximize swimming efficiency by traveling within 15 ft (5 m) of the surface (Eckert 2002).

4.2.7.7 **Social Behavior**

Male leatherbacks do not return to land after they hatch from their nests whereas mature females return to land only to lay eggs (Spotila 2004). Aside from this brief terrestrial period, which lasts approximately three months during egg incubation and hatching, leatherback turtles are rarely encountered out of the water. Hatchling leatherbacks are pelagic, but nothing is known about their distribution during the first 4 years of life (Musick and Limpus 1997).

The Pacific coast of Mexico is generally regarded as the most important leatherback breeding ground in the world, although nesting on Pacific beaches under U.S. jurisdiction has always been rare (NMFS and USFWS 1998). Based on a single aerial survey in 1980 of Michoacán, Guerrero, and Oaxaca, and on published and anecdotal data, Pritchard (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 (Lux et al. 2003). 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 large geographic areas and lay on average two times as many clutches as other species (Eckert 1987). 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). 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 and USFWS 1998). Other principal nesting sites in the Pacific Ocean indicate that gene flow between eastern and western Pacific nesting populations is restricted (Dutton et al. 2005; Dutton et al. 2006; Dutton et al. 1999; Dutton et al. 1996; Dutton et al. 2003).

4.2.7.8 **Vocalization and Hearing**

Sea turtles do not have an external ear pinnae or 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 sounds to the middle ear and into the cavity of the inner ear (Ridgway et al. 1969). Sound also arrives by bone conduction through the skull. Sound arriving at the inner ear via the columella (homologous to the mammalian stapes or stirrup) is transduced by the bones of the middle ear.

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. It has been suggested that 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).

Lenhardt et al. (1983) applied audio frequency vibrations at 250 hertz (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 and Vernon 1956). At the maximum upper limit of the vibratory delivery system,

the sea 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 was low as threshold detection levels in water are relatively high at 160 to 200 decibels referenced to one micro Pascal at a distance of one meter (dB re 1 μPa-m), which is the standard reference measure for underwater sound energy in this regard) (Lenhardt et al. 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 the 400 Hz frequency, the green turtle's hearing threshold was about 64 dB in air (approximately 126 dB in water). At 70 Hz, it was about 70 dB in air (approximately 132 dB in water). We may be able to extrapolate this data to pertain to all hard-shell sea turtles (i.e., the olive ridley, green, loggerhead, and Kemp's ridley turtles). No audiometric data are available for the leatherback turtle, but based on other sea turtle hearing capabilities, they probably also hear best in the low frequencies.

For exposures to impulsive sound, a recent study on the effects of air guns on sea turtle behavior also suggests that sea turtles are most likely to respond to low-frequency sounds (McCauley et al. 2000). Loggerhead sea turtles will avoid air-gun arrays at 2 km and at 1 km, with received levels of 166 dB re 1 μPa-m and 175 dB re 1 μPa, respectively (McCauley et al. 2000). The sea turtles' response was consistent: above a level of about 166 dB re 1 μPa, the sea turtles noticeably increased their swimming activity. Above 175 dB re 1 μPa, their behavior became more erratic, possibly indicating that they were agitated (McCauley et al. 2000).

Currently it is believed that the range of maximum sensitivity for sea turtles is 200 to 800 Hz, with an upper limit of about 2,000 Hz (Lenhardt 1994; Moein et al. 1994). Green turtles are most sensitive to sounds between 200 and 700 Hz, with peak sensitivity at 300 to 400 Hz (Ridgway et al. 1969). They possess an overall hearing range of approximately 60 to 1,000 Hz (Ridgway et al. 1969). Juvenile loggerhead turtles hear sounds between 250 and 1,000 Hz and, therefore, often avoid low-frequency sounds (Bartol et al. 1999). Finally, sensitivity even within the optimal hearing range is apparently low—threshold detection levels in water are relatively high at 160 to 200 dB re 1 μPa-m (Lenhardt 1994). Given the lack of audiometric information for leatherback turtles, the potential for TTS among leatherback turtles must be classified as unknown but would likely follow those of other sea turtles. In terms of sound emission, nesting leatherback turtles produce sounds in the 300 to 500 Hz range (Mrosovsky 1972).

4.2.8 Southern Population of Pacific Eulachon

Eulachon, *Thaleichthys pacificus*, (commonly called smelt, candlefish, or hooligan) are a small, anadromous fish from the eastern Pacific Ocean. They are distinguished by the large canine teeth on the vomer, a bone in the roof of the mouth, and 18 to 23 rays in the anal fin. Like Pacific salmon they have an adipose fin; it is sickle-shaped. The paired fins are longer in males than in females. All fins have well-developed breeding tubercles (raised tissue "bumps") in ripe males, but these are poorly developed or absent in females. Adult coloration is brown to blue on the back and top of the head, lighter to silvery white on the sides, and white on the ventral surface; speckling is fine, sparse, and restricted to the back. They feed on plankton but only while at sea.

Eulachon typically spend 3 to 5 years in saltwater before returning to freshwater to spawn from late winter through mid-spring. During spawning, males have a distinctly raised ridge along the middle of their bodies. Eggs are fertilized in the water column. After fertilization, the eggs sink and adhere to the river bottom, typically in areas of gravel and coarse sand. Most eulachon adults die after spawning. Eulachon eggs hatch in 20 to 40 days. The larvae are then carried downstream and are dispersed by estuarine and ocean currents shortly after hatching. Juvenile eulachon move from shallow nearshore areas to mid-depth areas. Within the Columbia River Basin, the major and most consistent spawning runs occur in the mainstem of the Columbia River as far upstream as the Bonneville Dam, and in the Cowlitz River.

4.2.8.1 **Distribution**

Eulachon is an anadromous species that spawns in the lower portions of certain rivers draining into the northeastern Pacific Ocean ranging from Northern California to the southeastern Bering Sea in Bristol Bay, Alaska (NMFS 2010a; Schultz and DeLacy 1935). Eulachon have been described as "common" in Grays Harbor and Willapa Bay on the Washington coast, "abundant" in the Columbia River, "common" in Oregon's Umpqua River, and "abundant" in the Klamath River in northern California. They have been described as "rare" in Puget Sound and Skagit Bay in Washington; Siuslaw River, Coos Bay, and Rogue River in Oregon; and Humboldt Bay in California (Emmett et al. 1991). However, Hay and McCarter (2000) and Hay (2002) identified 33 eulachon spawning rivers in British Columbia and 14 of these were classified as supporting regular yearly spawning runs.

The southern population of Pacific eulachon consists of populations spawning in rivers south of the Nass River in British Columbia, Canada, to, and including, the Mad River in California (75 FR 13012).

4.2.8.2 **Population Structure**

The southern population of Pacific eulachon consists of several ''core populations'' that include populations in the Columbia and Fraser Rivers with smaller populations in several other river systems in Canada, including the Nass and Skeena Rivers. Within the Columbia River Basin, the

major and most consistent spawning runs return to the mainstem of the Columbia River (from just upstream of the estuary, river mile 25, to immediately downstream of Bonneville Dam, river mile 146) and in the Cowlitz River. Periodic spawning also occurs in the Grays, Skamokawa, Elochoman, Kalama, Lewis, and Sandy rivers (tributaries to the Columbia River). Historically, there may have been a population in the Klamath River (75 FR 13012).

4.2.8.3 **Natural Threats**

Eulachon have numerous avian predators including harlequin ducks, pigeon guillemots, common murres, mergansers, cormorants, gulls, and eagles. Marine mammals such as humpback whales, orcas, dolphins, Steller sea lions, California sea lions, northern fur seals, harbor seals, and beluga whales are known to feed on eulachon. During spawning runs, bears and wolves have been observed consuming eulachon. Fishes that prey on eulachon include white sturgeon, spiny dogfish, sablefish, salmon sharks, arrowtooth flounder, salmon, Dolly Varden charr, Pacific halibut, and Pacific cod. In particular, eulachon and their eggs seem to provide a significant food source for white sturgeon in the Columbia and Fraser Rivers (75 FR 13012).

4.2.8.4 **Anthropogenic Threats**

Southern eulachon are primarily threatened by increasing temperatures in the marine, coastal, estuarine, and freshwater environments of the Pacific Northwest that are at least causally related to climate change; dams and water diversions, water quality degradation, dredging operations in the Columbia and Fraser Rivers; commercial, recreational, and subsistence fisheries in Oregon and Washington that target eulachon; and bycatch in commercial fisheries.

Eulachon are particularly vulnerable to capture in shrimp fisheries in the United States and Canada as the marine areas occupied by shrimp and eulachon often overlap. In Oregon, the bycatch of various species of smelt (including eulachon) has been as high as 28 percent of the total catch of shrimp by weight (Hannah and Jones 2007). There are directed fisheries in Alaska state waters for eulachon in Upper Cook Inlet, the Copper River area, and in southeast Alaska. There has been little commercial activity in recent years, due to either lack of interest or closures resulting from concerns over diminished spawning runs, but there is potential for substantial amounts of harvest (Ormseth and Vollenweider 2007).

4.2.8.5 **Status**

The southern population of eulachon was listed as threatened on 18 March 2010 (75 FR 13012).

4.2.8.6 **Vocalizations and Hearing**

We do not have specific information on hearing in eulachon, but we assume that they are hearing generalists whose hearing sensitivities would be similar to salmon. Species in the family Salmonidae have similar auditory systems and hearing sensitivities (Popper 1977; Popper et al. 2007; Wysocki et al. 2007). Most of the data available on this group resulted from studies of the hearing capability of Atlantic salmon (*Salmo salar*), which is a "hearing generalist" with a

relatively poor sensitivity to sound (Hawkins and Johnstone 1978). Based on the information available, we assume that the eulachon considered in this consultation have hearing sensitivities ranging from less than 100 Hz to about 580 Hz (Hawkins and Johnstone 1978; Knudsen et al. 1992; Knudsen et al. 1994; Popper 2008).

4.2.9 Chinook Salmon

Chinook salmon are the largest of any salmon, with adults often exceeding 40 pounds (18 kg); individuals over 120 pounds (54 kg) have been reported. Chinook mature at about 36 inches and 30 pounds. Chinook salmon are blue-green back with silver flanks at sea, with small black spots on both lobes of the tail, and black pigment along the base of the teeth. Adults migrate from a marine environment into the freshwater streams and rivers of their birth in order to mate (called anadromy). They spawn only once and then die (called semelparity).

Juvenile Chinook may spend from 3 months to 2 years in freshwater before migrating to estuarine areas as smolts and then into the ocean to feed and mature. Chinook salmon remain at sea for 1 to 6 years (more commonly 2 to 4 years), with the exception of a small proportion of yearling males (called jack salmon) which mature in freshwater or return after 2 or 3 months in salt water. They feed on terrestrial and aquatic insects, amphipods, and other crustaceans while young, and primarily on other fishes when older.

There are different seasonal (i.e., spring, summer, fall, or winter) "runs" in the migration of Chinook salmon from the ocean to freshwater, even within a single river system. These runs have been identified on the basis of when adult Chinook salmon enter freshwater to begin their spawning migration. However, distinct runs also differ in the degree of maturation at the time of river entry, the temperature and flow characteristics of their spawning site, and their actual time of spawning. Freshwater entry and spawning timing are believed to be related to local temperature and water flow regimes.

Two distinct types or races among Chinook salmon have evolved. One race, described as a "stream-type" Chinook, is found most commonly in headwater streams of large river systems. Stream-type Chinook salmon have a longer freshwater residency, and perform extensive offshore migrations in the central North Pacific before returning to their birth, or natal, streams in the spring or summer months. Stream-type juveniles are much more dependent on freshwater stream ecosystems because of their extended residence in these areas. A stream-type life history may be adapted to areas that are more consistently productive and less susceptible to dramatic changes in water flow. At the time of saltwater entry, stream-type (yearling) smolts are much larger, averaging 3 to 5.25 inches (73-134 mm) depending on the river system, than their ocean-type (subyearling) counterparts, and are therefore able to move offshore relatively quickly.

The second race, called the "ocean-type" Chinook, is commonly found in coastal streams in North America. Ocean-type Chinook typically migrate to sea within the first three months of life, but they may spend up to a year in freshwater prior to emigration to the sea. They also spend their ocean life in coastal waters. Ocean-type Chinook salmon return to their natal streams or rivers as spring, winter, fall, summer, and late-fall runs, but summer and fall runs predominate. Ocean-type Chinook salmon tend to use estuaries and coastal areas more extensively than other pacific salmonids for juvenile rearing. The evolution of the ocean-type life history strategy may have been a response to the limited carrying capacity of smaller stream systems and unproductive watersheds, or a means of avoiding the impact of seasonal floods. Ocean-type Chinook salmon tend to migrate along the coast. Populations of Chinook salmon south of the Columbia River drainage appear to consist predominantly of ocean-type fish.

4.2.9.1 **Distribution**

The Chinook salmon's historical range in North America extended from the Ventura River in California to Point Hope, Alaska. 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). Because of similarities in the life history and threats to the survival and recovery of the six Chinook salmon "species" (as that term is defined in section 3 of the ESA) or evolutionary significant units (ESUs) that are included in this Opinion, we summarize the threats to Chinook salmon and their hearing sensitivity generally. Then we separately discuss specific information on their listing status, population status and trends, and impacts that are not shared for each of these species.

Chinook salmon distribute in the North Pacific Ocean north of about 40º North latitude where they may remain for 1 to 6 years, although 2 to 4 years are more common. Although salmon generally occur near the surface (within 8 to 10 meters of the surface), Chinook salmon have been caught at depths up to 110 meters.

4.2.9.2 **Impacts of Human Activity on Chinook Salmon**

Over the past few decades, the size and distribution of Chinook salmon populations have declined because of natural phenomena and human activity, including the operation of hydropower systems, harvest, hatcheries, and habitat degradation. Natural variations in freshwater and marine environments have substantial effects on the abundance of salmon populations. Of the various natural phenomena that affect most populations of Pacific salmon, changes in ocean productivity are generally considered most important.

Chinook salmon are exposed to high rates of natural predation, particularly during freshwater rearing and migration stages. Ocean predation probably contributes to significant natural

mortality, although the levels of predation are largely unknown. In general, Chinook are prey for pelagic fishes, birds, and marine mammals, including harbor seals, sea lions, and killer whales. There have been recent concerns that the increasing size of tern, seal, and sea lion populations in the Pacific Northwest has dramatically reduced the survival of adult and juvenile salmon.

4.2.9.3 **Hearing**

Based on the information available, we assume that the Chinook salmon considered in this consultation have hearing sensitivities ranging from less than 100 Hz to about 580 Hz (Hawkins and Johnstone 1978; Knudsen et al. 1992; Knudsen et al. 1994; Popper 2008).

4.2.9.4 **Status**

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 2005b). 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)(70 FR 37160). The remaining seven ESUs were found to not warrant listing under the ESA (NMFS 2005b). The ESUs of concern in this Opinion are summarized below.

4.2.9.5 **Puget Sound Chinook Salmon ESU**

Puget Sound Chinook salmon were listed as a threatened species on March 24, 1999 and the threatened status reaffirmed on June 28, 2005. The ESU includes all naturally spawned populations of Chinook salmon from rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca from the Elwha River, eastward, including rivers and streams flowing into Hood Canal, South Sound, North Sound and the Strait of Georgia in Washington, as well as twenty-six artificial propagation programs: the Kendal Creek Hatchery, Marblemount Hatchery (fall, spring yearlings, spring subyearlings, and summer run), Harvey Creek Hatchery, Whitehorse Springs Pond, Wallace River Hatchery (yearlings and subyearlings), Tulalip Bay, Issaquah Hatchery, Soos Creek Hatchery, Icy Creek Hatchery, Keta Creek Hatchery, White River Hatchery, White Acclimation Pond, Hupp Springs Hatchery, Voights Creek Hatchery, Diru Creek, Clear Creek, Kalama Creek, George Adams Hatchery, Rick's Pond Hatchery, Hamma Hamma Hatchery, Dungeness/Hurd Creek Hatchery, Elwha Channel Hatchery Chinook hatchery programs were listed as threatened under the ESA in 1999. Critical habitat for this species was designated on September 2, 2005.

4.2.9.6 **Lower Columbia River Chinook Salmon ESU**

Lower Columbia River Chinook salmon were listed as threatened on March 24, 1999 with the threatened status reaffirmed on June 28, 2005. The ESU includes all naturally spawned populations of Chinook salmon from the Columbia River and its tributaries from its mouth at the

Pacific Ocean upstream to a transitional point between Washington and Oregon east of the Hood River and the White Salmon River, and includes the Willamette River to Willamette Falls, Oregon. The eastern boundary for this species occurs at Celilo Falls, which corresponds to the edge of the drier Columbia Basin Ecosystem and historically may have been a barrier to salmon migration at certain times of the year. Stream-type spring-run Chinook salmon found in the Klickitat River are not included in this species (they are considered Mid-Columbia River spring-run Chinook salmon) or the introduced Carson spring-Chinook salmon strain. Seventeen artificial propagation programs are included in the listed ESU: the Sea Resources Tule Chinook Program, Big Creek Tule Chinook Program, Astoria High School (STEP) Tule Chinook Program, Warrenton High School (STEP) Tule Chinook Program, Elochoman River Tule Chinook Program, Cowlitz Tule Chinook Program, North Fork Toutle Tule Chinook Program, Kalama Tule Chinook Program, Washougal River Tule Chinook Program, Spring Creek NFH Tule Chinook Program, Cowlitz spring Chinook Program in the Upper Cowlitz River and the Cispus River, Friends of the Cowlitz spring Chinook Program, Kalama River spring Chinook Program, Lewis River spring Chinook Program, Fish First spring Chinook Program, and the Sandy River Hatchery (ODFW stock #11) Chinook hatchery programs. Critical habitat for this species was designated on September 2, 2005 (70 FR 52630).

4.2.9.7 **California Coast Chinook Salmon ESU**

California Coastal Chinook salmon includes all naturally spawned populations of Chinook salmon from rivers and streams south of the Klamath River to the Russian River, Californian. Seven artificial propagation programs are part of this species' listing. The Humboldt Fish Action Council (Freshwater Creek), Yager Creek, Redwood Creek, Hollow Tree, Van Arsdale Fish Station, Mattole Salmon Group, and Mad River Hatchery fall-run Chinook hatchery programs. These artificially propagated populations are no more divergent relative to the local natural populations than would be expected between closely related populations within this species' listing.

California Coastal Chinook salmon are a fall-run, ocean-type fish. A spring-run (river-type) component existed historically, but is now considered extinct (Bjorkstedt et al. 2005).

Listing Status

California Coastal Chinook salmon were listed as threatened on 16 September 1999 (64 FR 50393), and they retained their threatened status on 28 June 2005 (70 FR 37160). Critical habitat for this species was designated on September 2, 2005.

California Coastal Chinook salmon were listed due to the combined effect of dams that prevent them from reaching spawning habitat, logging, agricultural activities, urbanization, and water withdrawals in the river drainages that support them.

Population Status and Trends

California coastal Chinook are listed as threatened as a result of habitat blockages, logging, agricultural activities, urbanization, and water withdrawals in the river drainages that support California coastal salmon. These have resulted in widespread declines in abundance of Chinook relative to historical levels and the present distribution of small populations with sporadic occurrences. Smaller coastal drainages such as the Noyo, Garcia and Gualala rivers may have supported Chinook salmon runs historically, but they contain few or no fish today. The Russian River probably contains some natural production, but the origin of those fish is uncertain because of a number of introductions of hatchery fish over the last century. The Eel River contains a substantial fraction of the remaining Chinook salmon spawning habitat within the species. Where available, surveys of coastal Chinook spawner abundance in some cases show improvement relative to the extremely low escapements of the early 1990s; other streams, such as Tomki Creek remain extremely depressed.

Historical estimates of escapement, based on professional opinion and evaluation of habitat conditions, suggest abundance was roughly 73,000 in the early 1960s with the majority of fish spawning in the Eel River (Good et al. 2005). The species exists as small populations with highly variable cohort sizes. The Russian River probably contains some natural production, but the origin of those fish is not clear because of a number of introductions of hatchery fish over the last century. The Eel River contains a substantial fraction of the remaining Chinook salmon spawning habitat for this species. Since its original listing and status review, little new data are available or suitable for analyzing trends or estimating changes in this population's growth rate (Good et al. 2005).

Long-term trends in Freshwater Creek are positive, and in Canyon Creek, although only slightly different than zero, the trend is positive. Long-term trends in Sprowl and Tomki creeks (tributaries of the Eel River), however, are negative. Good et al. (Good et al. 2005) caution making inferences on the basin-wide status of these populations as they may be weak because the data likely include unquantified variability due to flow-related changes in spawners' use of mainstem and tributary habitats. Unfortunately, none of the available data is suitable for analyzing the long-term trends of the ESU or estimating the population growth rate.

4.2.9.8 **Upper Columbia River Spring-run Chinook ESU**

The Upper Columbia River Spring-run Chinook ESU was listed as endangered on 28 June 2005 (70 FR37160-37204). This ESU includes all naturally spawned populations of spring Chinook salmon in all river reaches accessible to spring Chinook salmon in Columbia River tributaries upstream of Rock Island Dam and downstream of Chief Joseph Dam in Washington, and six artificial propagation programs. These propagation programs include Twisp River, Chewuch River, Methow Composite, Winthrop National Fish Hatchery, Chiwawa River, and White River.

4.2.9.9 **Upper Willamette River Chinook ESU**

The Willamette River Chinook salmon ESU was listed as threatened on 28 June 2005 (70 FR 37160-37204). This ESU includes all naturally spawned populations of spring-run Chinook salmon in the Clackamas River and Willamette River, and its tributaries, above Willamette Falls, Oregon, and seven artificial propagation programs. The artificial propagation programs are the McKenzie River Hatchery (Oregon Department of Fish and Wildlife [ODFW] stock #24), Marion Forks/North Fork Santiam River (ODFW stock #21), South Santiam Hatchery (ODFW stock #23) in the South Fork Santiam River, South Santiam Hatchery in the Calapooia River, South Santiam Hatchery in the Mollala River, Willamette Hatchery (ODFW stock #22), and Clackamas hatchery (ODFW stock #19).

4.2.9.10 **Central Valley Spring-Run Chinook ESU**

On 16 September 1999, the Central Valley Spring-run Chinook salmon ESU was listed as threatened, and it was reaffirmed as threatened on 25 June 2005 (70 FR 37160). Populations included in this ESU occur in Deer, Mill, and Butte creeks, as well as Big Chico, Antelope, Clear, Thomes, and Beegum creeks. A population also occurs in the Feather River but it is dependent on Feather River Hatchery production which is also considered part of the ESU but has hybridized with fall-run Chinook.

4.2.9.11 **Snake River Spring/Summer Run Chinook ESU**

On 28 June 2005, the Snake River Chinook salmon spring/summer-run ESU was listed as threatened (70 FR 37160-37204). This ESU includes all naturally spawned populations of spring/summer-run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins, and 15 artificial propagation programs. These artificial propagation programs include the Tucannon River conventional Hatchery, Tucannon River Captive Broodstock Program, Lostine River, Catherine Creek, Lookingglass Hatchery, Upper Grande Ronde, Imnaha River, Big Sheep Creek, McCall Hatchery, Johnson Creek Artificial Propagation Enhancement, Lemhi River Captive Rearing Experiment, Pahsimeroi Hatchery, East Fork Captive Rearing Experiment, West Fork Yankee Fork Captive Rearing Experiment, and Sawtooth Hatchery.

4.2.9.12 **Snake River Fall Run Chinook ESU**

The Snake River Chinook salmon fall-run ESU was listed as threatened on 28 June 2005 (70 FR 37160-37204). This ESU includes all naturally spawned populations of fall-run Chinook salmon in the mainstem Snake River below Hells Canyon Dam, and in the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River, and four artificial propagation programs: the Lyons Ferry Hatchery, Fall Chinook Acclimation Ponds Program, Nez Perce Tribal Hatchery, and Oxbow Hatchery fall-run Chinook hatchery programs.

4.2.9.13 Central Valley Spring-Run Chinook ESU

On 16 September 1999 the Central Valley Spring-Run Chinook salmon ESU was listed as threatened (64 FR 50394). This ESU includes all naturally spawned populations of spring-run Chinook salmon from the Sacramento River and its tributaries in California, including the Feather River. One artificial propagation program is considered part of the ESU, the Feather River hatchery spring-run Chinook program.

4.2.9.14 Sacramento River Winter Run Chinook ESU

On 4 January 1994 the Sacramento River Winter Run Chinook salmon ESU was listed as endangered (59 FR 10104). This ESU includes all naturally spawned populations of winter-run Chinook salmon in the Sacramento River and its tributaries in California. It also includes two artificial propagation programs: winter-run Chinook from the Livingston Stone National Fish Hatchery, and winter-run Chinook in a captive broodstock program maintained at Livingston Stone National Fish Hatchery and the University of California Bodega Marine Laboratory.

4.2.10 Chum Salmon

Second only to Chinook salmon in adult size, chum salmon (*Oncorhynchus keta*) individuals have been reported up to 3.6 feet (1.1 m) and 46 pounds (20.8 kg). However, average weight is around 8 to 15 pounds (3.6 to 6.8 kg).

Chum salmon are best known for the enormous canine-like fangs and striking body color of spawning males (a calico pattern, with the front two-thirds of the flank marked by a bold, jagged, reddish line and the posterior third by a jagged black line). Females are less flamboyantly colored and lack the extreme dentition of the males. Ocean stage chum salmon are metallic greenish-blue along the back with black speckles. They closely resemble both sockeye and coho salmon at this stage. As chum salmon enter fresh water, their color and appearance changes dramatically. Both sexes develop a "tiger stripe" pattern of bold red and black stripes.

In order to mate, chum salmon adults migrate from a marine environment into the freshwater streams and rivers of their birth (called anadromy). They spawn only once and then die (called semelparity). Unlike most species that rear extensively in fresh water, chum salmon form schools, presumably to reduce predation. Chum salmon feed on insects and marine invertebrates while in rivers. As adults, their diet consists of "copepods", fishes, "mollusks", squid and "tunicates".

Age at maturity appears to follow a latitudinal trend in which a greater number of fish mature at a later age in the northern portion of the species' range. Most chum salmon mature and return to their birth stream to spawn between 3 and 5 years of age, with 60 to 90 percent of the fish maturing at 4 years of age. The species has only a single form (sea-run) and does not reside in fresh water. As the time for migration to the sea approaches, juvenile chum salmon lose their parr marks (vertical bars and spots useful for camouflage). They then gain the dark back and

light belly coloration used by fish living in open water. They seek deeper water and avoid light; their gills and kidneys begin to change so that they can process salt water.

4.2.10.1 Distribution

Historically, chum salmon were distributed throughout the coastal regions of western Canada and the United States, as far south as Monterey Bay, California. Presently, major spawning populations are found only as far south as Tillamook Bay on the northern Oregon coast. Chum salmon are semelparous, spawn primarily in freshwater and, apparently, exhibit obligatory anadromy (there are no recorded landlocked or naturalized freshwater populations).

Chum salmon spend two to five years in feeding areas in the northeast Pacific Ocean, which is a greater proportion of their life history than other Pacific salmonids. Chum salmon distribute throughout the North Pacific Ocean and Bering Sea, although North American chum salmon (as opposed to chum salmon originating in Asia), rarely occur west of 175o E longitude (Johnson et al. 1997).

North American chum salmon migrate north along the coast in a narrow coastal band that broadens in southeastern Alaska, although some data suggest that Puget Sound chum, including Hood Canal summer run chum, may not make extended migrations into northern British Columbian and Alaskan waters, but instead may travel directly offshore into the north Pacific Ocean (Johnson et al. 1997).

Chum salmon, like pink salmon, usually spawn in the lower reaches of rivers, with redds usually dug in the mainstem or in side channels of rivers from just above tidal influence to nearly 100 km from the sea. Juveniles outmigrate to seawater almost immediately after emerging from the gravel that covers their redds (Salo 1991). This ocean-type migratory behavior contrasts with the stream-type behavior of some other species in the genus *Oncorhynchus* (e.g., coastal cutthroat trout, steelhead, coho salmon, and most types of Chinook and sockeye salmon), which usually migrate to sea at a larger size, after months or years of freshwater rearing. This means that survival and growth in juvenile chum salmon depend less on freshwater conditions (unlike stream-type salmonids which depend heavily on freshwater habitats) than on favorable estuarine conditions. Another behavioral difference between chum salmon and species that rear extensively in freshwater is that chum salmon form schools, presumably to reduce predation (Pitcher 1986), especially if their movements are synchronized to swamp predators (Miller and Brannon 1982).

Chum salmon have been threatened by overharvests in commercial and recreational fisheries, adult and juvenile mortalities associated with hydropower systems, habitat degradation from forestry and urban expansion, and shifts in climatic conditions that changed patterns and intensity of precipitation.

4.2.10.2 Hearing

Although the data available on the hearing sensitivities of Pacific salmon is limited, that information suggests that the species in the family Salmonidae have similar auditory systems and hearing sensitivities (Popper 1977; Popper et al. 2007; Wysocki et al. 2007). Most of the data available resulted from studies of the hearing capability of Atlantic salmon (*Salmo salar*), which is a "hearing generalist" with a relatively poor sensitivity to sound (Hawkins and Johnstone 1978). Based on the information available, we assume that the chum salmon considered in this consultation have hearing sensitivities ranging from less than 100 Hz to about 580 Hz (Hawkins and Johnstone 1978; Knudsen et al. 1992; Knudsen et al. 1994; Popper 2008).

4.2.10.3 Status and Trends

There are currently four ESUs of chum, two of which (Columbia River and the Hood Canal Summer-run) have been designated as threatened (70 FR 37161). The Puget Sound/Strait of Georgia and Pacific Coast ESUs have not yet warranted a designation of threatened or endangered (NMFS 2005b). They are not listed on the IUCN Red List of Threatened Species (IUCN 2010) or by CITES.

Chum salmon may historically have been the most abundant of all Pacific salmonids. Seven of 16 historical spawning populations in the Hood River ESU are extinct. Recently some of these populations have shown encouraging increases in numbers, but the 2005 status review report shows that the population trend overall is a 6 percent decline per year. In the Columbia River, historical populations reached hundreds of thousands to a million adults each year. In the past 50 years, the average has been a few thousand a year. Currently, it is thought that 14 of the 16 spawning populations in the Columbia River ESU are extinct. About 500 spawners occur in the ESU presently, and the long-term trend is flat (NMFS 2005b).

4.2.10.4 Columbia River Chum Salmon

Columbia River chum salmon were listed as threatened on March 25, 1999 (64 FR 14508) and reaffirmed as threatened on June 28, 2005. Columbia River chum salmon includes all natural-origin chum salmon in the Columbia River and its tributaries in Washington and Oregon, as well as three artificial propagation programs: the Chinook River (Sea Resources Hatchery), Grays River, and Washougal River/Duncan Creek chum hatchery programs. Critical habitat for this species was designated on September 2, 2005.

4.2.10.5 Hood Canal Summer-run Chum Salmon

Hood Canal summer-run chum salmon were listed as endangered under the ESA on March 25, 1999 and reaffirmed as threatened on June 28, 2005. Hood Canal summer-run chum salmon includes summer-run chum salmon populations in Hood Canal in Puget Sound and in Discovery and Sequim Bays on the Strait of Juan de Fuca. It may also include summer-run fish in the Dungeness River, but the existence of that run is uncertain. Five hatchery populations are

considered part of the species including those from the Quilcene National Fish Hatchery, Long Live the Kings Enhancement Project (Lilliwaup Creek), Hamma Hamma River Supplementation Project, Big Beef Creek reintroduction Project, and the Salmon Creek supplementation project in Discovery Bay. Although included as part of the species, none of the hatchery populations were listed. Critical habitat for this species was designated on September 2, 2005.

4.2.11 Coho Salmon

Coho salmon (*Oncorhynchus kisutch*) have dark metallic blue or greenish backs with silver sides and a light belly and there are small black spots on the back and upper lobe of the tail while in the ocean. The gumline in the lower jaw has lighter pigment than does the Chinook salmon. Spawning fish in inland rivers are dark with reddish-maroon coloration on the sides. Adult coho salmon may measure more than 2 feet (61 cm) in length and can weigh up to 36 pounds (16 kg). However, the average weight of adult coho is 8 pounds (3.6 kg)

Coho salmon adults migrate from a marine environment into freshwater streams and rivers of their birth in order to mate (called anadromy). They spawn only once and then die (called semelparity). Adults return to their stream of origin to spawn and die, usually at around three years old. Some precocious males known as "jacks" return as two-year-old spawners. Spawning males develop a strongly hooked snout and large teeth. Females prepare several redds (nests) where the eggs will remain for six to seven weeks until they hatch.

As the time for migration to the sea approaches, juvenile coho salmon lose their parr marks, a pattern of vertical bars and spots useful for camouflage, and gain the dark back and light belly coloration used by fish living in open water. Their gills and kidneys also begin to change at this time so that they can process salt water. In their freshwater stages, coho feed on plankton and insects, and switch to a diet of small fishes as adults in the ocean.

4.2.11.1 Distribution

Coho salmon occur naturally in most major river basins around the North Pacific Ocean from central California to northern Japan (Laufle et al. 1986). After entering the ocean, immature coho salmon initially remain in near-shore waters close to the parent stream. Most coho salmon adults are 3-year-olds, having spent approximately 18 months in freshwater and 18 months in salt water. Wild female coho return to spawn almost exclusively at age 3. Spawning escapements of coho salmon are dominated by a single year class. The abundance of year classes can fluctuate dramatically with combinations of natural and human-caused environmental variation.

North American coho salmon migrate north along the coast in a narrow coastal band that broadens in southeastern Alaska. During this migration, juvenile coho salmon tend to occur in both coastal and offshore waters. During spring and summer, coho salmon will forage in waters between 46o N, the Gulf of Alaska, and along Alaska's Aleutian Islands.

The factors threatening naturally reproducing coho salmon throughout its range are numerous and varied. For coho salmon populations in California and Oregon, the present depressed condition is the result of several longstanding, human-induced factors (e.g., habitat degradation, water diversions, harvest, and artificial propagation) that serve to exacerbate the adverse effects of natural environmental variability from such factors as drought, floods, and poor ocean conditions. The major activities responsible for the decline of coho salmon in Oregon and California are logging, road building, grazing, mining activities, urbanization, stream channelization, dams, wetland loss, water withdrawals and unscreened diversions for irrigation.

4.2.11.2 Hearing

Although the data available on the hearing sensitivities of Pacific salmon is limited, that information suggests that the species in the family Salmonidae have similar auditory systems and hearing sensitivities (Popper 1977; Popper et al. 2007; Wysocki et al. 2007). Most of the data available resulted from studies of the hearing capability of Atlantic salmon (*Salmo salar*), which is a "hearing generalist" with a relatively poor sensitivity to sound (Hawkins and Johnstone 1978). Based on the information available, we assume that the coho salmon considered in this consultation have hearing sensitivities ranging from less than 100 Hz to about 580 Hz (Hawkins and Johnstone 1978) (Knudsen et al. 1992; Knudsen et al. 1994).

4.2.11.3 Status and Trends

There are currently seven ESUs of coho salmon in Washington, Oregon, and California (NMFS 2005b). 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 2005b)(70 FR 37160).

Coho salmon are considered to be particularly vulnerable to anthropogenic activities such as timber harvesting, mining, and road building since they have an extended residency in freshwater environments (streams, ponds, and lakes). Catch rates for coho salmon in Alaska are at historically high levels, and most stocks are rated as stable (Navy 2006). They are not listed on the IUCN Red List of Threatened Species (IUCN 2010) or by CITES.

The long-term trend for the listed ESUs is still downward, although there was one recent good year with an increasing trend in 2001 (NMFS 2005b).

4.2.11.4 Lower Columbia River Coho Salmon

Originally part of a larger Lower Columbia River/Southwest Washington ESU, Lower Columbia coho were identified as a separate ESU and listed as threatened on June 28, 2005. The ESU includes all naturally spawned populations of coho salmon in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia up to and including the Big White Salmon and Hood Rivers, and includes the Willamette River to Willamette Falls, Oregon, as well as twenty-five artificial propagation programs: the Grays River, Sea Resources

Hatchery, Peterson Coho Project, Big Creek Hatchery, Astoria High School (STEP) Coho Program, Warrenton High School (STEP) Coho Program, Elochoman Type-S Coho Program, Elochoman Type-N Coho Program, Cathlamet High School FFA Type-N Coho Program, Cowlitz Type-N Coho Program in the Upper and Lower Cowlitz Rivers, Cowlitz Game and Anglers Coho Program, Friends of the Cowlitz Coho Program, North Fork Toutle River Hatchery, Kalama River Type-N Coho Program, Kalama River Type-S Coho Program, Washougal Hatchery Type-N Coho Program, Lewis River Type-N Coho Program, Lewis River Type-S Coho Program, Fish First Wild Coho Program, Fish First Type-N Coho Program, Syverson Project Type-N Coho Program, Eagle Creek National Fish Hatchery, Sandy Hatchery, and the Bonneville/Cascade/Oxbow complex coho hatchery programs.

4.2.11.5 Oregon Coast Coho Salmon

The Oregon Coast Coho salmon ESU includes all naturally spawned populations of Coho salmon in Oregon coastal streams south of the Columbia River and north of Cape Blanco (63 FR 42587; August 1998). One hatchery population, the Cow Creek hatchery Coho salmon, is considered part of the ESU.

4.2.11.6 Southern Oregon-Northern California Coho Salmon

This species includes all naturally-spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California, and progeny of three artificial propagation programs. The Southern Oregon-Northern California Coho Salmon (SONCC) Technical Review Team identified 50 populations that were historically present based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity (Williams et al. 2006). In some cases, the SONCC Technical Review Team also identified groups of populations referred to as "diversity strata" largely based on the geographical arrangement of the populations and basin-scale environmental and ecological characteristics. Of those populations, 13 strata and 17 populations occur within Oregon.

In most cases, populations appear to be well below the proposed viability thresholds, and the steps needed to move them toward viability will be similar, regardless of the specific recovery targets, which can be refined as more information becomes available. The SONCC Technical Review Team developed a framework to assess the viability of this species and recommended: (1) Securing all extant populations, (2) collecting distribution and abundance data, (3) minimizing straying from hatcheries to natural spawning areas, and (4) beginning critical research on climate change and its potential impacts (Williams et al. 2008). Although long-term data on abundance of SONCC coho salmon are scarce, available evidence from shorter-term research and monitoring efforts indicate that conditions have worsened for populations since the last formal status review was published (Good et al. 2005). Many independent populations are

well below low-risk abundance targets, and several are likely below the high-risk depensation thresholds specified by the Technical Review Team (Williams et al. 2008).

4.2.11.7 Central California Coho Salmon

Central California coho salmon consist of all coho salmon that reproduce in streams between Punta Gorda and the San Lorenzo River, including hatchery populations (except for the Warm Springs Hatchery on the Russian River), although hatchery populations are not listed.

4.2.12 Sockeye Salmon

Sockeye salmon (*Oncorhynchus nerka*) are the second most abundant of the seven Pacific salmon species. They have silvery sides with a green or blue back and white tips on the ventral and anal fins. Sockeye salmon have no large spots on back or tail, but some may have speckling on the back. They have no silver pigment on the tail, and they have a prominent gold eye color.

Sockeye salmon exhibit a very diverse life history, characteristically using both riverine and lake habitat throughout its range, exhibiting both freshwater resident and anadromous forms. The vast majority of sockeye salmon are anadromous fish that make use of lacustrine habitat for juvenile rearing. These "lake-type" fish typically spawn in the outlet streams of lakes and occasionally in the lakes themselves. Juvenile sockeye salmon will then use the lake environment for rearing for up to 3 years before migrating to sea. After 1 to 4 years at sea, sockeye salmon will return to their natal lake to spawn. Some sockeye, however, spawn in rivers without lake habitat for juvenile rearing. Offspring of these riverine spawners tend to use the lower velocity sections of rivers as the juvenile rearing environment for 1 to 2 years, or may migrate to sea in their first year.

Sockeye salmon also have a wholly freshwater life history form, called kokanee (Burgner 1991). In some cases a single population will give rise to both the anadromous and freshwater life history form. While in fresh water juveniles of both life history types prey primarily upon insects. The presence of both life history types may be related to the energetic costs of outmigrating to sea, and the productivity of the lacustrine system they inhabit. In coastal lakes, where the migration to sea is relatively short and energetic costs are minimal, kokanee populations are rare.

4.2.12.1 Distribution

Sockeye salmon occur in the North Pacific and Arctic oceans and associated freshwater systems. This species ranges south as far as the Sacramento River in California and northern Hokkaido in Japan, to as far north as far as Bathurst Inlet in the Canadian Arctic and the Anadyr River in Siberia (Burgner 1991). The largest populations, and hence the most important commercial populations, occur north of the Columbia River.

4.2.12.2 Hearing

Although the data available on the hearing sensitivities of Pacific salmon is limited, that information suggests that the species in the family Salmonidae have similar auditory systems and hearing sensitivities (Popper 1977; Popper et al. 2007; Wysocki et al. 2007). Most of the data available resulted from studies of the hearing capability of Atlantic salmon (*Salmo salar*), which is a "hearing generalist" with a relatively poor sensitivity to sound (Hawkins and Johnstone 1978). Based on the information available, we assume that the sockeye salmon considered in this consultation have hearing sensitivities ranging from less than 100 Hz to about 580 Hz (Hawkins and Johnstone 1978) (Knudsen et al. 1992; Knudsen et al. 1994).

4.2.12.3 Status and Trends

An analysis of total annual Ozette Lake sockeye salmon abundance (based on adult run size data presented in Jacobs et al. 1996) indicates a trend in abundance averaging -2 percent per year over the period 1977 through 1998 (NMFS 2009). The current tributary-based hatchery program was planned and initiated in response to the declining population trend identified for the Ozette Lake sockeye salmon population. The most recent (1996 to 2003) run-size estimates range from a low of 1,609 in 1997 to a high of 5,075 in 2003, averaging approximately 3,600 sockeye per year. For return years 2000 to 2003, the 4-year average abundance estimate was slightly over 4,600 sockeye. Because run-size estimates before 1998 are likely to be even more unreliable than recent counts, and new counting technology has resulted in an increase in estimated run sizes, no statistical estimation of trends is reported. The current trends in abundance are unknown for the beach spawning aggregations. Although overall abundance appears to have declined from historical levels, whether this resulted in fewer spawning aggregations, lower abundances at each aggregation, or both, is not known (Good et al. 2005). Based on estimates of habitat carrying capacity, a viable sockeye salmon population in Lake Ozette watershed would range between 35,500 to 121,000 spawners (Rawson et al. 2009).

There has been no harvest of Ozette Lake sockeye salmon for the past four brood-cycle years (since 1982). Prior to that time, ceremonial and subsistence harvests by the Makah Tribe were low, ranging from 0 to 84 fish per year. Harvest has not been an important mortality factor for the population in over 35 years. In addition, due to the early river entry timing of returning Ozette Lake sockeye salmon (beginning in late April, with the peak returns prior to late-May to mid-June), the fish are not intercepted in Canadian and United States marine area fisheries directed at Fraser River sockeye salmon. There are currently no known marine area harvest impacts on Ozette Lake sockeye salmon.

Overall abundance is substantially below historical levels (Good et al. 2005). Declines in abundance have been attributed to a combination of introduced species, predation, loss of tributary populations, a loss of quality of beach spawning habitat, temporarily unfavorable ocean conditions, habitat degradation, and excessive historical harvests (Jacobs et al. 1996). In the last

few years the number of returning adults has increased, although some of these individuals are of hatchery origin. This produces uncertainty regarding natural growth rate and productivity of the ESU's natural component. In addition, genetic integrity has perhaps been compromised due to the artificial supplementation that has occurred in this population, since approximately one million sockeye have been released into the Ozette watershed from the late 1930s to present (Boomer 1995; Kemmerich 1945).

4.2.12.4 Ozette Lake Sockeye Salmon

This ESU includes all naturally spawned sockeye salmon in Ozette Lake, Ozette River, Coal Creek, and other tributaries flowing into Ozette Lake, Washington. Composed of only one population, the Ozette Lake sockeye salmon ESU consists of five spawning aggregations or subpopulations which are grouped according to their spawning locations. The five spawning locations are Umbrella and Crooked creeks, Big River, and Olsen's and Allen's beaches (NMFS 2009).

Adult Ozette Lake sockeye salmon enter Ozette Lake through the Ozette River from mid-April to mid-August, holding three to nine months in Ozette Lake prior to spawning in late October through January. Sockeye salmon spawn primarily in lakeshore upwelling areas in Ozette Lake (particularly at Allen's Bay and Olsen's Beach), and in two tributaries Umbrella Creek and Big River. Minor spawning may occur below Ozette Lake in the Ozette River or in Coal Creek, a tributary of the Ozette River. Beach spawners are almost all age-4 adults, while tributary spawners are ages 3 and 5 (NMFS 2009). Spawning occurs in the fall through early winter, with peak spawning in tributaries in November and December. Eggs and alevins remain in the gravel until the fish emerge as fry in spring. Fry then migrate immediately to the limnetic zone in Ozette Lake, where the fish rear. After one year of rearing, in late spring, Ozette Lake sockeye salmon emigrate seaward as age-1+ smolts, where they spend between 1 and 3 years in ocean before returning to fresh water.

Snake River sockeye salmon

On 28 June 2005, the Snake River Sockeye ESU was listed as threatened (70 FR 37160). This ESU includes all anadromous and residual sockeye salmon from the Snake River Basin, Idaho, and artificially propagated sockeye salmon from the Redfish Lake captive propagation program.

4.2.13 Steelhead

Steelhead trout (*Oncorhynchus mykiss*) are usually dark-olive in color, shading to silvery-white on the underside with a heavily speckled body and a pink to red stripe running along their sides. Steelhead trout can reach up to 55 pounds (25 kg) in weight and 45 inches (120 cm) in length, though average size is much smaller. They

They are a unique species; individuals develop differently depending on their environment. While all *O. mykiss* hatch in gravel-bottomed, fast-flowing, well-oxygenated rivers and streams, some stay in fresh water all their lives. These fish are called rainbow trout. The steelhead that migrate to the ocean develop a much more pointed head, become more silvery in color, and typically grow much larger than the rainbow trout that remain in fresh water.

Adults migrate from a marine environment into the freshwater streams and rivers of their birth in order to mate (called anadromy). Unlike other Pacific salmonids, they can spawn more than one time (called iteroparity). Migrations can be hundreds of miles. Young animals feed primarily on zooplankton. Adults feed on aquatic and terrestrial insects, mollusks, crustaceans, fish eggs, minnows, and other small fishes (including other trout).

Maximum age is about 11 years. Males mature generally at two years and females at three. Juvenile steelhead may spend up to seven years in freshwater before migrating to estuarine areas as smolts and then into the ocean to feed and mature. They will remain at sea for up to three years before returning to freshwater to spawn. Some populations actually return to freshwater after their first season in the ocean, but do not spawn, and then return to the sea after one winter season in freshwater. Timing of return to the ocean can vary, and even within a stream system there can be different seasonal runs.

Steelhead can be divided into two basic reproductive types, stream-maturing or ocean-maturing, based on the state of sexual maturity at the time of river entry and duration of spawning migration. The stream-maturing type (summer-run steelhead in the Pacific Northwest and northern California) enters freshwater in a sexually immature condition between May and October and requires several months to mature and spawn. The ocean-maturing type (winter-run steelhead in the Pacific Northwest and northern California) enters freshwater between November and April, with well-developed gonads, and spawns shortly thereafter. Coastal streams are dominated by winter-run steelhead, whereas inland steelhead of the Columbia River basin are almost exclusively summer-run steelhead.

Steelhead spawn in cool, clear streams featuring suitable gravel size, depth, and current velocity. Intermittent streams may also be used for spawning (Barnhart 1986; Everest 1972). Depending on water temperature, steelhead eggs may incubate for 1.5 to 4 months (August 9, 1996, 61 FR 41542) before hatching. Juveniles rear in fresh water from one to four years before migrating to the ocean as smolts (August 9, 1996, 61 FR 41542). Winter steelhead populations generally smolt after two years in fresh water (Busby et al. 1996).

Steelhead typically reside in marine waters for two or three years before migrating to their natal streams to spawn as four- or five-year olds (August 9, 1996, 61 FR 41542). Populations in Oregon and California have higher frequencies of age-1-ocean steelhead than populations to the

north, but age-2-ocean steelhead generally remain dominant (Busby et al. 1996). Age structure appears to be similar to other west coast steelhead, dominated by four-year-old spawners (Busby et al. 1996).

Adult female steelhead will prepare a redd (or nest) in a stream area with suitable gravel type composition, water depth, and velocity. The adult female may deposit eggs in 4 to 5 "nesting pockets" within a single redd. The eggs hatch in 3 to 4 weeks

4.2.13.1 Distribution

The ocean distributions for listed steelhead are not known in detail, but steelhead are caught only rarely in ocean salmon fisheries. The total catch of steelhead in Canadian fisheries is low and consideration of the probable population composition suggests that these fewer than 10 of the individual captured in these fisheries represent individuals from the combination of the five endangered or threatened steelhead populations.

Summer steelhead enter freshwater between May and October in the Pacific Northwest (Busby et al. 1996). They require cool, deep holding pools during summer and fall, prior to spawning. They migrate inland toward spawning areas, overwinter in the larger rivers, resume migration in early spring to natal streams, and then spawn (Bjornn and Reiser 1991).

Winter steelheads enter freshwater between November and April in the Pacific Northwest (Busby et al. 1996), migrate to spawning areas, and then spawn in late winter or spring. Some adults, however, do not enter coastal streams until spring, just before spawning. Steelhead typically spawn between December and June, and the timing of spawning overlaps between populations regardless of run type (Busby et al. 1996).

4.2.13.2 Hearing

Although the data available on the hearing sensitivities of Pacific salmon is limited, that information suggests that the species in the family Salmonidae have similar auditory systems and hearing sensitivities (Popper 1977; Popper et al. 2007; Wysocki et al. 2007). Most of the data available resulted from studies of the hearing capability of Atlantic salmon (*Salmo salar*), which is a "hearing generalist" with a relatively poor sensitivity to sound (Hawkins and Johnstone 1978). Based on the information available, we assume that the steelhead considered in this consultation have hearing sensitivities ranging from less than 100 Hz to about 580 Hz (Hawkins and Johnstone 1978) (Knudsen et al. 1992; Knudsen et al. 1994).

4.2.13.3 Lower Columbia River Steelhead

Lower Columbia River steelhead include naturally-produced steelhead returning to Columbia River tributaries on the Washington side between the Cowlitz and Wind rivers in Washington and on the Oregon side between the Willamette and Hood rivers, inclusive. In the Willamette River, the upstream boundary of this species is at Willamette Falls. This species includes both

winter and summer steelhead. Two hatchery populations are included in this species, the Cowlitz Trout Hatchery winter-run stock and the Clackamas River stock (ODFW stock 122) but neither was listed as threatened.

4.2.13.3.1 Listing status

Lower Columbia River steelhead were listed as threatened under the ESA on January 5, 2006. Critical habitat for this species was designated on September 5, 2005 (70 FR 52630).

4.2.13.3.2 Population status and trends

There are no historical estimates of this species' abundance. Because of their limited distribution in upper tributaries and urbanization in the lower tributaries (e.g., the lower Willamette, Clackamas, and Sandy Rivers run through Portland or its suburbs), habitat degradation appears to have threatened summer steelhead more than winter steelhead. Steelhead populations in the lower Willamette, Clackamas, and Sandy Rivers appear stable or slightly increasing although sampling error limits the reliability of this trend. Total annual run size data are only available for the Clackamas River (1,300 winter steelhead, 70 percent hatchery; 3,500 wild summer steelhead).

Middle Columbia River steelhead

The Middle Columbia River Steelhead DPS was listed as threatened on 5 January 2006 (71 FR 834-862). Critical habitat has been designated for this DPS. This DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in streams from above the Wind River, Washington, and the Hood River, Oregon, upstream to, and including, the Yakima River, Washington, excluding steelhead from the Snake River Basin, and seven artificial propagation programs. The seven artificial propagation programs included are Touchet River Endemic, Yakima River Kelt Reconditioning Program in Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River, as well as Umatilla River, and Deschutes River.

Lower Columbia River steelhead

On 5 January 2006, the Lower Columbia River Steelhead DPS was listed as threatened (71 FR 834-862). Critical habitat has been designated for this DPS. This DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in streams and tributaries to the Columbia River between the Cowlitz and Wind Rivers, Washington, and the Willamette and Hood Rivers, Oregon, and 10 artificial propagation programs. The ten artificial propagation programs include Cowlitz Trout Hatchery in the Cispus, Upper Cowlitz, Lower Cowlitz, and Tilton Rivers; the Kalama River Wild winter and summer run, Clackamas Hatchery, Sandy Hatchery, and the Hood River Hatchery winter and summer run. Populations excluded from this DPS are in the upper Willamette River Basin

Upper Willamette River steelhead

The Upper Willamette River DPS was listed as threatened on 5 January 2006 (71 FR 834-862). Critical habitat has been designated for this DPS. This DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River.

Snake River Basin steelhead

The Snake River Basin Steelhead DPS was listed as threatened on 5 January 2006 (71 FR 834-862). Critical habitat has been designated for this DPS. This DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in streams in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho, and six artificial propagation programs. These artificial propagation programs are Tucannon River, Dworshak National Fish Hatchery, Lolo Creek, North Fork Clearwater, East Fork Salmon River, and Little Sheep Creek/Imnaha River.

4.2.13.4 Puget Sound Steelhead

The Puget Sound steelhead species includes all naturally spawned anadromous winter-run and summer-run steelhead populations, in streams in the river basins of the Strait of Juan de Fuca, Puget Sound, and Hood Canal, Washington, bounded to the west by the Elwha River (inclusive) and to the north by the Nooksack River and Dakota Creek (inclusive), as well as the Green River natural and Hamma Hamma winter-run steelhead hatchery stocks.

4.2.13.4.1 Listing Status

Puget Sound steelhead were listed as threatened under the ESA on May 11, 2007 (72 FR 26722) and affirmed as threatened on August 15, 2011 (76 FR 50448). Critical habitat for this species has not been designated.

4.2.13.4.2 Population Status and Trends

The DPS was listed as a threatened species on 7 May 2007 (72 FR 26722). Run size was calculated in the early 1980s at about 100,000 winter-run fish and 20,000 summer-run fish. It is not clear what portion were hatchery fish, but a combined estimate with coastal steelhead suggested that roughly 70 percent of steelhead in ocean runs were of hatchery origin. The percentage in escapement to spawning grounds would be substantially lower due to differential harvest and hatchery rack returns. By the 1990s, total run size for four major stocks exceeded 45,000; roughly half of which was natural escapement.

Nehlsen et al. (1991) identified nine Puget Sound steelhead stocks at some degree of risk or concern, while the WDFW et al. (1993) estimated that 31 of 53 stocks were of native origin and predominantly natural production. Their assessment of the status of these 31 stocks was 11 healthy, three depressed, one critical, and 16 of unknown status. Their assessment of the status of the remaining (not native/natural) stocks was three healthy, 11 depressed, and eight of unknown status.

Of the 21 populations in the Puget Sound DPS reviewed by Busby et al. (1996), 17 had declining and four increasing trends, with a range from 18 percent annual decline (Lake Washington winter-run steelhead) to 7 percent annual increase (Skykomish River winter-run steelhead). These trends were for the late-run naturally produced component of winter-run steelhead populations; no adult trend data were available for summer-run steelhead. Most of these trends were based on relatively short data series. The Skagit and Snohomish River winter-run populations have been approximately three to five times larger than the other populations in the DPS, with average annual spawning of approximately 5,000 and 3,000 total adult spawners, respectively. These two basins exhibited modest overall upward trends at the time of the Busby et al. (1996) report. Busby et al. (1996) estimated five-year average natural escapements for streams with adequate data range from less than 100 to 7,200, with corresponding total run sizes of 550 to 19,800.

4.2.13.5 Northern California Steelhead

The Northern California steelhead species includes steelhead in California coastal river basins from Redwood Creek south to the Gualala River, inclusive. Major river basins containing spawning and rearing habitat for this species comprise approximately 6,672 square miles in California.

4.2.13.5.1 Listing Status

Northern California steelhead were listed as threatened under the ESA on January 5, 2006. Critical habitat for this species was designated on September 5, 2005 (70 FR 52488).

4.2.13.5.2 Population Status and Trends

Population abundances are very low relative to historical estimates. While no overall recent abundance estimates are available for the species, counts at Cape Horn Dam have declined from 4,400 adults in the 1930s to an average of 30 wild adults in 1996.

4.2.13.6 Central California Coast Steelhead

The Central California Coast steelhead species includes steelhead in river basins from the Russian River to Soquel Creek, Santa Cruz County (inclusive) and the drainages of San Francisco and San Pablo bays; the Sacramento-San Joaquin River Basin of the Central Valley of California is excluded.

4.2.13.6.1 Listing Status

Northern California steelhead were listed as threatened under the ESA on 5 January 2006. Critical habitat for this species was designated on 5 September 2005 (70 FR 52488).

4.2.13.6.2 Population Status and Trends

Abundance in the Russian and San Lorenzo Rivers, the river systems with the two largest spawning populations of this steelhead has been estimated at about 15 percent of historical abundance. There are no recent estimates of abundance for this species.

4.2.13.7 California Central Valley steelhead

The California Central Valley Steelhead DPS was listed as threatened on 5 January 2006 (71 FR 834-862). Critical habitat has been designated for this DPS. This DPS includes all naturally spawned populations of steelhead (and their progeny) in the Sacramento and San Joaquin Rivers and their tributaries, excluding steelhead from San Francisco Bay and San Pablo Bays and their tributaries.

4.2.13.8 Central California Coast steelhead

The Central California Coast Steelhead DPS was listed as threatened on 5 January 2006 (71 FR 834-862). Critical habitat has been designated for this DPS. This DPS includes all naturally spawned populations of steelhead (and their progeny) in streams from the Russian River to Aptos Creek, Santa Cruz County, California (inclusive). It also includes the drainages of San Francisco and San Pablo Bays.

4.2.13.9 South-Central California Coast steelhead

The South-Central California Coast Steelhead DPS was listed as threatened on 5 January 2006 (71 FR 834-862). Critical habitat has been designated for this DPS. This DPS includes all naturally spawned populations of steelhead (and their progeny) in streams from the Pajaro River (inclusive), located in Santa Cruz County, California, to, but not including, the Santa Maria River, California.

4.2.13.10 Southern California Coast steelhead

The Southern California Coast Steelhead DPS was listed as threatened on 5 January 2006 (71 FR834-862). Critical habitat has been designated for this DPS. This DPS includes all naturally spawned anadromous steelhead populations below natural and man-made impassable barriers in streams from the Santa Maria River, San Luis Obispo County, California (inclusive) to the U.S.-Mexico Border.

4.2.14 Trends in the Status of ESA-Listed Species Present in the Action Area

The Endangered Species Act (ESA) Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species (the "Report") summarizes efforts to recover all domestic species under NOAA Fisheries' jurisdiction. The current report spans October 1, 2010 to

September 30, 2012 and is summarized in **Table 10** below for the purpose of establishing a baseline for assessing changes in the status of the species in the reasonably foreseeable future.

Table 10. Trends in the Status of ESA-Listed Species Present in the Action Area

Species Status ESA-Listed species under NMFS jurisdiction including listing status, trends, priority numbers, recovery plan status, and 5-year completion						
SEA TURTLES						
Species/ESU/DPS	**Date Listed/Reclassified**	**ESA Status**	**Species/ESU/DPS Trend**	**Recovery Priority Number**[9]	**Status of Recovery Plan**	**Date 5-Year Status Review**
Leatherback sea turtle	6/2/1970	E	Declining (Pacific); Mixed (Atlantic)	1	Completed 1/1998 (Pacific); 4/1992 (Atlantic)	08/2007, review initiated 10/2012
PACIFIC SALMON						
Northwest Region						
Puget Sound Chinook ESU	3/24/1999; 6/28/2005[10]	T	Stable or Increasing	1	Completed 1/2007	08/2011
Hood Canal Summer-run chum ESU	3/25/1999; 6/28/2005[10]	T	Stable or Increasing	1	Completed 5/2007	08/2011
Ozette Lake sockeye ESU	3/25/1999; 6/28/2005[10]	T	Stable or Increasing	1	Completed 5/2009	08/2011
Puget Sound steelhead DPS	5/11/2007	T	Declining	1	Under Developed	08/2011
Upper Wilamette River Chinook ESU	3/24/1999; 6/28/2005[10]	T	Stable or Increasing	1	Completed 8/2011	08/2011
Lower Columbia River Chinook ESU	6/28/2005[10]	T	Stable or Increasing	1	Draft Completed 5/2012	08/2011
Lower Columbia River Steelhead DPS	3/19/1998; 1/5/2006[10]	T	Stable or Increasing	1	Draft Completed 5/2012	08/2011
Lower Columbia River Coho ESU	3/24/1999; 6/28/2005[10]	T	Stable or Increasing	1	Draft Completed 5/2012	08/2011

[9] Recovery Priority Numbers are designated according to guidelines published by NMFS on June 15, 1990 (55 FR 24296). Priorities are designated from 1 (high) to 12 (low) based on the following factors: degree of threat, recovery potential, and conflict with development projects or other economic activity. See Appendix A for further information on NMFS Recovery Priority Numbers, including criteria used to designate numbers.

[10] In Alsea Valley Alliance V. Evans, 161 F. Supp, 2d 1154 (D.Or. 2001)(Alsea), the U.S. District Court in Eugene, Oregon, ruled that NMFS could not exclude hatchery fish within the ESU when listing. Although the Alsea ruling affected only one ESU, subsequent to the ruling, NMFS initiated new status reviews for 27 ESUs and, in 2005, re-listed 15 ESUs of salmon with revised definitions of the populations to be included in the ESU, delisted one ESU (OR Coast coho) and listed one ESU (Lower Columbia River coho); and in 2006, re-listed 10 ESUs of steelhead (and called them DPSs).

Columbia River chum ESU	3/25/1999; 6/28/2005	T	Stable or Increasing	1	Draft Completed 5/2012	08/2011
Upper Wilamette River steelhead DPS	3/25/1999; 1/5/2006[10]	T	Stable or Increasing	1	Completed 8/2011	08/2011
Upper Columbia River, Spring Run Chinook ESA	3/24/1999; 6/28/2005[10]	E	Stable or Increasing	1	Completed 10/2007	08/2011
Snake River Spring/Summer-run Chinook ESU	4/22/1992; 6/28/2005[10]	T	Stable or Increasing	1	Under Development	08/2011
Snake River Fall-run Chinook ESU	4/22/1992; 6/28/2005[10]	T	Stable or Increasing	1	Under Development	08/2011
Upper Columbia River steelhead DPS	8/18/1997; 1/5/2006[10]	T	Stable or Increasing	1	Completed 10/2007	08/2011
Middle Columbia River steelhead DPS	3/25/1999; 1/5/2006[10]	T	Stable or Increasing	1	Completed 09/2009	08/2011
Snake River Basin steelhead DPS	8/18/1997; 1/5/2006[10]	T	Stable or Increasing	1	Under Development	08/2011
Snake River sockeye ESU	11/20/1991; 6/28/2005[10]	E	Unknown	3	Under Development	08/2011
Oregon Coast coho ESU	8/10/1998[10]	T	Stable or Increasing	1	Under Development	08/2011
Northwest and Southwest Regions						
Southern Oregon/Northern California Coast coho ESU	5/6/1997; 6/28/2005[10]	T	Unknown	1	Draft Completed 1/2012	11/2011
Southwest Region						
Central California Coast coho ESU	10/31/1996; 6/28/2005[10]	E	Declining	1	Completed 09/2012	08/2011
Northern California steelhead DPS	6/7/2000; 1/5/2006[10]	T	Unknown	5	Under Development	12/2011
California Coastal Chinook ESU	9/16/1999; 6/28/2005[10]	T	Unknown	3	Under Development	08/2011
Central California Coast steelhead DPS	8/18/1997; 1/5/2006[10]	T	Unknown	3	Under Development	12/2011
South-Central California	8/18/1997;	T	Unknown	3	Draft Completed	12/2011

Coast steelhead DPS	1/5/2006[10]				10/2012	
Southern California Coast steelhead DPS	8/18/1997; 05/01/2002[11]; 1/5/2006[10]	E	Unknown	3	Completed 1/2012	12/2011
Sacramento River Winter-run Chinook ESU	11/5/1990; 1/4/1994; [12]6/28/2005[10]	E	Stable or Increasing	3	Draft Completed 10/2009	08/2011
Central Valley Spring-run Chinook ESU	9/16/1999; 6/28/2005[10]	T	Stable or Increasing	7	Draft Completed 10/2009	08/2011
California Central Valley	3/19/1998; 6/28/2005[10]	T	Unknown	7	Draft Completed 10/2009	08/2011
CETACEANS						
Blue Whale	6/2/1970	E	Unknown	5	Completed 7/1998	N/A
Fin whale	6/2/1970	E	Unknown	9	Completed 7/2010	12/2011
Humpback whale	6/2/1970	E	Increasing	5	Completed 11/1991	In progress
Killer whale-Southern Resident DPS	11/18/2005	E	Declining	3	Completed 1/2008	03/2011
Sperm whale	6/2/1970	E	Unknown	5	Completed 12/2010	01/2009

[11] This ESU was first listed on 8/18/1997; the southern range extension to the U.S. –Mexico border was added to the listing for this ESU Via a final rule on 5/1/2002.

[12] This ESU was First emergency-listed as threatened on 8/4/1989, then officially listed as threatened on 11/5/1990, then reclassified as endangered on 1/4/1994.

5 ENVIRONMENTAL BASELINE

By regulation, environmental baselines for biological opinions include the past and present impacts of all state, Federal or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR §402.02). The environmental baseline for this Opinion includes the effects of several activities that affect the survival and recovery of listed species.

Some of those activities, most notably commercial whaling, occurred extensively in the past, ended, and no longer appear to affect the whale populations, although the effects of these reductions likely persist today. Similarly harvest of salmon and other listed marine fishes have been reduced or eliminated to protect listed species. Other human activities are ongoing and appear to continue to affect listed species. The following discussion summarizes the principal phenomena that are known to affect the likelihood that these endangered and threatened species will survive and recover in the wild.

5.1.1 The Environmental Setting

The action area includes Puget Sound, the Georgia Basin, and waters off the Pacific coast of the states of Washington, Oregon, and California. Because all of the military readiness activities associated with the NWTRC occur in Puget Sound and waters off the Pacific coast of Washington State, this section of this Opinion focuses on Puget Sound, the adjacent Georgia Basin, and waters off the Pacific coast of Washington.

Puget Sound is a system of marine waterways and basins that connect to the Strait of Juan de Fuca and the Pacific Ocean. Puget Sound proper encompasses all waters south of a line connecting Point Wilson on the Olympic Peninsula and Partridge on Whidbey Island; West Point on Whidbey Island, Deception Island, and Rosario Head on Fidalgo Island; and the southern end of Swinomish Channel between Fidalgo Island and McGlinn Island. The sound extends about 144 kilometers (90 miles) from Deception Pass in the north to Olympia, Washington, in the south.

However, the term "Puget Sound" also refers to the Puget Sound Basin, which includes the waters around the San Juan Islands; Bellingham, Padilla, and Samish Bays, and Hale Passage. This basin encompasses a 13,700-square-mile area that drains into Puget Sound and adjacent marine waters; the basin includes all or part of 13 counties in western Washington, as well as the headwaters of the Skagit River and part of the Nooksack River in British Columbia, Canada. Streams and rivers that flow into the Sound drain three physiographic provinces — the Olympic Mountains on the west, the Cascade Range on the east, and the Puget Lowlands in the center of

the basin. More than 10,000 streams and rivers drain into the Puget Sound basin, with almost 85 percent of the basin's annual surface water runoff coming from 10 rivers: the Nooksack, Skagit, Snohomish, Stillaguamish, Cedar/Lake Washington Canal, Green/Duwamish, Puyallup, Nisqually, Skokomish and Elwha Rivers.

The Strait of Georgia, or Gulf of Georgia, is a strait between Vancouver Island, the Gulf Islands, and the mainland coast of British Columbia. The Strait is about 240 kilometers (150 mi) long and varies in width from 18.5 to 55 km (11.5 to 34 mi). The Gulf Islands and San Juan Islands mark the southern boundary of the strait while the Discovery Islands mark the northern boundary of the strait. On the southern boundary, the Strait of Georgia is connected to the Strait of Juan de Fuca through Haro Strait and Rosario Strait. On the northern boundary, Discovery Passage is the primary channel that connects the Strait to Johnstone Strait. The Strait has a mean depth of about 156 meters (510 ft), with a maximum depth of 420 meters (1,400 ft). Its surface area is approximately 6,800 square kilometers (2,600 sq mi). The Fraser River contributes about 80 percent of the freshwater entering the Strait of Georgia.

In 2000, nearly seven million people were living in the Georgia Basin-Puget Sound Region (a region that is also known as the Salish Sea). Of this total, about four million (57 percent) people lived in the United States and three million (43 percent) lived in Canada. These totals represented a 17 percent increase for the Puget Sound region and a 21 percent increase in the Georgia Basin from 1991 population estimates. By 2020 the population is projected to exceed five million people (29 percent increase) in the Puget Sound basin and exceed four million people (35 percent increase) in the Georgia Basin.

In 2000, the greater Vancouver (British Columbia, Canada) Regional District and King County (Washington State) accounted for 29 percent and 25 percent of the total population in the two basins; as a result, more than half of the population in the Georgia Basin-Puget Sound Basin lived in those two metropolitan areas. Urban growth is rapid; by 2020, the population is expected to increase by 1.1 million people, with most of that increase occurring in urban and suburban areas of the sound. Urban and agricultural land uses, which cover about 9 and 6 percent of the basin, respectively, are concentrated in the lowlands. Forest dominates land use and cover in the basin and is concentrated in the foothills and mountains.

Puget Sound, the Georgia Basin, and waters off the Pacific coast of Washington State are critically important to several endangered and threatened species under NMFS's jurisdiction, including southern resident killer whales, Puget Sound Chinook salmon, Hood canal summer-run chum salmon, and Puget Sound steelhead. Waters off the southwest coast of Vancouver Island are a foraging destination for blue whales and fin whales and might support a resident population of blue whales (Burtenshaw et al. 2004), and are important for the continued persistence and recovery of blue whales.

5.1.2 Climate Change

There is now widespread consensus within the scientific community that average atmospheric temperatures on earth are increasing (warming) and that this will continue for at least the next several decades (IPCC 2014) (IPCC 2001; Oreskes 2004; Poloczanska et al. 2013). There is also consensus within the scientific community that this warming trend will alter current weather patterns and patterns associated with climatic phenomena, including the timing and intensity of extreme events such as heat-waves, floods, storms, and wet-dry cycles. The threats posed by the direct and indirect effects of global climate change are, or will be, common to all of the species we discuss in this Opinion (Doney et al. 2012; Hazen et al. 2012; Poloczanska et al. 2013).

Climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the reasonably foreseeable future (Houghton 2001; IPCC 2001; Parry et al. 2007) (IPCC 2001; IPCC 2002). The direct effects of climate change will result in increases in atmospheric temperatures, changes in sea surface temperatures, patterns of precipitation, and sea level. Oceanographic models project a weakening of the thermohaline circulation resulting in a reduction of heat transport into high latitudes of Europe, an increase in the mass of the Antarctic ice sheet, and a decrease in the Greenland ice sheet, although the magnitude of these changes remain unknown. Species that are shorter-lived, of larger body size, or generalist in nature are liable to be better able to adapt to climate change over the long term versus those that are longer-lived, smaller-sized, or rely upon specialized habitats (Brashares 2003; Cardillo 2003; Cardillo et al. 2005; Issac 2009; Purvis et al. 2000). Climate change is most likely to have its most pronounced effects on species whose populations are already in tenuous positions (Issac 2009). As such, we expect the risk of extinction to listed species to rise with the degree of climate shift associated with global warming.

The Intergovernmental Panel on Climate Change (IPCC) (IPCC 2014) estimated that by the mid-21st century, the spatial shifts of marine species will cause species richness to increase at mid and high latitudes (high confidence) and to decrease at tropical latitudes (medium confidence), resulting in global redistribution of catch potential for fishes and invertebrates, with implications for food security. Animal displacements are projected to lead to high-latitude invasions and high local-extinction rates in the tropics and semi-enclosed seas. This will cause a 30–70% increase in the fisheries yield of some high-latitude regions by 2055 (relative to 2005), a redistribution at mid latitudes, but a drop of 40%- 60% in the tropics and the Antarctic, based on 2°C warming above pre-industrial values (medium confidence in the direction of trends in fisheries yields, low confidence in the magnitude of change). If a decrease in global net primary production (NPP) or a shift towards smaller primary producers occurs, the overall fisheries catch potential may also decrease.

The genetic and physiological underpinning of climate sensitivity of organisms sets the boundaries for ecosystem response and provides crucial information on sensitivities, resilience, and the direction and scope of future change. As anthropogenic climate change accelerates, a key issue is whether and how quickly organisms can compensate for effects of individual or multiple drivers, by short-term acclimatization or long-term evolutionary adaptation across generations. Evolutionary adaptation depends on the genetic variation within a population, from which the environment selects the fittest genotypes (Rando and Verstrepen, 2007; Reusch and Wood, 2007). Genetic variation depends on mutation rates, generation time, and population size (Bowler et al., 2010). However, epigenetic mechanisms, such as modifications of the genome by DNA methylation, can also influence fitness and adaptation (Richards, 2006) and can be remarkably rapid as seen in terrestrial ecosystems (Bossdorf et al., 2008). In plants and animals the rate of evolutionary adaptation is constrained by long generation times, but enhanced by high phenotypic variability and high mortality rates among early life stages as a selection pool (e.g., Sunday et al., 2011).

The limits to acclimatization or adaptation capacity are presently unknown. However, mass extinctions occurring during much slower rates of climate change in Earth history suggest that evolutionary rates in some organisms may not be fast enough to cope. (IPCC 2014)

Local adaptation may reduce climate vulnerability at the species level, by causing functional and genetic differentiation between populations, thereby enabling the species to cover wider temperature ranges and live in heterogeneous environments. Local adaptation on small spatial scales is particularly strong in intertidal organisms (Kelly et al., 2012). On larger scales, the widening biogeographic and roaming ranges of Northern hemisphere eurytherms into Arctic waters (Pörtner et al., 2008) are supported by the differentiation into populations with diverse thermal ranges, combined with high acclimatization capacity. By contrast, such capacity is small in high polar, e.g. Antarctic species (Peck et al., 2010). Tropical reef fishes undergo rapid warm acclimation across generations (Donelson et al., 2012) but some may approach animal heat limits. The rates, mechanisms and limits of thermal acclimatization and evolutionary adaptation are poorly understood (low confidence).

The IPCC also estimated that average global land and sea surface temperature has increased by 0.6°C (±0.2) since the mid-1800s, with most of the change occurring since 1976. Eleven of the 12 warmest years on record since 1850 have occurred since 1995 (Poloczanska et al. 2009). Furthermore, the Northern Hemisphere (where a greater proportion of ESA-listed species occur) is warming faster than the Southern Hemisphere, although land temperatures are rising more rapidly than over the oceans (Poloczanska et al. 2009). This temperature increase is greater than what would be expected given the range of natural climatic variability recorded over the past 1,000 years (Crowley 2000). Furthermore, the Northern Hemisphere (where a greater proportion of ESA-listed species occur) is warming faster than the Southern Hemisphere, although land

temperatures are rising more rapidly than over the oceans (Poloczanska et al. 2009). The Intergovernmental Panel on Climate Change reviewed computer simulations of the effect of greenhouse gas emissions on observed climate variations that have been recorded in the past and evaluated the influence of natural phenomena such as solar and volcanic activity. Based on their review, the Intergovernmental Panel on Climate Change concluded that natural phenomena are insufficient to explain the increasing trend in land and sea surface temperature, and that most of the warming observed over the last 50 years is likely to be attributable to human activities (IPCC 2001). Climatic models estimate that global temperatures would increase between 1.4 to 5.8°C from 1990 to 2100 if humans do nothing to reduce greenhouse gas emissions (IPCC 2001). Fiedler et al. (2013) for the 50-year period from 1958-2008 concluded that climatic variability has led to documented changes in the pycnocline in the eastern tropical and North Pacific. In particular, "in the eastern equatorial Pacific the pycnocline shoaled by 10 m and weakened by 5 percent over the 50 years, while in the California Current the pycnocline deepened by ~5 m but showed little net change in stratification (which weakened by 5 percent to the mid-1970s, strengthened by 8 percent to the mid-1990s, and then weakened by 4 percent to 2008)". These projections identify a suite of changes in global climate conditions that are relevant to the future status and trend of endangered and threatened species (Table 11).

Table 11. Phenomena associated with projections of global climate change including levels of confidence associated with projections (adapted from (IPCC 2001) and (Patz et al. 2008)).

Phenomenon	**Confidence in Observed Changes (observed in the latter 20th Century)**	**Confidence in Projected Changes (during the 21st Century)**
Higher maximum temperatures and a greater number of hot days over almost all land areas	Likely	Very likely
Higher minimum temperatures with fewer cold days and frost days over almost all land areas	Very likely	Very likely
Reduced diurnal temperature range over most land areas	Very likely	Very likely
Increased heat index over most land areas	Likely over many areas	Very likely over most areas
More intense precipitation events	Likely over many mid- to high-latitude areas in Northern Hemisphere	Very likely over many areas
Increased summer continental drying and associated probability of drought	Likely in a few areas	Likely over most mid-latitude continental interiors (projections are inconsistent for other areas)
Increase in peak wind intensities in tropical cyclones	Not observed	Likely over some areas
Increase in mean and peak precipitation intensities in tropical cyclones	Insufficient data	Likely over some areas

The indirect effects of climate change would result from changes in the distribution of

temperatures suitable for calving and rearing calves, the distribution and abundance of prey, and the distribution and abundance of competitors or predators. For example, variations in the recruitment of krill (*Euphausia superba*) and the reproductive success of krill predators have been linked to variations in sea-surface temperatures and the extent of sea-ice cover during the winter months. The 2001 Intergovernmental Panel on Climate Change (2001) did not detect significant changes in the extent of Antarctic sea-ice using satellite measurements, Curran (2003) analyzed ice-core samples from 1841 to 1995 and concluded Antarctic sea ice cover had declined by about 20 percent since the 1950s. The most recent report by the Intergovernmental Panel on Climate Change has found that over the last two decades, the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink almost worldwide, and Arctic sea ice and Northern Hemisphere spring snow cover have continued to decrease in extent (www.climatechange2013.org/images/uploads/WGIAR5-SPM_Approved27Sep2013.pdf).

The indirect effects of climate change would result from changes in the distribution of temperatures suitable for reproduction, the distribution and abundance of prey and abundance of competitors or predators. For species that undergo long migrations, individual movements are usually associated with prey availability or habitat suitability. If either is disrupted by changing ocean temperature regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott. 2009). For sea turtles, warming ocean temperatures may extend poleward the habitat which they can utilize (Poloczanska et al. 2009). Seagrass habitats have declined by 29 percent in the last 130 years and 19 percent of coral reefs have been lost due to human degradation, reducing lower latitude habitat for some sea turtle species (Poloczanska et al. 2009). Primary production is estimated to have declined by 6 percent between the early 1980s and 2010, making foraging more difficult for marine species (Hoegh-Guldberg and Bruno 2010).

The Antarctic Peninsula, which is the northern extension of the Antarctic continent, contains the richest areas of krill in the Southern Ocean. The extent of sea ice cover around this Peninsula has the highest degree of variability relative to other areas within the distribution of krill. Relatively small changes in climate conditions are likely to exert a strong influence on the seasonal pack-ice zone in the Peninsula area, which is likely to affect densities of krill in this region. Because krill are important prey for baleen whales or form a critical component of the food chains on which baleen whales depend, increasing the variability of krill densities or causing those densities to decline dramatically is likely to have adverse effect on populations of baleen whales in the Southern Ocean.

Reid and Croxall (2001) analyzed a 23-year time series of the reproductive performance of predators that depend on krill for prey — Antarctic fur seals (*Arctocephalus gazella*), gentoo penguins (*Pygoscelis papua*), macaroni penguins (*Eudyptes chrysolophus*), and black-browed albatrosses (*Thalassarche melanophrys*) — at South Georgia Island and concluded that these populations experienced increases in the 1980s followed by significant declines in the 1990s

accompanied by an increase in the frequency of years with reduced reproductive success. The authors concluded that macaroni penguins and black-browed albatrosses had declined by as much as 50 percent in the 1990s, although incidental mortalities in longline fisheries probably contributed to the decline of the albatross. These authors concluded, however, that these declines result, at least in part, from changes in the structure of the krill population, particularly reduced recruitment into older age classes, which lowers the number of predators this prey species can sustain. The authors concluded that the biomass of krill within the largest size class was sufficient to support predator demand in the 1980s but not in the 1990s.

Similarly, a study of relationships between climate and sea-temperature changes and the arrival of squid off southwestern England over a 20-year period concluded that veined squid (*Loligo forbesi*) migrate eastwards in the English Channel earlier when water in the preceding months is warmer, and that higher temperatures and early arrival correspond with warm phases of the North Atlantic oscillation (Sims et al. 2001). The timing of squid peak abundance advanced by 120- 150 days in the warmest years compared with the coldest. Seabottom temperatures were closely linked to the extent of squid movement and temperature increases over the five months prior to and during the month of peak squid abundance did not differ between early and late years. These authors concluded that the temporal variation in peak abundance of squid seen off Plymouth represents temperature-dependent movement, which is in turn mediated by climatic changes associated with the North Atlantic Oscillation. Changes in oxygen concentrations and positon within the California Current have the potential to impact the prey of sperm whales.

Hazen et al. (2012) predicted up to 35 pecent change in core habitat for some key Pacific species based on climate change scenarios predicated on the rise in average sea surface temperature by 2100. Climate-mediated changes in the distribution and abundance of keystone prey species like krill and climate-mediated changes in the distribution of cephalopod populations worldwide is likely to affect marine mammal populations as they re-distribute throughout the world's oceans in search of prey. Blue whales, as predators that specialize in eating krill, seem likely to change their distribution in response to changes in the distribution of krill (for example, see Payne et al. 1990; Payne 1986); if they did not change their distribution or could not find the biomass of krill necessary to sustain their population numbers, their populations seem likely to experience declines similar to those observed in other krill predators, which would cause dramatic declines in their population sizes or would increase the year-to-year variation in population size; either of these outcomes would dramatically increase the extinction probabilities of these whales.

Sperm whales, whose diets can be dominated by cephalopods, would have to re-distribute following changes in the distribution and abundance of their prey. This statement assumes that projected changes in global climate would only affect the distribution of cephalopod populations, but would not reduce the number or density of cephalopod populations. If, however, cephalopod

populations collapse or decline dramatically, sperm whale populations are likely to collapse or decline dramatically as well.

Periodic weather patterns such as El Niño, La Niña, the Pacific decadal oscillation, and North Pacific Gyre Oscillation can fundamentally change oceanographic conditions in the northeastern Pacific and the biology that is based upon it (Chenillat et al. 2013; Chenillat et al. 2012; Doney et al. 2012; Kudela et al. 2008; Litzow and Mueter 2013; Mundy and Cooney 2005; Mundy and Olsson 2005; Stabeno et al. 2004; Sydeman et al. 2013). (. Roughly every 3-7 years, El Niño can influence the northeastern Pacific (JOI/USSSP 2003; Stabeno et al. 2004). Typical changes include increased winter air temperature, precipitation, sea level, and down welling favorable conditions (Royer and Weingartner 1999; Whitney et al. 1999). La Niña events tend to swing these conditions in the negative direction (Stabeno et al. 2004). However, sea surface temperatures (SSTs) can take 1 year to change following an El Niño event or change to varying degrees (Bailey et al. 1995; Brodeur et al. 1996a; Freeland 1990; Royer 2005). The 1982/1983 El Niño and other down welling events are generally regarded to have reduced food supplies for marine mammals along the U.S. west coast (Feldkamp et al. 1991; Hayward 2000; Le Boeuf and Crocker 2005). During La Niña conditions in the Gulf of California, Bryde's whales were found to be more abundant, possibly due to increased availability of their prey under La Niña conditions (Salvadeo et al. 2011). Marine mammal distribution and social organization (group size) is also believed to have shifted northward in response to persistent or extralimital prey occurrence in more northerly waters during El Niño events (Benson et al. 2002; Danil and Chivers 2005; Lusseau et al. 2004; Norman et al. 2004b; Shane 1994; Shane 1995). Low reproductive success and body condition in humpback whales have also been suggested to have resulted from the 1997/1998 El Niño (Cerchio et al. 2005). El Niño events in the winters of 1952-1953, 1957-1958, 1965-1966, and 1982-1983 were associated with strong down welling anomalies, which reduces nutrient availability for plankton (Bailey et al. 1995; Thomas and Strub 2001; Wheeler and Hill 1999). Plankton diversity also shifts, as smaller plankton are better able to cope with reduced nutrient availability (Corwith and Wheeler 2002; Sherr et al. 2005).

The Pacific decadal oscillation is the leading mode of variability in the North Pacific and operates over longer periods than either El Niño or La Niña and is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua 2002; Mantua and Hare 2002b; Stabeno et al. 2004). Unlike El Niño and La Niña events, Pacific decadal oscillation events can persist for 20-30 years, are more prominent outside the tropics, and mechanisms controlling them are relatively unknown (Hare and Mantua 2000; Mantua and Hare 2002b; Minobe 1997; Minobe 1999). During positive Pacific decadal oscillations, the northeastern Pacific experiences above-average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Mundy and Olsson 2005; Royer 2005). Warm Pacific decadal oscillation regimes, as with El Niño events, tends to decrease productivity along the U.S. west

coast (Childers et al. 2005; Hare et al. 1999). However, during the 1977 warm phase of the Pacific decadal oscillation, euphausiid biomass remained the same and copepod abundance actually increased in the Pacific northwest; zooplankton biomass doubled in offshore waters of the Gulf of Alaska (Brodeur et al. 1996b; Brodeur and Ware 1992; Francis and Hare 1997; MacCall et al. 2005; McFarlane and Beamish 1992). Opposite sea surface temperature regimes occur during negative Pacific decadal oscillations (Mundy and Olsson 2005). Positive Pacific decadal oscillations occurred from 1925-1946 and 1977-1999. Negative Pacific decadal oscillations occurred from 1890-1924, 1947-1976, and 1999-present (Childers et al. 2005; Mantua et al. 1997; Minobe 1997).

Recently, additional research has shown that the North Pacific Gyre Oscillation as impacted by the Pacific Decadal Oscillation and El Niño or La Niña events may have a dominant influence on California Current oceanography and associated biological productively (Chenillat et al. 2013; Di Lorenzo et al. 2008; Litzow and Mueter 2013; Patara et al. 2012; Sydeman et al. 2013). While fluctuations in the North Pacific Gyre Oscillation are strongly influenced by the Pacific Decadal Oscillation, the North Pacific Gyre Oscillation in turn has a more dramatic impact and is better correlated with North Pacific variability in salinity, nutrients, chlorophyll, and a variety of zooplankton taxa (Di Lorenzo et al. 2008). Chenillat et al. (2013) found that within the California Current System, changes in the North Pacific Gyre Oscillation impacted timing of spring time favorable winds responsible for the wind driven upwelling and associated nutrient and biological productivity. Sydeman et al. (2013) showed how variation in the North Pacific Gyre Oscillation could account for North Pacific krill productively (primarily *Thysanoessa spinifera*). Thysanoessa spinifera is a key prey species for blue whales off Central and Southern California (Fiedler et al. 1998; Schoenherr 1991).

Foraging is not the only aspect that climate change could influence. Acevedo-Whitehouse and Duffus (2009) proposed that the rapidity of environmental changes, such as those resulting from global warming, can harm immunocompetence and reproductive parameters in wildlife to the detriment of population viability and persistence. An example of this is the altered sex ratios observed in sea turtle populations worldwide (Fuentes et al. 2009a; Mazaris et al. 2008; Reina et al. 2008; Robinson et al. 2008). This does not appear to have yet affected population viabilities through reduced reproductive success, although nesting and emergence dates of days to weeks in some locations have changed over the past several decades (Poloczanska et al. 2009). Altered ranges can also result in the spread of novel diseases to new areas via shifts in host ranges (Simmonds and Eliott. 2009). It has also been suggested that increases in harmful algal blooms could be a result from increases in sea surface temperature (Simmonds and Eliott. 2009).

Changes in global climatic patterns will likely have profound effects on the coastlines of every continent by increasing sea levels and the intensity, if not the frequency, of hurricanes and tropical storms (Wilkinson and Souter 2008). A half degree Celsius increase in temperatures

during hurricane season from 1965-2005 correlated with a 40 percent increase in cyclone activity in the Atlantic. Sea levels have risen an average of 1.7 mm/year over the 20th century due to glacial melting and thermal expansion of ocean water; this rate will likely increase. Based on computer models, these phenomena would inundate nesting beaches of sea turtles, change patterns of coastal erosion and sand accretion that are necessary to maintain those beaches, and would increase the number of turtle nests destroyed by tropical storms and hurricanes (Wilkinson and Souter 2008). The loss of nesting beaches, by itself, would have catastrophic effects on sea turtle populations globally if they are unable to colonize new beaches that form or if the beaches do not provide the habitat attributes (sand depth, temperature regimes, refuge) necessary for egg survival. In some areas, increases in sea level alone may be sufficient to inundate sea turtle nests and reduce hatching success (Caut et al. 2009). Storms may also cause direct harm to sea turtles, causing "mass" strandings and mortality (Poloczanska et al. 2009). Increasing temperatures in sea turtle nests alters sex ratios, reduces incubation times (producing smaller hatchling), and reduces nesting success due to exceeded thermal tolerances (Fuentes et al. 2009b; Fuentes et al. 2010; Fuentes et al. 2009c). Additionally, green sea turtle hatchling size also appears to be influenced by incubation temperatures, with smaller hatchlings produced at higher temperatures (Glen et al. 2003). More ominously, an air temperature increase of 3°C is likely to exceed the thermal threshold of most clutches, leading to death (Hawkes et al. 2007). Smaller individuals likely experience increased predation (Fuentes et al. 2009b) Climatic anomalies influencing the Marianas Islands include El Niño/Southern Oscillation (ENSO) and La Niña events (Giese and Carton 1999; Mantua and Hare 2002a; NOAA 2005a; NOAA 2005b; Sugimoto et al. 2001; Trenberth 1997). Although Guam and the Southern Marianas Islands do not appear to experience altered rainfall patterns during El Niño events, the Northern Marianas tend to experience drier dry seasons and wetter wet seasons (Pacific ENSO Applications Center 1995). Sea surface temperature in the regions also increases due to a weakening of a high pressure system over the western Pacific, potentially influencing the distribution of fish (Kubota 1987; Lehodey et al. 1997). Although typhoons tend to be more frequent during El Niño events (likely occurring at present), their tracks tend to be more to the northwest, away from the action area (Elsner and Liu 2003; Saunders et al. 2000).

Recent research egg and hatchling mortality of leatherback turtles in northwest Costa Rica were affected by climatic variability (precipitation and air temperature) driven by the El Niño Southern Oscillation (ENSO). Drier and warmer conditions associated with El Niño increased egg and hatchling mortality (Santidrián Tomillo et al. 2012). The fourth assessment report of the IPCC projects a warming and drying in Central America and other regions of the World (IPCC 2007). Using projections from an ensemble of global climate models contributed to the Intergovernmental Panel on Climate Change report, Santidrián et al. (2012) projected that egg and hatchling survival will rapidly decline in the region over the next 100 years, due to warming

and drying in northwestern Costa Rica. Warming and drying trends may threaten the survival of sea turtles.

5.1.3 Natural Mortality

Natural mortality rates in cetaceans, especially large whale species, 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*) has been attributed to congestive kidney failure and death in some large whale species (Lambertsen 1986). A well-documented observation of killer whales attacking a blue whale off Baja, California proves that blue whales are at least occasionally vulnerable to these predators (Tarpy 1979). Other stochastic events, such as fluctuations in weather and ocean temperature affecting prey availability, may also contribute to large whale natural mortality.

Sea turtles are also affected by disease and environmental factors. Turtles can be injured by predators such as birds, fish, and sharks (George 1997). Hypothermic or cold stunning occurs when a turtle is exposed to cold water for a period of time. Cold stunned turtles often have decreased salt gland function which may lead to plasma electrolyte imbalance and a lowered immune response (George 1997).

Changes in the abundance of salmonid populations are substantially affected by changes in the freshwater and marine environments. Evidence suggests that marine survival of salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hollowed et al. 2001; Lehodey et al. 2006; Mantua and Hare 2002c). This phenomenon has been referred to as the Pacific Decadal Oscillation. Also, large-scale climatic regimes, such as El Niño, appear to affect changes in ocean productivity and influence local environmental rainfall patterns that can result in drought and fluctuating flows. During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years and very low stream flows. In more recent years, severe flooding has adversely affected some stocks. The listed salmon species included in this Opinion are affected by this broad environmental cycle; thus, the survival and recovery of these species will depend on their ability to persist through periods of low natural survival rates.

Natural predators include birds, killer whales, and sea lions. Researchers estimated that Caspian terns nesting on Crescent Island, Washington, located below the confluence of the Snake and Columbia Rivers, consumed several hundred thousand juvenile salmonids each year of the study (679,000 smolts in 2001; 95 percent confidence interval (CI): 533,000-825,000 smolts) than in 2000 (465,000 smolts in 2000; 95 percent CI: 382,000-547,000 smolts) (Antolos et al. 2005) and 7 to 15 million outmigrating smolts during 1998 (Collis et al. 2002; Maranto et al. 2010). Field observations of predation and stomach contents of stranded killer whales collected over a 20-

year period documented 22 species of fish and 1 species of squid in the diet of resident-type killer whales; 12 of these are previously unrecorded as prey of *O. orca*. Despite the diversity of fish species taken, resident whales have a clear preference for salmon prey. In field observations of feeding, 96 percent of fish taken were salmonids. Six species of salmonids were identified from prey fragments, with Chinook salmon being the most common (Ford et al. 1998b). Steller sea lions shift diet composition in response to changes in prey availability of pollock (*Theragra chalcogramma*), hake (*Merluccius productus*), herring (*Clupea pallasi*) and salmon (*Oncorhynchus spp*.) (Sigler et al. 2009).

5.1.4 Human-Induced Mortality

Large whale population numbers in the action areas have historically been impacted by commercial exploitation, mainly in the form of whaling. Prior to current prohibitions on whaling, such as the International Whaling Commission's 1966 moratorium, most large whale species had been depleted to the extent it was necessary to list them as endangered under the Endangered Species Act of 1966. For example, from 1900 to 1965 nearly 30,000 humpback whales were captured and killed in the Pacific Ocean with an unknown number of additional animals captured and killed before 1900 (Perry et al. 1999a). Sei whales are estimated to have been reduced to 20 percent (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific (Tillman 1977). In addition, 9,500 blue whales were reported killed by commercial whalers in the North Pacific between 1910-1965 (Ohsumi and Wada. 1972); 46,000 fin whales between 1947-1987 (Rice 1984); and 25,800 sperm whales (Barlow et al. 1997). North Pacific right whales once numbered 11,000 animals but commercial whaling has now reduced their population to 29-100 animals (Wada 1973).

Entrapment and entanglement in commercial fishing gear is one of the most frequently documented sources of human-caused mortality in large whale species and sea turtles. For example, in 1978, Nishimura and Nakahigashi (1990) estimated that 21,200 turtles, including greens, leatherback turtles, loggerheads, olive ridleys and hawksbills, were captured annually by Japanese tuna longliners in the Western Pacific and South China Sea, with a reported mortality of approximately 12,300 turtles per year. Using commercial tuna longline logbooks, research vessel data and questionnaires, Nishimura and Nakahigashi (1990) estimated that for every 10,000 hooks in the Western Pacific and South China Sea, one turtle is captured, with a mortality rate of 42 percent.

NMFS has observed 3,251 sets, representing approximately 3,874,635 hooks (data from February 1994 through December 31, 1999). The observed entanglement rate for sperm whales would equal about 0.31 whales per 1,000 sets or 0.0002 per 1,000 hooks. At those rates, we would expect about 200 sperm whales entanglements per 1,000 sets. However, only one sperm whale has been entangled in this gear; as a result, NMFS believes that the estimated entanglement rate substantially overestimates a sperm whale's actual probability of becoming entangled in this gear and the potential hazards longline gear poses to sperm whales.

Collisions with commercial ships are an increasing threat to many large whale species, particularly as shipping lanes cross important large whale breeding and feeding habitats or migratory routes. The number of observed physical injuries to humpback whales as a result of ship collisions has increased in Hawaiian waters (Glockner-Ferrari et al. 1987). On the Pacific coast, a humpback whale is probably killed about every other year by ship strikes (Barlow *et al.* 1997). From 1996-2002, eight humpback whales were reported struck by vessels in Alaskan waters. In 1996, a humpback whale calf was found stranded on Oahu with evidence of vessel collision (propeller cuts; NMFS unpublished data). From 1994 to 1998, two fin whales were presumed to have been killed in ship strikes.

Chronic exposure to the neurotoxins associated with paralytic shellfish poisoning (PSP) via zooplankton prey has been shown to have detrimental effects on marine mammals. Estimated ingestion rates are sufficiently high to suggest that the PSP toxins are affecting marine mammals, possibly resulting in lower respiratory function, changes in feeding behavior and lower reproduction fitness (Durbin et al. 2002). Other human activities, including discharges from wastewater systems, dredging, ocean dumping and disposal, aquaculture and additional impacts from coastal development are also known to impact marine mammals and their habitat. Point-source pollutants from coastal runoff, offshore mineral and gravel mining, at-sea disposal of dredged materials and sewage effluent, potential oil spills, as well as substantial commercial vessel traffic, and the impact of trawling and other fishing gear on the ocean floor are continued threats to marine mammals in the action area.

The impacts from these activities are difficult to measure. However, some researchers have correlated contaminant exposure to possible adverse health effects in marine mammals. Studies of captive harbor seals have demonstrated a link between exposure to organochlorines (*e.g.*, DDT, PCBs, and polyaromatic hydrocarbons) and immunosuppression (De Swart et al. 1996; Harder et al. 1992; Ross et al. 1995). Organochlorines are chemicals that tend to bioaccumulate through the food chain, thereby increasing the potential of indirect exposure to a marine mammal via its food source. During pregnancy and nursing, some of these contaminants can be passed from the mother to developing offspring. Contaminants like 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 (O'Hara and Rice 1996; O'Hara et al. 1999; O'Shea and Brownell Jr. 1994).

The marine mammals that occur in the action area are regularly exposed to several sources of natural and anthropogenic sounds. Anthropogenic noises that could affect ambient noise arise 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; sonars; explosions; and ocean research activities (Richardson et al. 1995b).

5.1.4.1 **Ambient Noise**

Noise in the marine environment has received a lot of attention in recent years and is likely to continue to receive attention in the foreseeable future. Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (Jasny et al. 2005; NRC 1994a; NRC 2000; NRC 2003a; NRC 2005; Richardson et al. 1995b). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003a). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003a). The military uses sound to test the construction of new vessels as well as for naval operations. In some areas where oil and gas production takes place, noise originates from the drilling and production platforms, tankers, vessel and aircraft support, seismic surveys, and the explosive removal of platforms (NRC 2003a).

Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995b). Most observations have been limited to 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. 1983; Bauer and Herman 1986; Hall 1982; Krieger and Wing 1984), but the long-term effects, if any, are unclear or not detectable. Carretta et al.(2001) and Jasny et al. (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate.

Commercial shipping traffic is a major source of low frequency (5 to 500 Hz) human generated sound in the world's oceans (NRC 2003a; Simmonds and Hutchinson 1996). The radiated noise spectrum of merchant ships ranges from 20 to 500 Hz and peaks at approximately 60 Hz. Ross (Ross 1976) estimated that between 1950 and 1975 shipping had caused a rise in ambient ocean noise levels of 10 dB; based on his estimates, Ross predicted a continuously increasing trend in ocean ambient noise of 0.55 dB per year. Chapman and Price (2011) recorded low frequency deep ocean ambient noise in the Northeast Pacific Ocean from 1976 to 1986 and reported that the

trend of 0.55 dB per year predicted by Ross (1976) persisted until at least around 1980; afterward, the increase per year was significantly less, about 0.2 dB per year. Within the action area identified in this Opinion, the vessel sound inside the western half of the Strait of Juan de Fuca and off the Washington coast comes from cargo ships (86 percent), tankers (6 percent), and tugs (5 percent) (NMFS 2008 citing Mintz and Filadelfo 2004a, 2004b)).

In addition to the disturbance associated with the presence of a vessel, the vessel traffic affects the acoustic ecology of southern resident killer whales, which would affect their social ecology. Foote et al. (2004) compared recordings of southern resident killer whales that were made in the presence or absence of boat noise in Puget Sound during three time periods between 1977 and 2003. They concluded that the duration of primary calls in the presence of boats increased by about 15 percent during the last of the three time periods (2001 to 2003). At the same time, Holt et al. (2009) reported that southern resident killer whales in Haro Strait off the San Juan Islands in Puget Sound, Washington, increased the amplitude of their social calls in the face of increased sounds levels of background noise. Although the costs of these vocal adjustments remains unknown, Foote et al. (2004) suggested that the amount of boat noise may have reached a threshold above which the killer whales needs to increase the duration of their vocalization to avoid masking by the boat noise. (Williams et al. 2014a) measured ocean noise levels at 12 sites in the Canadian Pacific Ocean, including Haro Strait, and reported that noise levels were high enough to reduce the communication spaces for fin, humpback and killer whales under typical (median) conditions by 1, 52 and 62%, respectively, and 30, 94 and 97% under noisy conditions.

Bassett et al. (2012) paired one year of AIS data with hydrophone recordings in Puget Sound's Admiralty Inlet to assess ambient noise levels and the contribution of vessel noise to these levels. Results suggested ambient noise levels between 20 Hz and 30 kHz were largely driven by vessel activity and that the increases associated with vessel traffic were biologically significant. Throughout the year, at least one AIS-transmitting vessel was within the study area 90% of the time and multiple vessels were present 68% of the time. A vessel noise budget showed cargo vessels accounted for 79% of acoustic energy, while passenger ferries and tugs had lower source levels but spent substantially more time in the study site and contributed 18% of the energy in the budget. All vessels generated acoustic energy at frequencies relevant to all marine mammal functional hearing groups.

Urick (1983) provided a discussion of the ambient noise spectrum expected in the deep ocean. Shipping, seismic activity, and weather are primary causes of deep-water ambient noise. Noise levels between 20 and 500 Hz appear to be dominated by distant shipping noise that usually exceeds wind-related noise. Above 300 Hz, the level of wind-related noise might exceed shipping noise. Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500 to 50,000 Hz. The ambient noise frequency spectrum and level 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 frequencies between 100 and 500 Hz, Urick (1983) has 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.

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, and marine animals (Urick 1983). At any given time and place, the ambient noise level is a mixture of these noise types. 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 sound levels tend to be higher than when the bottom is absorptive.

McDonald et al. (2006) reported that wind-driven wave noise was an important contributor to ocean ambient noise in the 200–500 Hz band. Ross (1976) and Wenz (Wenz 1962) compared wind data for five northeast Pacific sites and concluded wind was the primary cause for differences in average ambient noise levels above 200 Hz. Assuming the observed increases in ambient noise these authors reported are representative of the larger coast, McDonald et al. (2006) concluded that the breakpoint between shipping and wind dominated noise has probably now moved well above 200 Hz.

Measurements taken at San Nicolas Island, which were considered representative of patterns that would occur across the Pacific Coast of Washington, identified seasonal differences in ocean ambient levels due to seasonal changes in wind driven waves, biological sound production, and shipping route changes (McDonald et al. 2006). The strongest seasonal signal at the San Nicolas South site was attributed to blue whale singing (Burtenshaw et al. 2004) which had a broad peak near 20 Hz in the spectral data (because fin whales occur in the area throughout the year, the seasonal difference was attributed to blue whales, which only occur in the areas seasonally). When the band of fin whale calls were excluded, the average February 2004 ambient pressure spectrum level was 10–14 dB higher than the February 1965 and 1966 levels over the 10–50 Hz band. Above 100 Hz, there was a 1–2 dB difference between the two sets of February noise data (McDonald et al. 2006). Afterward, the increase per year was significantly less, about 0.2dB/yr.

5.1.4.2 **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. Based on the data available from Douglas et al. (2008), Jensen and Silber (2004), and Laist et al. (2001), there have been at least 25 incidents in which marine mammals are known to have been struck by ships in the Puget Sound region and southwestern British Columbia. The marine mammals that were involved in almost half of these incidents died as a result of the strike and they suffered serious injuries in four of those strikes.

Fin whales were struck most frequently, accounting for almost 30 percent of the total number of incidents and two-thirds of the incidents in which the whale died as a result of the collision. Northern resident killer whales were struck slightly less frequently, although a cluster of ship strikes in 2006 accounted for four of the six ship strikes involving this population of killer whales. Humpback whales were third in frequency, followed by southern resident killer whales, offshore killer whales, and blue whales. About two-thirds (17 out of the 25) of the incidents occurred in waters off British Columbia, although the locations were variable.

The adult male southern resident killer whale (L98) that was killed in a collision with a tug boat in 2006 may have reduced the demographic health of this killer whale population. At population sizes between 75 and 90 individuals, we would expect southern resident killer whales to have higher probabilities of becoming extinct because of demographic stochasticity, demographic heterogeneity (Coulson et al. 2006; Fox 2007) — including stochastic sex determination (Lande et al. 2003) — and the effects of phenomena interacting with environmental variability. Although the small number of adult male southern resident killer whales might represent a stable condition for this species, it might also reflect the effects of stochastic sex determination. If the latter is the case, the death of L98 in a population with a smaller percentage of males would increase the imbalance of male-to-female gender ratios in this population and increase the population's probability of further declines in the future.

Allen et al. (2012) recorded the noises from 24 ships ranging in length from 10.4 m to 294.1 m at hydrophone depths of 5, 15, and 25m and calculated source levels to characterize the three-dimensional acoustic environment a mysticete would encounter during a whale/ship approach. Results indicated that mysticetes near the sea surface may experience greater difficulty localizing oncoming ships than in deeper waters as a combined result of lower SLs at the surface in shallow locations, bow null effect acoustic shadow zones, and masking from ambient noise. As a consequence, the range of detection for a ship may be too close for a mysticete to execute a successful avoidance maneuver.

5.1.4.3 **Fishery Harvests**

Listed salmon are incidentally caught in several fisheries that operate in the action area, including groundfish fisheries that operate off the coasts of Washington; fisheries for Pacific salmon that operate under the Pacific Salmon Treaty; salmon fisheries that are managed by the U.S. Pacific Fisheries Management Council under the Pacific Coast Management Plan; salmon fisheries managed by the U.S. Fraser River Panel; commercial ocean salmon troll fisheries that operate off the coasts of Oregon and Washington; and subsistence, commercial, and recreational fisheries for Pacific salmon that operate in the Columbia River. These fisheries incidentally capture endangered and threatened salmon.

The whiting fishery, which is a component of the groundfish fisheries, were expected to incidentally capture not more than 11,000 Chinook salmon per year and have been estimated to have caught an average of 7,281 each year from 1991 to 2005 (NMFS 2006b). The bottom trawl component of the groundfish fishery was expected to capture between 6,000 and 9,000 Chinook salmon each year, with 5,000 to 8,000 of these salmon captured in the Vancouver and Columbia catch areas. On average, the bottom trawl groundfish fisheries captured 11,320 Chinook salmon, 40 coho salmon, and 13 chum salmon from 2002-2004 (NMFS 2006b).

Biological opinions that NMFS has issued on these fisheries concluded that the fisheries were not likely to jeopardize the continued existence of endangered or threatened salmon that were likely to be captured in the fisheries. Biological opinions on the effects of these fisheries on southern resident killer whales, which rely on salmon for food, concluded that fishery-related removals of salmon were not likely to jeopardize the continued existence of southern resident killer whales.

5.1.4.4 **Water Quality Degradation**

Between 2000 and 2006, counties in Puget Sound increased by 315,965 people or by more than 50,000 people per year, with associated increases in the area of impervious surface and population density per square mile of impervious surface in the Puget Sound region (PSAT 2007). Between 1991 and 2001, the area of impervious surface in the Puget Sound basin increased 10.4 percent (PSAT 2007). By 2001, impervious surface covered 7.3 percent of the Puget Sound region below 1,000 feet elevation; in some counties and watersheds in the region, this area was substantially higher.

Over the same time interval, about 190 square miles of forest (about 2.3 percent of the total forested area of the Puget Sound basin) was converted to other uses. In areas below 1,000 feet elevation, the change was more dramatic: 3.9 percent of total forest area was converted to other uses. By 2004, about 1,474 fresh and marine waters in Puget Sound were listed as "impaired waters" in Puget Sound. Fifty-nine percent of these waters tested were impaired because of toxic contamination, pathogens, low dissolved oxygen or high temperatures. Less than one-third of these impaired waters have cleanup plans in place. Chinook salmon from Puget Sound have 2-to-6 times the concentrations of PCBs in their bodies as other Chinook salmon populations on the Pacific Coast. Because of this contamination, the Washington State Department of Health issued consumption advisories for Puget Sound Chinook (PSAT 2007).

The quality of water in the Puget Sound Basin and aquatic biota those water support have been affected by a range of forestry, agricultural, and urban development practices. The chemical quality of surface water in the foothills and mountains is generally suitable for most uses. However, the physical hydrology, water temperature, and biologic integrity of streams have been influenced to varying degrees by logging (Ebbert et al. 2000).

Because of development, many streams in the Puget Lowlands have undergone changes in structure and function with a trend toward simplification of stream channels and loss of habitat (Ebbert et al. 2000). Sources of contaminants to lowland streams and lower reaches of large rivers are largely nonpoint because most major point sources discharge directly to Puget Sound. Compared with that in small streams in the Puget Lowlands, the quality of water in the lower reaches of large rivers is better because much of the flow is derived from the forested headwaters.

More than half of the agricultural acreage in the basin is located in Whatcom, Skagit, and Snohomish Counties. Agricultural land use consists of about 60 percent cropland and 40 percent pasture. Livestock produce a large amount of manure that is applied as fertilizer to cropland, some- times in excess amounts, resulting in runoff of nitrogen and phosphorus to surface water and leaching of nitrate to ground water. Runoff from agricultural areas also carries sediment, pesticides, and bacteria to streams (Ebbert et al. 2000). Pesticides and fumigant-related compounds are present, usually at low concentrations, in shallow ground water in agricultural areas.

Heavy industry is generally located on the shores of the urban bays and along the lower reaches of their influent tributaries, such as Commencement Bay and the Puyallup River in Tacoma and Elliott Bay and the Duwamish Waterway in Seattle. High-density commercial and residential development occurs primarily within and adjacent to the major cities. Development in recent years has continued around the periphery of these urban areas but has trended toward lower density. This trend has resulted in increasing urban sprawl in the central Puget Sound Basin.

Urban land-use activities have significantly reduced the quality of streams in the Puget Sound Basin (Ebbert et al. 2000). Water-quality concerns related to urban development include providing adequate sewage treatment and disposal, transport of contaminants to streams by storm runoff, and preservation of stream corridors.

Water availability has been and will continue to be a major, long- term issue in the Puget Sound Basin. It is now widely recognized that ground-water withdrawals can deplete streamflows (Ebbert et al. 2000), and one of the increasing demands for surface water is the need to maintain instream flows for fish and other aquatic biota.

Pollutants founds in Puget Sound Chinook salmon have found their way into the food chain of the Sound. Harbor seals in southern Puget Sound, which feed on Chinook salmon, have PCB levels that are seven times greater than those found in harbor seals from the Georgia Basin. Concentrations of polybrominated diphenyl ether (also known as PBDE, a product of flame retardants that are used in household products like fabrics, furniture, and electronics) in seals

have increased from less than 50 parts per billion in fatty tissue to more than 1,000 ppb over the past 20 years (PSAT 2007).

Water quality appears poised to have larger-scale effects on the marine ecosystem of the Puget Sound – Georgia Basin as evidenced by the intensity and persistence of water stratification in the basin. Historically, Puget Sound was thought to have an unlimited ability to assimilate waste from cities, farms and industries in the region and decisions about human occupation of the landscape were based on that belief. More recent data suggests that the marine ecosystems of the basin have a much more limited ability to assimilate pollution, particularly in areas such as Hood Canal, south Puget Sound, inner Whidbey basin and the central Georgia Basin. In these areas, as strong stratification has developed and persisted, the respective water quality has steadily decreased. As waters become more stratified, through weather, climate or circulation changes, they become even more limited in their ability to assimilate pollution.

The presence of high levels of persistent organic pollutants, such as PCBs, DDT, and flame–retardants have also been documented in southern resident killer whales (Herman et al. 2005; Ross et al. 2000; Ylitalo et al. 2001). Although the consequences of these pollutants on the fitness of individual killer whales and the population itself remain unknown, in other species these pollutants have been reported to suppress immune responses (Kakuschke and Prange. 2007), impair reproduction, and exacerbate the energetic consequences of physiological stress responses when they interact with other compounds in an animal's tissues (Martineau 2007). Because of their long life span, position at the top of the food chain, and their blubber stores, killer whales would be capable of accumulating high concentrations of contaminants.

5.1.5 Anthropogenic Noise

The marine mammals that occur in the action area are regularly exposed to several sources of natural and anthropogenic sounds. Anthropogenic noises that could affect ambient noise arise 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; sonars; explosions; and ocean research activities (Richardson et al. 1995b).

Noise in the marine environment has received a lot of attention in recent years and is likely to continue to receive attention in the foreseeable future. Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (Jasny et al. 2005; NRC 1994b; NRC 2000; NRC 2003a; NRC 2005; Richardson et al. 1995b). There can be regional and temporal variations including reductions in anthropogenic noise, especially from commercial shipping volume as it is affected by economic drivers (McKenna et al 2012). As discussed in the preceding section, much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003a).

Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003a). The military uses sound to test the construction of new vessels as well as for naval operations. In some areas where oil and gas production takes place, noise originates from the drilling and production platforms, tankers, vessel and aircraft support, seismic surveys, and the explosive removal of platforms (NRC 2003a).

Kipple and Gabriele (2007) measured sounds emitted from 38 vessels ranging in size from 14 to 962 feet at speeds of 10 knots and at a distance of 500 yards from the hydrophone in Glacier Bay, Alaska. Sound levels ranged from a minimum of 157 to a maximum of 182 dB re 1 µPa@1m, with sound levels showing an increasing trend with both increasing vessel size and with increasing vessel speed. Vessel sound levels also showed dependence on propulsion type and horsepower. Vessel noise can result from several sources including propeller cavitation, vibration of machinery, flow noise, structural radiation, and auxiliary sources such as pumps, fans and other mechanical power sources. (McKenna et al. 2012) measured radiated noise from several types of commercial ships, combining acoustic measurements with ship passage information from AIS. On average, container ships and bulk carriers had the highest estimated broadband source levels (186 dB re 1 lPa^2 20–1000 Hz), despite major differences in size and speed. Differences in the dominant frequency of radiated noise were found to be related to ship type, with bulk carrier noise predominantly near 100 Hz while container ship and tanker noise was predominantly below 40 Hz. The tanker had less acoustic energy in frequencies above 300 Hz, unlike the container and bulk carrier.

Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995b). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Smultea et al. (2008) documented a recognized "stress behavioral reaction" by a group of sperm whales in response to small aircraft fly-bys. The group ceased forward movement, moved closer together in a parallel flank-to-flank formation, and formed a fan-shaped semi-circlewith the lone calf remaining near the middle of the group. Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Baker et al. 1983; Bauer and Herman 1986; Hall 1982; Krieger and Wing 1984), but the long-term effects, if any, are unclear or not detectable. Carretta et al. (2001) and Jasny et al. (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate. Significant changes in odontocete behavior attributed to vessel noise have been documented up to at least 5.2 kilometers away from the vessel (Pirotta et al. 2012).

Erbé (2002b) recorded underwater noise of whale-watching boats in the popular killer whale-watching region of southern British Columbia and northwestern Washington State. Source levels ranged from 145 to 169 dB re 1 Pa - 1 m and increased as the vessel's speed increased. Based on sound propagation models, she concluded that the noise of fast boats would be audible to killer

whales over 16 km, would mask killer whale calls over 14 km, would elicit behavioral response over 200 m, and would cause a temporary threshold shifts of 5 dB within 450 m after 30-50 minutes of exposure. She concluded that boats cruising at slow speeds would be audible and would cause masking at 1 km, would elicit behavioral responses at 50 m, and would result in temporary threshold shifts at 20 m.

Galli et al. (2003) measured ambient noise levels and source levels of whale-watch boats in Haro Strait. They measured ambient noise levels of 91 dB (at frequencies between 50-20,000 Hz) on extremely calm days (corresponding to sea states of zero) and 116 dB on the roughest day on which they took measures (corresponding to a sea state of ~5). Mean sound spectra from acoustic moorings set off Cape Flattery, Washington, showed that close ships dominated the sound field below 10 kHz while rain and drizzle were the dominant sound sources above 20 kHz. At these sites, shipping noise dominated the sound field about 10 to 30 percent of the time but the amount of shipping noise declined as weather conditions deteriorated. The large ships they measured produced source levels that averaged 184 dB at 1 m ± 4 dB, which was similar to the 187 dB at 1 m reported by Greene (1995).

The engines associated with the boats in their study produced sounds in the 0.5 – 8.0 KHz range at source levels comparable to those of killer whale vocalizations. They concluded that those boats in their study that travelled at their highest speeds proximate to killer whales could make enough noise to make hearing difficult for the whales.

In addition to the disturbance associated with the presence of vessel, the vessel traffic affects the acoustic ecology of southern resident killer whales, which would affect their social ecology. Foote et al. (2004) compared recordings of southern resident killer whales that were made in the presence or absence of boat noise in Puget Sound during three time periods between 1977 and 2003. They concluded that the duration of primary calls in the presence of boats increased by about 15 percent during the last of the three time periods (2001 to 2003). At the same time, Holt et al. (2009) reported that southern resident killer whales in Haro Strait off the San Juan Islands in Puget Sound, Washington, increased the amplitude of their social calls in the face of increased sounds levels of background noise. Although the costs of these vocal adjustments remains unknown, Foote et al. (2004) suggested that the amount of boat noise may have reached a threshold above which the killer whales needs to increase the duration of their vocalization to avoid masking by the boat noise.

5.1.6 Commercial and Private Marine Mammal Watching

In addition to the federal vessel operations, private and commercial shipping vessels, vessels (both commercial and private) engaged in marine mammal watching also have the potential to impact whales in the action area. A recent study of whale watch activities worldwide has found that the business of viewing whales and dolphins in their natural habitat has grown rapidly over

the past decade into a billion dollar ($US) industry involving over 80 countries and territories and over 9 million participants (Hoyt 2001). In 1988, the Center for Marine Conservation and the NMFS sponsored a workshop to review and evaluate whale watching programs and management needs (CMC and NMFS 1988). That workshop produced several recommendations for addressing potential harassment of marine mammals during wildlife viewing activities that include developing regulations to restrict operating thrill craft near cetaceans, swimming and diving with the animals, and feeding cetaceans in the wild.

Since then, NMFS has promulgated regulations at 50 CFR §224.103 that specifically prohibit: (1) the negligent or intentional operation of an aircraft or vessel, or the doing of any other negligent or intentional act which results in disturbing or molesting a marine mammal; (2) feeding or attempting to feed a marine mammal in the wild; and (3) approaching humpback whales in Hawai'i and Alaska waters closer than 100 yards (91.4 m). In addition, NMFS launched an education and outreach campaign to provide commercial operators and the general public with responsible marine mammal viewing guidelines which in part state that viewers should: (1) remain at least 50 yards from dolphins, porpoise, seals, sea lions and sea turtles and 100 yards from large whales; (2) limit observation time to 30 minutes; (3) never encircle, chase or entrap animals with boats; (4) place boat engine in neutral if approached by a wild marine mammal; (5) leave the water if approached while swimming; and (6) never feed wild marine mammals. 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 with, 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 may become more vulnerable to vessel strikes once they habituate to vessel traffic. Another concern is that preferred habitats may be abandoned if disturbance levels are too high.

The number and proximity of vessels, particularly whale-watch vessels in the areas occupied by southern resident killer whales, represents a source of chronic disturbance for this population. Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Goodwin and Cotton 2004; Lusseau 2006). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994;

Evans et al. 1992; Evans et al. 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

Several investigators have studied the effects of whale watch vessels on marine mammals (Amaral and Carlson 2005; Au and Green 2000a; Christiansen et al. 2013; Christiansen et al. 2011; Corkeron 1995; Erbe 2002b; Felix 2001; Magalhaes et al. 2002; May-Collado and Quinones-Lebron 2014; Richter et al. 2006; Scheidat et al. 2004; Simmonds 2005a; Watkins 1986; Williams et al. 2002a). The whale's behavioral responses to whale watching vessels depended on the distance of the vessel from the whale, vessel speed, vessel direction, vessel noise, and the number of vessels. Responses changed with these different variables and, in some circumstances, the whales or dolphins 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.

5.1.7 Navy Training Activities in the Action Area

The Navy has been conducting training exercises in the NWTRC for over 60 years. In terms of surface combatant ships, currently there are two aircraft carriers, two Navy destroyers, and three Navy frigates home-ported at naval facilities within Puget Sound. In addition, frigates including those home-ported in Puget Sound are slated for retirement from the Navy over the next two years. Monitoring in conjunction with Navy training exercises to determine the effects of active sonar and explosives on marine mammals was initiated in 2010 as part of the MMPA regulations that allowed NMFS to issue LOAs for Navy military readiness activities in the NWTRC. Stranding data has been collected by researchers in the NWTRC for approximately 30 years as well as by NMFS for roughly 22 years. Though not all dead or injured marine mammals can be accounted for, if marine mammals were being harmed by the Navy training exercises in the NWTRC with any regularity, more evidence would have been detected over the 30-year period.

5.1.7.1 **Summary of Activities Under Previous LOAs and Biological Opinions**

Here we provide information regarding the U.S. Navy's activities under the 2010-2011, 2011-2012 and the 2012-2015 LOAs and biological opinions. This information was provided by the U.S. Navy in annual exercise reports, monitoring reports, and the ESA consultation request package. We also reviewed the classified reports to verify compliance with previous ESA biological opinions and Incidental Take Statements.

5.1.7.1.1 Activities Conducted Through May 2014

In the annual exercise reports, the Navy reported that no individual category of authorized system(s) or training event(s) exceeded authorized quantities (to include sonar and explosives) within the NWTRC (Navy 2011; Navy 2012). The Navy did not provide the number of exercises, expended/detonated rounds, or the number of IEER events in the unclassified reports (Navy 2011; Navy 2012).

5.1.7.1.2 Activities Not Conducted

The Navy did not conduct the following activities under the 2010-2011, 2011-2012, or to date per the 2012-2015 LOA and biological opinions:

- Sinking exercises (SINKEX)
- Installation of the Portable Undersea Tracking Range (PUTR);
- Installation of the underwater training minefield (non-explosive).

While no EOD underwater detonations (UNDETs) were undertaken through 2012, there were a few, low level EOD UNDETs in 2013-2014 (source: Navy 2013 and 2014 annual exercise reports). The 2013 NWTRC Annual Exercise Report included one UNDET (15 Nov 2012 one 1.5 lbs NEW charge). The 2014 NWTRC Annual Exercise Report included seven UNDETs (all reduced charge weight events, <1 ounce each) [28 Aug 2013; three 1 oz NEW charges; and 02 Apr 2014 four 1 oz NEW charges]. A total of three EOD UNDET events with eight underwater explosions ocurred within NWTRC from November 2013 through April 2014. The maximum NEW was 1.5 lb. Most (88%) were 1-oz charges.

5.1.7.1.3 Estimated Take of ESA-listed Species Through May 2014

The Navy's classified annual NWTRC Exercise Report contains the list of authorized systems used for the reporting year through May 2014. Of the sonar systems authorized under NMFS Final Rule and LOA for the NWTRC, one system reported annual use (May 2012-May 2013) higher than the average annual use authorized in the LOA and incidental take statement of the 2012-2015 biological opinion. This occurred over a one-week period in September 2012 during an additional unscheduled training event in the offshore waters of the NWTRC, and accounted for over 116% of the annual authorization for this system as reported in the classified NWTRC Exercise Report. However, in terms of the five-year authorization from the NWTRC Final MMPA Rule, the system in question is still only at 38% of total authorized use after three of five years. Accordingly, for purposes of the now-superceded 2010 and 2012 biological opinions, NMFS has determined that this estimated annual exceedance would not result in a change to those earlier conclusions that the Navy training activities in the NWTRC are not likely to jeopardize listed species or likely to destroy or adversely modify critical habitat. NMFS will consider the estimated take from these activities as well as those identified in the Navy's May 2014 annual report, as part of the environmental baseline for this reinitiated consultation.

The table below contains annual NWTRC estimated post-calculation annual potential exposures through May 2014 as well as cumulative species specific estimates for the entire period through May 2014. It should be noted the Navy's post-calculations are based on mathematical modeled results originally derived for the NWTRC Environmental Impact Statement\Overseas Environmental Impact Statement and subsequent LOA applications. Post-calculation comparisons may not be indicative of actual exposures based on real-world short and long-term

spatial movements of various species and their relative occurrence within the NWTRC. Additionally, post-calculated takes are relative to the model-predicted values derived for the 2010 programmatic biological opinion and MMPA rule/LOA. These values and post-calculations have changed with this reinitiated biological opinion due to the new modeling effort with different methodology and are not comparable to previous year take estimates.

During the 2012-2013 reporting period, based on calculations using the earlier model, humpback whale takes exceeded the 15 annual take estimates (19 post-calculated) by four exposures potentially resulting in behavioral harassment. Of the 19 exposures, 19 were from active sonar and zero from explosive sources. Fin whale estimated takes (57) were also exceeded by four exposures potentially resulting in behavioral harassment. Of the 61 exposures to fin whales, 60 were from sonar and 1 from explosive sources. Sperm whale takes were exceeded by19 exposures (130 post-calculation vs. 111 annual authorized). Of The 130 exposures, 129 were from sonar and 1 from explosive sources. All post-calculated explosive exposures were from 76-mm GUNEX only.

Due to difficulty in determining particular stock densities of killer whales, all stocks of killer whales were combined for NWTRC modeling exposures. This included offshore, transient, and southern resident killer whale stocks. There was no Navy modeled exposure to killer whales from explosives. Most (86%) of modeled exposures to killer whales in general were from surface ship sonar (12 Level B/behavioral harrassment exposures) and 14% from DICAS sonobuoys (2 Level B/behavioral harrassment exposures). Likelihood of offshore exposure to surface ship sonar by southern resident killer whales is low given southern resident killer whale summer inshore Puget Sound preference, and winter nearshore transient movements along the Washington-Oregon-northern California coasts. Therefore, the Navy assumed that any May 2012-May 2014 exposures based solely on the post-calculation, would be to offshore or transient stocks of killer whales and not to southern resident killer whales.

5.1.7.1.4 Training Use May 2013-May 2014

The Navy's 2014 classified annual NWTRC Exercise Report contains the list of authorized systems and their reported use from 2 May 2013 to 1 May 2014. Of the sonar systems and explosives authorized under NMFS' NWTRC Final Rule, Letters of Authorization (LOA), and biological opinions (BO) for the NWTRC during this period, no sonar system exceeded any authorized amount and there was no offshore explosive use reported.

5.1.7.1.5 Exposures during the current year and predicted through the November 2015

Table 12 contains NWTRC estimated post-calculation annual potential exposures from May 2013 to May 2014; cumulative species-specific estimates for the period from November 2010 through May 2014; and an estimate of total percentage of exposures compared to the amount authorized over 5-years if in the final year there was 100% system use.

The post-calculation estimates for this period indicate annual species-specific estimates of exposure for the period May 2013 to May 2014 range from zero percent of annual authorization to four percent of the annual authorization. In terms of cumulative potential exposures under the NWTRC Final Rule from November 2010 through May 2014, species-specific exposures range from 25-43 percent of total five-year authorization at the end of the fourth of five years.

In terms of quantity of potential exposures to Endangered Species Act (ESA) cetacean species, of the six ESA species (blue whale, fin whale, humpback whale, sei whale, sperm whale, Southern Resident killer whale), there was potentially only one exposure to sperm whales.

If the Navy were to use 100% of all sonar system and explosive use authorized under the NWTRC Final Rule, LOA, and the 2012, the cumulative species-specific exposure estimates would be between 36-59 percent of total authorized over the five-year period. All ESA species would be below 50 percent of the authorized take. Navy post calculations for remaining years will not be comparable to previous years due to the change in modeling criteria; however relative percentages might be appropriate for comparison to previous performance.

Table 12. Navy Post-calculation Annual Potential Exposures from November 2010 through May 2014 and Cumulative Totals

Species	Authorized Level B Harrassment			Predicted Level B, Harrassment Takes Based on Reported Training								Percent of Predicted Takes vs. Authorized
				November 2010 – May 2011		May 2011 – May 2012		May 2012 – May 2013		May 2013 – May 2014		
	Nov 2010-May 2011	May 2011 - May 2012	May 2012-May 2015	Level B/ Harrass	% Potential Takes Compared to Authorized	Level B/ Harrass	% Potential Takes Compared to Authorized	Level B/ Harrass (explosives)	% Potential Takes Compared to Authorized	Level B/ Harrass (explosives	% Potential Takes Compared to Authorized	Nov 2010 – May 2014
Humpback whale	15	15	15	0	0%	2	13%	19 (0)	**127%**	0	0%	**35%**
Fin whale	40	69	57	0	0%	8	12%	61 (1)	**107%**	0	0%	**31%**
Blue whale	11	17	16	0	0%	2	18%	16	100%	0	0%	**30%**
Sei whale	1	1	1	0	0%	0	0%	1	100%	0	0%	**25%**
Sperm whale	84	127	111	1	1%	18	14%	130 (0)	**117%**	**1**	**1%**	**35%**

5.1.7.2 **Monitoring**

The U.S. Navy provided the following summary (also see Table 13) of monitoring related to the NWTRC training activities accomplished from November 2011 through May 2014. This information was provided as part of the *Comprehensive Marine Species Monitoring Report for The U.S. Navy's Northwest Training Range Complex 2011-2014*. U.S. Pacific Fleet, Pearl Harbor, Hawaii. Final July 1, 2014.:

1) Long-term fixed passive acoustic monitoring is an effective way to determine seasonal species-specific occurrence of vocalizing and potentially foraging animals. It does not account for non-vocalizing animals. Passive acoustic monitoring can also be used to record natural and anthropogenic sounds leading to better assessment of ambient noise conditions.

By the summer of 2014, Navy funded passive acoustic monitoring will have been ongoing off the coast of Washington State for close to 10 years. Navy research funding and reporting occurred from 2004-2010 (Oelson et al. 2009, Oleson and Hildebrand. 2012). Under NWTRC compliance monitoring from 2011-2014, over 27,000 hours of passive acoustic data has been collected from two passive acoustic devices on the shelf and slope Department of the Navy 2011, 2012, 2013a).

Specific passive acoustic monitoring observations include:

- Future National Marine Fisheries Service (NMFS) and Navy adaptive management should be conducted with an eye toward reviewing the relevance of continued data collection. Toward that end, the Navy in 2014-2015 will focus on analysis from just one NWTRC passive device (slope site).

- Passive acoustic monitoring confirmed that highly infrequent low levels of U.S. Navy active mid-frequency sonar were detected by the two fixed monitoring sites off the Washington coast. From 2008 to 2013, passive sensors only detected four to seven days per year from temporally separated mid-frequency sonar events lasting at most a few hours in duration. This is consistent with the a) overall low level of at-sea sonar training in the NWTRC as compared to other Navy range complexes, and b) the general tendency for unit-level sonar and explosive training to occur further offshore, sometimes >50 miles.

- Passive acoustic monitoring has the potential, via expanded analysis tools, to begin addressing the possible impacts of anthropogenic sources on marine mammal vocalization and echolocation, with the assumptions that changes in vocalizations and echolocation rates are indicative of behavioral changes. However, this kind of analysis is better suited for those areas where the Navy in-water training occurs more frequently

such as Southern California or Hawaii vice the more limited Navy in-water training within the NWTRC.

2) Satellite tracking tags can be an effective indicator of marine mammal distribution and movement patterns at short (days-weeks) and long time scales (months-year) (Department of the Navy 2011, 2012, 2013a, Schorr et al 2013, Mate 2013, 2014).

The Navy believes for future NWTRC tagging efforts from 2014 forward, longer term tags are preferred for continued monitoring. Long term tags will not only provide information on baleen whale distributions in terms of local bathymetric features, but also allow determination of percentages of time individuals spend within and outside of the NWTRC.

In particular, certain offshore sub-areas within NWTRC are more likely to have in-water Navy training events as compared to the rest of the NWTRC. Therefore, comparisons of baleen whale residence times and area restricted searches (potential foraging metric) in sub-areas of the NWTRC can be valuable in comparing potential baleen whale interactions or lack of interactions with Navy training events.

Specific tagging observations include:

- Navy funded gray whale projects from 2011-2013 in NWTRC provided valuable distribution information. To support the need for longer term tracking of additional cetacean species following the success of the gray whale tagging, the Navy funded a new large scale tagging effort for blue and fin whales. The focus of this study will be movement patterns and residency pattern of blue and fin whales along the U.S. West Coast, including within NWTRC. This project was funded in spring 2014 for a planned summer 2014 field season. Initial data from this tagging effort should be available by summer 2015.

3) Finally, as the Navy prepares for future study question-based monitoring within the Pacific Northwest, the Navy funded a new study in the spring of 2014 to model offshore movements of Southern Resident killer whales. Work will be performed by scientists affiliated with NMFS' Northwest Fisheries Science Center (NWFSC).

This project will occur from fall to spring 2015 and involve the: a) deployment of 15 bottom-mounted acoustic monitoring devices, b) purchase of four (4) satellite tracking tags for eventual attachment to Southern Resident killer whales, c) and development of a new state-space model to predict Southern Resident killer whale offshore movement and habitat. Model development will be started concurrently with the 2014-2015 field data collection. Previously collected NWFSC passive acoustic and tagging data from the past two years of offshore Southern Resident effort will be used to initiate model development.

Table 13. Monitoring Plan Metrics Accomplished in the NWTRC through May 2014

Metric	November 2011 to May 1, 2014
Navy Funded Opportunistic/Fully Funded Marine Mammal Tagging	1) Multiple Cetacean species: Ten (10) Andrews-style LIMPET (Low Impact Minimally Percutaneous External Transmitter) tags were purchased by the Navy and supplied to researchers at Cascadia Research Collective for use within a collaborative study of marine mammal movement patterns within offshore waters of Washington State. All ten (10) Navy-funded tags were deployed from 2011-2012 within offshore waters of Washington State. Satellite tags deployed during field efforts were associated with grants research from National Marine Fisheries Service's Alaska Regional Office and Southwest Fisheries Science Center, and a collaborative project with Washington Department of Fish and Wildlife. In total, over 21 tags were attached (see Schorr et al. 2013 and Section 2.2 in this report) 2) Gray whale: 19 Telonics ST-15 ultra-high frequency location only tags and Wildlife Computer Spot-5 tags were purchased by the Navy and Navy funded associated field work by Oregon State University. Tags were attached to Pacific Coast Feeding Group of gray whales from October to November 2012, and in October 2013 (see Mate 2013, Mate et al. 2014 and Section 2.2 in the report). 3) Baleen (blue and fin) whales: Up to 24 location-only SPOT-5 tags and 4 newly designed Advance Dive Behavior tags are planned for attachment in summer 2014. While tagging location will be in Southern California, the goal is to study and document blue and fin whale movements along the entire U.S. West Coast including Navy range areas like the Southern California Range Complex and NWTRC (See Section 2.2 in the report). 4) Pinniped: Started in late 2013, with multiple tags and visual observations to be done on pinnipeds around and adjacent to select Navy waterfront facilities within Puget Sound (see Section 2.4 of the report)
Deploy Two Long-term Passive Acoustic Monitoring (PAM) Devices	Two (2) high-frequency acoustic recording packages (HARP) from Scripps Institute of Oceanography were funded by Navy for deployment at offshore Washington State locations monitored under previous Navy Research funding from 2004-2010. Under the NWTRC monitoring plan and associated U.S. Pacific Fleet funding, the two devices have been in place from November 2011 to present. Through March 2013, the last series analyzed so far, over 27,000 hours of passive acoustic data have been analyzed for baleen whale calls; toothed whale calls/whistles/echolocation clicks; and anthropogenic sounds. These devices have been continuously maintained and data analyzed for the duration of this period. Analysis confirmed detection of four baleen whale species (blue whales, fin whales, gray whales, humpback whales); and seven toothed whale species. Ship and boat noise was common anthropogenic sound at both sites.

Future New Study Question Projects starting in fall 2014:

"*What is the distribution, residency time, and spatial extent of Southern Resident killer whale winter movements off the coasts of Washington, Oregon, and northern California, and relationship of this movement to NWTRC*?"

Navy-funded study in spring of 2014 on "**Modeling the Distribution of Southern Resident Killer Whales in the Pacific Northwest**."

5.1.7.3 **Navy Compliance Monitoring For the NWTRC 2014-2015**

For the fifth and final year of Navy Compliance Monitoring within the NWTRC (May 2, 2014 to November 2015), the Navy with NMFS concurrence during annual adaptive management meetings is restructuring the NWTRC monitoring metrics, so that at the end of the final year of monitoring (May 2, 2014 to May 1, 2015) there is an end focus on marine mammal tagging vice continued passive acoustic data collection.

Given continued fishery interaction and high shelf currents leading to equipment difficulties, along with the renewed focus on baleen whale tagging and new Southern Resident killer whale research, the Navy will only report on deployment and data analysis from one long-term bottom-mounted passive acoustic device, the slope HARP-QC discussed in Section 2.3 of the report. The shelf HARP-CE will be retrieved. Instead, a greater focus will be placed on results from the U.S. West Coast blue and fin whale tag as it relates to the NWTRC/NWTT, and on the start of the new Southern Resident killer whale study by NWFSC (Table 14).

Table 14. Navy NWTRC Compliance Monitoring For Year 5 Compared To Preceeding Effort.

Monitoring Technique	**Implementation and Transition**	
	Year 4 (May 2, 2013-May 1, 2014)	**Year 5 (May 2, 2014-November 2015)**
Marine Mammal Tagging	Initiate contracting with focus on baleen whale tagging to prioritize blue whales and fin whales. Report results on FY13 funded study and resulting tagging through May 2014.	Purchase additional tags and continue collecting tag track data on blue whales and fin whales. Tag attachment will start in the summer of 2014 in Southern California. Tag tracks will be displayed for movements along the entire US West Coast including NWTRC Annual reporting of progress.
Passive Acoustic Monitoring	Present data analysis from two Navy funded offshore passive acoustic monitoring devices	Continue deployment of one (1) bottom-mounted passive acoustic device at the slope site (HARP-QC discussed in Section 2.3 of the report) Annual reporting of detections.
2014-2015 Study Question New Start	-	Begin new study: " **Modeling the Distribution of Southern Resident Killer Whales in the Pacific Northwest** " discussed in Section 3.1 of the report

In addition to offshore projects involving long-term passive acoustic monitoring and opportunistic or directed marine mammal tagging, the Navy from 2012-2014 also funded and conducted several marine mammal studies within Puget Sound for multiple species (Department of the Navy 2013a, Jefferies 2013, Jefferies 2014, Smultea et al. 2014).

The Navy assessed that long-term fixed passive acoustic monitoring is an effective way to determine seasonal species-specific occurrence of vocalizing and potentially foraging animals. It does not account for non-vocalizing animals. Passive acoustic monitoring can also be used to record natural and anthropogenic sounds leading to better assessment of ambient noise conditions. Passive acoustic monitoring has potential via expanded analysis to begin addressing possible impacts of anthropogenic sources on marine mammal vocalization and echolocation, with the assumptions that changes in vocalizations and echolocation rates are indicative of behavioral changes. However, the Navy concluded that this kind of analysis is better suited for those areas where the Navy in-water training occurs more frequently such as Southern California or Hawaii vice the more limited Navy in-water training within the NWTRC.

In the report the Navy also concluded that satellite tracking tags can be an effective indicator of marine mammal distribution and movement patterns at short (days-weeks) and long time scales (months-year). Longer term tag tracks are needed in order to better determine baleen whale distributions in terms of bathymetric features, and to determine what percentage of time individuals spend within the NWTRC and outside of the NWTRC.

Finally, the Navy is beginning to transition NWTRC compliance monitoring away from strictly metric-based accomplishments (i.e., number of devices deployed, # of tags attached), to a more region-specific and species-specific format. To that end two new ecological based studies have been initiated in 2014. One study using passive acoustic tools, satellite tagging, and advanced modeling will attempt to refine predictions of offshore occurrence and locations for Southern Resident killer whales. Another new study using satellite location tags and advanced modeling will detail long-term blue and fin whale occurrence, migration, and local residency patterns along the U.S. West Coast including within and outside of NWTRC.

5.1.8 Scientific Research and Permits

Scientific research permits issued by the NMFS currently authorize studies listed species in the North Pacific Ocean, some of which extend into portions of the action area for the proposed project. Authorized research on ESA-listed whales includes close vessel and aerial approaches,

biopsy sampling, tagging, ultrasound, and exposure to acoustic activities, and breath sampling. Research activities involve non-lethal "takes" of these whales by harassment, with none resulting in mortality. Sea turtle research includes capture, handling, restraint, tagging, biopsy, blood sampling, lavage, ultrasound, and tetracycline injection. Lethal take of male Hawaiian monk seals has been authorized in specific instances of mobbing; the removal of specific individuals involved in the mobbing, is expected to preserve the health and life of female and young individuals that will provide greater contributions (NRC 1994b) to the survival and recovery of the species as a whole. Table 15 describes the cumulative number of takes for each listed species in the action area authorized in scientific research permits.

Table 15. Authorized permitted takes of listed whales, pinnipeds, and sea turtles in the Pacific Ocean under the Endangered Species Act and the Marine Mammal Protection Act.

Species	2009-2014 lethal take	2009-2014 sub-lethal take
Blue Whale	0	107,785
Fin Whale	0	154,771
Western North Pacific Gray Whale	0	0
Sei Whale	0	41,745
Humpback Whale	0	372,260
North Pacific Right Whale	0	5,762
Sperm Whale	0	142,700
Main Hawaiian Island Insular False Killer Whale	0	9,195
Guadalupe Fur Seal	0	1,125
Hawaiian Monk Seal	142	23,437
Green Turtle	0	7,545
Hawksbill Turtle	0	1,085
Leatherback Turtle	0	1,178
Loggerhead Turtle	0	519
Olive Ridley Turtle	0	2,198

5.1.9 The Impact of the Baseline on Listed Resources

The action area includes Puget Sound, the Georgia Basin, and waters off the Pacific coast of the states of Washington, Oregon, and California. Because all of the military readiness activities associated with the NWTRC occur in Puget Sound and waters off the Pacific coast of Washington State, this section of this Opinion focuses on Puget Sound, the adjacent Georgia Basin, and waters off the Pacific coast of Washington.

Loss of natural habitat as a result of population growth and urbanization is a constant threat to the birds, mammals, fish, reptiles, amphibians and invertebrates in the Georgia Basin-Puget Sound region. Although killer whales in British Columbia are assessed as vulnerable by the Conservation Data Centre in British Columbia, there is great concern about the status of the southern resident killer whale population that resides in the Georgia Basin-Puget Sound region. Recent studies have revealed high persistent organic pollution levels in the tissues of this population. There is also concern about recent mortalities in the population, a reduction in food (prey) availability and increasing stress from whale watchers and boaters.

Sixty-four of the vertebrate species that are native to Puget Sound are considered at some risk of extinction within the Sound, including one out of four native reptile species, 18 percent of the freshwater fish species, 15 percent of all native amphibian species, 12 percent of all native mammal species, and 12 percent of the native breeding bird species. Forty-one of the 298 vertebrates that are native to the Georgia Basin are either threatened, endangered, or candidates for these designations, including white sturgeon, marbled murrelet, Vancouver Island marmot, Oregon spotted frog, and sharp-tailed snake. Fourteen of the 41 species of freshwater fish that are native to the Georgia Basin and 10 mammal species are considered at risk of population collapses, declines, or extinction within the Georgia Basin. The Canadian government is examining 30 other species that are native to the Georgia Basin for potential as endangered species.

Southern resident killer whales were listed as endangered because of their exposure to the various stressors that occur in the action area for this consultation. Exposure to those stressors resulted in the species' decline from around 200 individuals to about 67 individuals in the 1970s and the species' apparent inability to increase in abundance above the 75 to 90 individuals that currently comprise this species. These phenomena would increase the extinction probability of southern resident killer whales and amplify the potential consequences of human-related activities on this species. Based on their population size and population ecology (that is, slow-growing mammals that give birth to single calves with several years between births), we assume that southern resident killer whales would have elevated extinction probabilities because of exogenous threats caused by anthropogenic activities that result in the death or injury of individual whales (for example, ship strikes or entanglement) and natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) *as well as* endogenous threats resulting from the small size of their population. Based on the number of other species in similar circumstances that have become extinct (and the

small number of species that have avoided extinction in similar circumstances), the longer southern resident killer whales remain in these circumstances, the greater their extinction probability becomes. (Williams et al. 2014b) indicated that northern resident killer whales showed moderate (severity score 2–4) responses to the presence of the large ships that use Johnstone Strait in summer months, but behavioral responses were best explained by combinations of time (Year and Month), age of the animal, number of ships (CAR, COL and TUG) and the broadband noise level received by the whale (RL_rms).

NMFS has consistently concluded that the various fisheries that incidentally capture endangered or threatened salmon or steelhead in the action area are not likely to jeopardize the continued existence of those species. However, the effects of the fisheries combined with the effects of water quality degradation in the Puget Sound – Georgia Basin region on Puget Sound Chinook salmon, Hood canal summer-run chum salmon, and Puget Sound steelhead are not known but have increased the extinction risks of other endangered or threatened anadromous fish species (for example, delta smelt in the San Francisco estuary).

Thus far under the current MMPA rule (2010-2015) the Navy's training activities on the NWTRC have resulted in estimated take that are well below the five-year levels evaluated in the 2010 and 2012 Biological Opinion. Annual authorized take levels were exceeded for three species in 2012. For purposes of the now-superceded 2010 and 2012 biological opinions, NMFS has determined that the estimated annual exceedance in 2012 would not result in a change to those earlier conclusions that the Navy training activities in the NWTRC are not likely to jeopardize listed species or likely to destroy or adversely modify critical habitat. We again consider the estimated take from these activities as well as those identified in the Navy's May 2014 annual report, as part of the environmental baseline for this reinitiated consultation. There have not been any vessel strikes of any species during training activities in the NWTRC during the five-year period.

6 EFFECTS OF THE ACTION

'Effects of the action' means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR §402.02). Indirect effects are those that are caused by the action and are later in time, but still are reasonably certain to

occur. This effects' analyses section is organized as stressor – exposure – response – risk assessment framework.

The ESA does not define "harassment" nor has NMFS defined this term, pursuant to the ESA, through regulation. However, the MMPA defines "harassment" as "any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering" [16 U.S.C. 1362(18) (A)]. For military readiness activities, this definition of "harassment" has been amended to mean, in part, "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behaviors are abandoned or significantly altered" (Public Law 106-136, 2004).

For the purposes of this consultation, "harassment" is defined such that it corresponds to the MMPA and U.S. Fish and Wildlife Service's definitions: "an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents." NMFS is particularly concerned about changes in animal behavior that are likely to result in animals that fail to feed, fail to breed successfully, or fail to complete their life history because those changes may have adverse consequences for populations of those species.

Each potential stressor associated with the activities the Navy proposes is discussed in greater detail below, followed by the results of NMFS's exposure analyses, which are designed to determine whether endangered or threatened individuals or designated critical habitat are likely to be exposed to the potential stressor. Those analyses are followed by the results of the response analyses.

This section concludes with an *Integration and Synthesis of Effects* that integrates information presented in the *Status of the Species* and *Environmental Baseline* sections of this Opinion with the results of the exposure and response analyses to estimate the probable risks the action poses to endangered and threatened species.

6.1 Potential Stressors Associated with the Action

NMFS has identified several aspects of the action as potential hazards to threatened or endangered species or critical habitat that has been designated for them:

1. Surface vessels and submarines involved in training activities and the associated risk of collisions;
2. Disturbance produced by surface vessels and aircraft involved in training activities;
3. Projectiles and expended materials;
4. Sound fields produced by the active sonar systems the U.S. Navy would employ;
5. Sound fields produced by the underwater detonations the U.S. Navy would employ;
6. Pressure waves produced by the underwater detonations.

The exposure analysis evaluates the available evidence to determine the likelihood of listed species or critical habitat being exposed to these potential stressors. Our analysis assumed that these stressors pose no risk to listed species or critical habitat if these potential stressors do not co-occur, in space or time, with (1) individuals of endangered or threatened species or units of critical habitat that has been designated for endangered or threatened species; (2) species that are food for endangered or threatened species; (3) species that prey on or compete with endangered or threatened species; (4) pathogens for endangered or threatened species. During our analyses, we did not identify situations where the proposed training activities are likely to indirectly affect endangered or threatened species by disrupting marine food chains, or by adversely affecting the predators, competitors, or forage base of endangered or threatened species.

6.1.1 Disturbance from Vessels

Vessel movements associated with training in the offshore portion of the study area are highly distributed with the majority of training activities occurring greater than 50 nm from shore. These activities consist of unit level training with typically only 1-2 vessels and are short term (hours to a few days) and infrequent. There are even fewer vessel movements associated with training in the inland waters of the NWTRC. Only three events occur within the inland waters that involve vessels - electronic combat training, mine countermeasure training, and Naval special warfare training at Indian Island.

The U.S. Navy plans to conduct anti-submarine warfare training events on the NWTRC. As proposed, these events will consist primarily of tracking exercises, in which the U.S. Navy trains aircraft, ship, and submarine crews in the tactics, techniques, and procedures for searching, detecting, localizing, and tracking submarines.

A typical scenario would involve a single maritime patrol aircraft (usually P-3 Orion or P-8 Poseidon aircraft; the U.S. Navy refers to the latters as multi-mission maritime aircraft) dropping sonobuoys, from an altitude below 3,000 ft (sometimes as low as 400 ft), into specific patterns designed to respond to the movement of a target submarine and specific water conditions. These training events usually last for two to four hours and do not involve firing torpedoes. The U.S. Navy conducts about 210 events per year in the offshore area of the NWTRC. The U.S. Navy also conducts about 26 training events involving guide-missile destroyers and 39 training events involving guided-missile frigates (59 hours of active sonar) on the NWTRC annually through November 2015.

In some circumstances, and depending on the level, duration, and persistency of the activities, the presence and movement of vessels can represent a source of acute and chronic disturbance for marine mammals. The underwater noise generated by vessels may disturb animals when the animal perceives that an approach has started and during the course of the interaction. Free-ranging cetaceans may engage in avoidance behavior when surface vessels move toward them. The combination of the physical presence of a surface vessel and the underwater noise generated by the vessel, or an interaction between the two may result in behavioral modifications of animals in the vicinity of the vessel or submarine (Goodwin and Cotton. 2004; Lusseau 2006). Several authors suggest that the noise generated by the vessels is probably an important contributing factor to the responses of cetaceans to the vessels (Blane and Jaakson 1994; Evans et al. 1992; Evans et al. 1994), such that we may not be able to treat the effects of vessel traffic as independent of engine and other sounds associated with the vessels.

6.1.2 Vessel Strike

The movement of surface and subsurface vessels in waters that also might be occupied by endangered or threatened marine species can pose collision or ship strike hazards to those species. A typical Navy training scenario in the NWTRC would involve a single maritime patrol aircraft (usually P-3s Orion or P-8 Poseidon aircraft; the U.S. Navy refers to the latters as multi-mission maritime aircraft) dropping sonobuoys, from an altitude below 3,000 ft (sometimes as low as 400 ft), into specific patterns designed to respond to the movement of a target submarine

and specific water conditions. These training events usually last for two to four hours and do not involve firing torpedoes. The U.S. Navy conducts about 210 events per year in the offshore area of the NWTRC. The U.S. Navy also conducts about 26 training events involving guide-missile destroyers and 39 training events involving guided-missile frigates (59 hours of active sonar) on the NWTRC through November 2015.

6.1.3 Projectiles and Expended Materials

Many of the activities the U.S. Navy plans to conduct on the NWTRC include firing of a variety of weapons, explosive and non-explosive practice munitions such as; bombs, small arms ammunition, medium caliber cannon, missiles, targets, marine markers, flares, and chaff (see Table 1). Parachutes associated with flares and sonobuoys, as well as sonobuoys themselves, may be left in the marine environment during training exercises. The risks associated with each of these expended materials are described below.

6.1.3.1 **Bombs**

The majority of the bombs that would be used during training activities would be practice bombs that are not equipped with explosive warheads. Practice bombs entering the water would consist of materials like concrete, steel, and iron, and would not contain the combustion chemicals found in the warheads of explosive bombs. These components are consistent with the primary building blocks of artificial reef structures. The steel and iron, although durable, would corrode over time, with no noticeable environmental impacts. The concrete is also durable and would offer a beneficial substrate for benthic organisms. After sinking to the bottom, the physical structure of bombs would be incorporated into the marine environment by natural encrustation and/or sedimentation (Navy 2010).

The chemical products of deep underwater explosions are initially confined to a thin, circular area called a "surface pool." Young (1991) estimated that 100 percent of the solid explosion products and 10 percent of the gases remain in the pool, which is fed by upwelling currents of water entrained by the rising bubble produced by a detonation. After the turbulence of an explosion has dispersed, the surface pool would stabilize and chemical products would become uniformly distributed within the pool. A surface pool is usually not visible after about five minutes. As a surface pool continues to expand, chemical products would be further diluted and become undetectable. Because of continued dispersion and mixing, there would be no buildup of explosion products in the water column.

About 24 percent of the bombs the U.S. Navy employs during training would contain high explosives. In the past, 99 percent of these bombs explode within 5 feet of the ocean surface leaving only fragments (Navy 2008b).

6.1.3.2 **Cannon and Small Arms Ammunition**

Naval gun fire within the NWTRC would use non-explosive and explosive 5-inch and 76-millimeter (mm) rounds, and non-explosive, practice, 2.75-inch rockets More than 80 percent of the 5-inch and 76-mm training rounds expended would be non-explosive and contain an iron shell with sand, iron grit, or cement filler. Rapid-detonating explosive would be used in explosive rounds. Unexploded shells and non-explosive practice munitions would not be recovered and would sink to the ocean floor. Solid metal components (mainly iron) of unexploded ordnance and non-explosive practice munitions would also sink.

High-explosive, 5-inch shells are typically fused to detonate within 3 feet of the water surface. Shell fragments rapidly decelerate through contact with the surrounding water and settle to the sea floor. Unrecovered ordnance would also sink to the ocean floor. Iron shells and fragments would be corroded by seawater at slow rates, with comparably slow release rates. Over time, natural encrustation of exposed surfaces would occur, reducing the rate at which corrosion occurred. Rates of deterioration would vary, depending on the material and conditions in the immediate marine and benthic environment. However, the release of contaminants from unexploded ordnance, non-explosive practice munitions, and fragments would not result in measurable degradation of marine water quality.

The rapid-detonating explosive material of unexploded ordnance would not typically be exposed to the marine environment. Should the rapid-detonating explosive be exposed on the ocean floor, it would break down within a few hours. Over time, the rapid-detonating explosive residue would be covered by ocean sediments or diluted by ocean water.

6.1.3.3 **Missiles**

Missiles would be fired by aircraft, ships, and naval special warfare operatives at a variety of airborne and surface targets within the NWTRC. In general, the single largest hazardous constituent of missiles is solid propellant, which is primarily composed of rubber (polybutadiene) mixed with ammonium perchlorate (for example, solid double-base propellant, aluminum and ammonia propellant grain, and arcite propellant grain). Hazardous constituents are also used in igniters, explosive bolts, batteries (potassium hydroxide and lithium chloride), and warheads (for example, PBX-N high explosive components; PBXN-106 explosive; and PBX

(AF)-108 explosive). Chromium or cadmium may also be found in anti-corrosion compounds coating exterior missile surfaces. In the event of an ignition failure or other launch mishap, the rocket motor or portions of the unburned propellant may cause environmental effects.

Experience with Hellfire missiles has shown that if the rocket motor generates sufficient thrust to overcome the launcher hold-back, all of the rocket propellant is consumed. In the rare cases where the rocket does not generate sufficient thrust to overcome the holdback (hang fire or miss fire), some propellant may remain unburned but the missile remains on the launcher. Jettisoning the launcher is a possibility for hang fire or miss fire situations, but in most cases the aircraft returns to base where the malfunctioning missile is handled by explosive ordnance disposal personnel.

Non-explosive practice missiles generally do not explode upon contact with the target or sea surface. The main environmental effect would be the physical structure of the missile entering the water. Practice missiles do not use rocket motors and, therefore, do not have potentially hazardous rocket fuel. Exploding warheads may be used in air-to-air missile exercises, but those missiles would explode at an offset to the target in the air, disintegrate, and fall into the ocean to avoid damaging the aerial target. High explosive missiles used in air-to-surface exercises explode near the water surface (Navy 2010).

The principal potential stressor from missiles would be unburned solid propellant residue. Solid propellant fragments would sink to the ocean floor and undergo changes in the presence of seawater. The concentration would decrease over time as the leaching rate decreased and further dilution occurred. The aluminum would remain in the propellant binder and eventually would be oxidized by seawater to aluminum oxide. The remaining binder material and aluminum oxide would pose no threat to the marine environment (Navy 2010).

6.1.3.4 **Targets**

At-sea targets are usually remotely operated airborne, surface, or subsurface traveling units, most of which are designed to be recovered for reuse. Small concentrations of fuel and ionic metals would be released during battery operation.

A typical aerial target drone is powered by a jet fuel engine, generates radio frequency signals for tracking purposes, and is equipped with a parachute to allow recovery. Drones also contain oils, hydraulic fluid, batteries, and explosive cartridges as part of their operating systems. There are also recoverable, remotely controlled target boats and underwater targets designed to

simulate submarines. If severely damaged or displaced, targets may sink before they can be retrieved. Aerial targets employed in the NWTRC would include AST/ALQ/ESM pods, Banner drones, BQM-74E drones, Cheyenne, Lear Jets, and Tactical Air-Launched Decoys, which are the only expended targets (these targets are non-powered, air-launched, aerodynamic vehicles).

Surface targets would include Integrated Maritime Portable Acoustic Scoring and Simulator Systems, Improved Surface Tow Targets, QST-35 Seaborne Powered Targets, and expendable marine markers (smoke floats). Expended surface targets commonly used in addition to marine markers include cardboard boxes, 55-gallon steel drums, and a 10-foot-diameter red balloon tethered by a sea anchor (also known as a "killer tomato"). Floating debris, such as Styrofoam, may be lost from target boats.

Most target fragments would sink quickly in the sea. Expended material that sinks to the sea floor would gradually degrade, be overgrown by marine life, and/or be incorporated into the sediments. Floating, non-hazardous expended material may be lost from target boats and would either degrade over time or wash ashore as flotsam. Non-hazardous expended materials are defined as the parts of a device made of non-reactive material. Typical non-reactive material includes metals such as steel and aluminum; polymers, including nylon, rubber, vinyl, and plastics; glass; fiber; and concrete. While these items represent persistent seabed litter, their strong resistance to degradation and their chemical composition mean they do not chemically contaminate the surrounding environment by leaching heavy metals or organic compounds.

6.1.3.5 **Marine Markers and Flares**

Marine markers and flares are pyrotechnic devices dropped on the water's surface to mark a surface position. The chemicals contained within markers and flares not only burn but also produce smoke. The smoke is expected to rapidly diffuse by air movement. The marker itself would eventually sink to the bottom and become encrusted and/or incorporated into the sediments. Phosphorus contained in the marker settles to the sea floor where it reacts with the water to produce phosphoric acid, until all phosphorus is consumed by the reaction. Combustion of red phosphorus produces phosphorus oxides, which have a low toxicity to aquatic organisms (Navy 2010).

Flares may contain magnesium or aluminum casings. Flares are designed to burn completely in air with only ash and a small plastic end cap entering the water. Flare end caps would eventually sink to the bottom and become encrusted and/or incorporated into the sediments. Solid flare and

pyrotechnic residues may contain aluminum, magnesium, zinc, strontium, barium, cadmium, and nickel, as well as perchlorates. Hazardous constituents in pyrotechnic residues are typically present in small amounts or low concentrations, and are bound in relatively insoluble compounds.

6.1.3.6 **Chaff**

Chaff would be used during the approximately 2,000 events of air combat maneuvers the U.S. Navy plans to conduct in the offshore and inshore areas of NWTRC. Radio frequency chaff is an electronic countermeasure designed to reflect radar waves and obscure aircraft, ships, and other equipment from radar-tracking sources. Chaff is non-hazardous and consists of aluminum-coated glass fibers (about 60 percent silica and 40 percent aluminum by weight) ranging in lengths from 0.3 to 3 inches with a diameter of about 40 micrometers. Chaff is released or dispensed from military vehicles in cartridges or projectiles that contain millions of chaff fibers. When deployed, a diffuse cloud of fibers undetectable to the human eye is formed. Chaff is a very light material that can remain suspended in air anywhere from 10 minutes to 10 hours. It can travel considerable distances from its release point, depending on prevailing atmospheric conditions (Arfsten et al. 2002).

For each chaff cartridge used, a plastic end-cap and Plexiglas piston is released into the environment in addition to the chaff fibers. The end-cap and piston are both round and are 1.3 inches in diameter and 0.13 inches thick. The fine, neutrally buoyant chaff streamers act like particulates in the water, temporarily increasing the turbidity of the ocean's surface. However, they are quickly dispersed and turbidity readings return to normal. The end-caps and pistons would sink. The expended material could also be transported long distances before becoming incorporated into the bottom sediments.

Based on the dispersion characteristics of chaff, large areas of open water within the NWTRC would be exposed to chaff, but the chaff concentrations would be low. For example, Hullar et al. (Hullar et al. 1999) calculated that a 4.97-mile by 7.46-mile area (37.1 square miles or 28 square nautical miles) would be affected by deployment of a single cartridge containing 150 grams of chaff. The resulting chaff concentration would be about 5.4 grams per square nautical mile. This corresponds to fewer than 179,000 fibers per square nautical mile or fewer than 0.005 fibers per square foot, assuming that each canister contains five million fibers.

6.1.3.7 **Parachutes and Sonobuoys**

The U.S. Navy deploys several sonobuoys, including passive acoustic DIFAR and VLAD sonobuoys, active acoustic DICASS sonobuoys, and sonobuoys with explosive sources (see Table 1). Aircraft-launched sonobuoys, flares, torpedoes, and expendable mobile ASW training targets (EMATTs) deploy nylon parachutes of varying sizes. When sonobuoys impact the water surface after being deployed from aircraft, their parachute assemblies are jettisoned and sink away from the sonobuoy. The parachutes are made of nylon and are about 8 feet in diameter. At maximum inflation, the canopies are between 0.15 to 0.35 square meters (1.6 to 3.8 square feet). The shroud lines range from 0.30 to 0.53 meters (12 to 21 inches) in length and are made of either cotton polyester with a 13.6 kilogram (30 pound) breaking strength or nylon with a 45.4 kilogram (100 pound) breaking strength. All parachutes are weighted with a 0.06 kilogram (2 ounce) steel material weight, which would cause the parachute to sink from the surface within about 15 minutes (although actual sinking rates would depend on ocean conditions and the shape of the parachute).

The sonobuoy system's subsurface assembly descends to a selected depth, the case falls away, and sea anchors deploy to stabilize the hydrophone (underwater microphone). The operating life of the seawater battery is about eight hours, after which the sonobuoy scuttles itself and sinks to the ocean bottom. For the sonobuoys, the Navy calculated concentrations of metals released from batteries as 0.0011 mg/L lead, 0.000015mg/L copper, and 0.0000001mg/L silver.

A sonobuoy is approximately 5 in (13 cm) in diameter, 3 ft (1 m) long, and weighs between 14 and 39 lbs (6 and 18 kg), depending on the type. Aircraft-launched sonobuoys deploy a nylon parachute of varying sizes, ranging from 1.6 to 3.8 ft2 (0.15 to 0.35 m2). The shroud lines range from 12 to 21 in (0.30 to 0.53 m) in length and are made of either cotton polyester with a 30-lb (13.6-kg) breaking strength or nylon with a 100-lb (45.4-kg) breaking strength. All parachutes are weighted with a 2 ounce (0.06-kg) steel material weight, which causes the parachute to sink from the surface within 15 minutes.

At water impact, the parachute assembly, battery, and sonobuoy will sink to the ocean floor where they will be buried into its soft sediments or land on the hard bottom where they will eventually be colonized by marine organisms and degrade over time. These components are not expected to float at the water surface or remain suspended within the water column. Over time, the amount of materials will accumulate on the ocean floor. However, the sonobuoys will not

likely be used in the exact same location each time. Additionally, the materials will not likely settle in the same vicinity due to ocean currents.

6.1.4 Sonar Sound Fields

The Navy plans to employ mid-and high-frequency sonar systems during several of the training events it conducts in the NWTRC. Naval sonars operate on the same basic principle as fish-finders (which are also a kind of sonar): brief pulses of sound, or "pings," are projected into the ocean and an accompanying hydrophone system in the sonar device listens for echoes from targets such as ships, mines or submarines. Tactical military sonars are designed to search for, detect, localize, classify, and track submarines. The Navy typically employs two types of sonars during anti-submarine warfare exercises:

1. 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.

2. Active sonars generate and emit acoustic energy specifically for the purpose of obtaining information concerning a distant object from the received and processed reflected sound energy.

The simplest active sonars emit omnidirectional pulses or "pings" and calculate the length of time the reflected echoes return from the target object to determine the distance between the sonar source and a target. More sophisticated active sonar emits an omnidirectional ping and then scans a steered receiving beam to calculate the direction and distance of a target. More advanced sonars transmit multiple preformed beams, listening to echoes from several directions simultaneously and providing efficient detection of both direction and range. The types of sound sources that would be used during military readiness activities in the NWTRC include:

6.1.4.1 **Mid-frequency Sonar**

The U.S. Navy conducts about 26 training events each year involving guided-missile destroyers and 39 training events involving guided-missile frigates (59 hours of active sonar) on the NWTRC annually through November 2015. Normally, the 26 annual training events involving guided missile destroyers would produce up to 39 hours of mid-frequency active sonar (from the AN/SQS-53 hull-mounted sonar system) while the 39 annual training events involving guided-missile frigates would produce up to 59 hours of mid-frequency active sonar (from the AN/SQS-56 hull-mounted sonar system).

1. The AN/SQS-53 which is a large, active-passive, bow-mounted sonar that has been operational since 1975. AN/SQS-53 is the U.S. Navy's most powerful surface ship sonar and is installed on Ticonderoga (22 units) and Arleigh Burke I/II/IIIa (51 units) Class vessels in the U.S. Navy (Polmar 2001, D`Spain et al. 2006). This sonar transmits at a center frequency of 3.5 kHz at sources levels of 235 dB_{rms} re: 1 µPa at 1 meter. The sonar has pulse durations between 1 and 2 seconds, with about 24-second intervals between pulses. AN/SQS-53 operates at depths of about 7 meters.

The AN/SQS-53 is a computer-controlled, hull-mounted surface-ship sonar that has both active and passive operating capabilities, providing precise information for anti-submarine warfare weapons control and guidance. The system is designed to perform direct-path anti-submarine warfare search, detection, localization, and tracking from a hull-mounted transducer array.

2. The AN/SQS-56 system is a lighter active-passive bow-mounted sonar that has been operational since 1977. AN/SQS-56 is installed on FFG-7 (33 units) class guided missile frigates in the U.S. Navy (Polmar 2001). This sonar transmits at a center frequency of 7.5 kHz and a source level of 225 dB_{rms} re: 1 µPa at 1 meter source level. This sonar also has pulse durations between 1 and 2 seconds, with about 24-second intervals between pulses. AN/SQS-56 operates at depths of about 6 meters.

The duration, rise times, and wave form of sounds transmitted from these sonar systems are classified; however, the characteristics of the transmissions that were used during exercises the U.S. Navy conducted in the Bahamas in 2000 (reviewed in (D'Spain et al. 2006) might help illustrate attributes of the transmissions from these two sonar sources. During the Bahamas exercises, these two sonars transmitted 1 – 2 second pulses once every 24 seconds (D'Spain et al. 2006). Pulses had rise times of 0.1 – 0.4 seconds and typically consisted of three waveforms with nominal bandwidths up to 100 Hz (D'Spain et al. 2006). Both sonars create acoustic fields that are omnidirectional in azimuth, although AN/SQS-53 also can create beams covering 120˚ azimuthal sectors that can be swept from side to side during transits (D'Spain et al. 2006). Waveforms of both sonar systems are frequency modulated with continuous waves (D'Spain et al. 2006).

6.1.4.2 **Sonar Systems Associated With Submarines**

Tactical military submarines equipped with hull-mounted mid-frequency use active sonar to detect and target enemy submarines and surface ships. The predominant active sonar system mounted on submarines is AN/BQQ-10 sonar that is used to detect and target enemy submarines and surface ships. Two other systems — AN/BQQ-5 and AN/BSY-1/2 — have operational parameters that would affect marine mammals in ways that are similar to the AN/BQQ-10. In addition, Seawolf Class attack submarines, Virginia Class attack submarines, Los Angeles Class attack submarines, and Ohio Class nuclear guided missile submarines also have the AN/BQS-15 sonar system, which uses high-frequency for under-ice navigation and mine-hunting.

1. The AN/BQQ-10 is characterized as mid-frequency active sonar, although the exact frequency range is classified. The AN/BQQ-10 is installed on Seawolf Class fast attack submarines, Virginia Class fast attack submarines, Los Angeles Class fast attack submarines, and Ohio Class nuclear guided missile submarines. The BQQ-10 systems installed on Ohio Class nuclear guided missile submarines do not have an active sonar capability.

2. The AN/BQQ-5 – a bow- and hull-mounted passive and active search and attack sonar system. The system includes the TB-16 and TB-23 or TB-29 towed arrays and Combat Control System MK 2. This sonar system is characterized as mid-frequency active sonar, although the exact frequency range is classified. The AN/BQQ-5 sonar system is installed on Los Angeles Class nuclear attack submarines and Ohio Class ballistic missile nuclear submarines, although the AN/BQQ-5 systems installed on Ohio Class ballistic missile nuclear submarines do not have an active sonar capability. The AN/BQQ-5 system is being phased out on all submarines in favor of the AN/BQQ-10 sonar.

3. AN/BQS-15 – an under-ice navigation and mine-hunting sonar that uses both mid- and high-frequency (i.e., greater than 10 kHz) active sonar, although the exact frequencies are classified. Later versions of the AN/BQS-15 are also referred to as Submarine Active Detection Sonar (SADS). The Advanced Mine Detection System is being phased in on all ships and will eventually replace the AN/BQS-15 and submarine active detection sonar. These systems are installed on Seawolf Class fast attack submarines, Virginia Class fast attack submarines, Los Angeles Class fast attack submarines, and Ohio Class nuclear guided missile submarines.

4. AN/WQC-25 – an MFA sonar underwater communications system that can transmit either voice or signal data in two bands, 1.5 to 3.1 kHz or 8.3 to 11.1 kHz. The AN/WQC-2, also referred to as the "underwater telephone," is on all submarines and most surface ships, and allows voice and tonal communications between ships and submarines.

6.1.4.3 **Sonar Systems Associated With Aircraft**

Aircraft sonar systems that could be deployed during active sonar events include sonobuoys (tonal [active], listening [passive], and extended echo ranging [EER] or improved extended echo ranging [IEER]) and dipping sonar (AN/AQS-13/22 or AN/AOS-22). Sonobuoys may be deployed by marine patrol aircraft or MH-60R helicopters. A sonobuoy is an expendable device used by aircraft for the detection of underwater acoustic energy and for conducting vertical water column temperature measurements. Most sonobuoys are passive, but some can generate active acoustic signals as well as listen passively. Dipping sonars are used by MH-60R helicopters. Dipping sonar is an active or passive sonar device lowered on cable by helicopters to detect or maintain contact with underwater targets. A description of various types of sonobuoys and dipping sonar is provided below.

1. AN/AQS-13 Helicopter Dipping Sonar – active scanning sonar that detects and maintains contact with underwater targets through a transducer lowered into the water from a hovering helicopter. It operates at mid-frequency, although the exact frequency is classified. The AN/AQS-13 is operated by MH-60R helicopters.

2. AN/AQS-22 A – the Navy's dipping sonar system for the MH-60R helicopter light airborne multi-purpose system III, which is deployed from aircraft carriers, cruisers, destroyers, and frigates. It operates at mid-frequency, although the exact frequency is classified. The AN/AQS-22 employs both deep- and shallow-water capabilities.

3. AN/SSQ-62C Directional Command Activated Sonobuoy System (DICASS) – sonobuoy that operates under direct command from ASW fixed-wing aircraft or MH-60R helicopters. The system can determine the range and bearing of the target relative to the sonobuoys position and can deploy to various depths within the water column. The active sonar operates at mid-frequency, although the exact frequency range is classified. After water entry, the sonobuoy transmits sonar pulses (continuous waveform or linear frequency modulation) upon command from the aircraft. The echoes from the active

sonar signal are processed in the buoy and transmitted to the receiving station onboard the launching aircraft.

4. AN/SSQ-110A Explosive Source Sonobuoy – a commandable, air-dropped, high source level explosive sonobuoy. The AN/SSQ-110A explosive source sonobuoy is composed of two sections, an active (explosive) section and a passive section. The upper section is called the "control buoy" and is similar to the upper electronics package of the AN/SSQ-62 DICASS sonobuoy. The lower section consists of two signal underwater sound explosive payloads of Class A explosive weighing 1.9 kg (4.2 lbs) each. The arming and firing mechanism is hydrostatically armed and detonated. Once in the water, the signal underwater sound 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. The AN/SSQ-110A explosive source sonobuoy is deployed by marine patrol aircraft.

5. AN/SSQ-53D/E Directional Frequency Analysis and Recording (DIFAR) – a passive sonobuoy deployed by MPA aircraft and MH-60R helicopters. The DIFAR sonobuoy provides acoustic signature data and bearing of the target of interest to the monitoring unit(s) and can be used for search, detection, and classification. The buoy uses a hydrophone with directional detection capabilities in the very low frequency, low frequency, and mid-frequency ranges, as well as an omnidirectional hydrophone for general listening purposes.

6.1.4.4 **Torpedoes**

Torpedoes (primarily MK-46 and MK-48) are the primary anti-submarine warfare weapon used by surface ships, aircraft, and submarines. The guidance systems of these weapons 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 guidance.

1. MK 48 and MK 48 Advanced capability are heavyweight torpedoes deployed on all classes of Navy submarines. MK 48 and MK 48 Advanced torpedoes are inert and considered HF sonar, but the frequency ranges are classified. Due to the fact that both

torpedoes are essentially identical in terms of environmental interaction, they will be referred to collectively as the MK 48 in this Opinion.

2. MK 46 Lightweight Torpedos are ASW torpedoes. They are less than half the size of the MK 48 and can be launched from surface ships, helicopters, and fixed wing aircraft. When used in training, the MK 46 is inert and considered HF sonar, but the exact frequency range is classified. When dropped from an aircraft, the MK 46 may have a parachute, which is jettisoned when it enters the water. The MK 46 torpedo also carries a small sea dye marker (Fluorescein) that marks the torpedo's position on the surface to facilitate recovery. The MK 46 is planned to remain in service until 2015.

In addition to these torpedoes, the Navy can employ acoustic device counter measures in their training exercises, which include MK-1, MK-2, MK-3, MK-4, noise acoustic emitter, and the AN/SLQ-25A NIXIE. These countermeasures act as decoys by making sounds that simulate submarines to avert localization or torpedo attacks.

6.1.4.5 **Targets**

Anti-submarine warfare training targets are used to simulate target submarines. They are equipped with one or a combination of the following devices:

(1) Acoustic projectors emanating sounds to simulate submarine acoustic signatures;

(2) Echo repeaters to simulate the characteristics of the echo of a particular sonar signal reflected from a specific type of submarine; and

(3) Magnetic sources to trigger magnetic detectors.

Training targets include TDU-34 towed target, anti-submarine warfare training targets, and MK-39 expendable mobile anti-submarine warfare training targets. Targets may be non-evading while operating on specified tracks or they may be fully evasive, depending on the training requirements of the training operation.

Weapon systems, targets, and other autonomous vehicles may involve a variety of active and passive acoustic systems. Active systems are those that emit acoustic energy or sound into the water. Passive acoustic systems do not generate acoustic energy in the water but are used to listen for sound in the water. The NWTRC uses a number of passive acoustic measurement

systems including a bottom moored array and various surface deployed arrays. Most test vehicles are instrumented with active acoustic sources to track real-time speed, location and recovery or retrieval at the end of activities.

6.1.5 Sound Fields and Pressure Waves from Underwater Detonations

The U.S. Navy plans to continue to employ several kinds of explosive ordnance on the NWTRC. Specifically, the U.S. Navy plans to conduct mine warfare training, explosive ordnance disposal, and sinking exercises on the range complex, all of which employ underwater detonations.

Two active EOD ranges are located in the Inland Waters at the following locations:

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

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

For the 2012-2015 LOA, the Navy changed the training ordnance such that they have the option of dividing the authorized explosive change into several smaller charges. As previously described, two underwater demolition events were authorized annually at each of the two training sites; Crescent Harbor and Hood Canal. The Crescent harbor site was previously= authorized for up to 2.5 pound explosive weight charges and the Hood Canal site was authorized for up to 1.5 pound charges. With the change, the unit conducting the training has the option of utilizing up to four, one ounce explosive charges in lieu of one 2.5 or 1.5 pound charge. The four small charges would be initiated individually with an approximately 15 minute interval between charge initiations. The overall quantity of explosive material utilized in four, one ounce events is substantially less than quantities utilized in either the 2.5 or 1.5 pound charges. All underwater detonation training events in the NWTRC utilize positive control, remote detonation of charges and none are to be initiated by time delayed firing devices.

As described previously, a typical training scenario would involve placing a dummy mine shape on the seafloor. Once the mine shape is located and marked, divers would place a C-4 charge on or around the mine and, typically, lift the mine shape and C-4 charge about 10 ft above the

seafloor. Once the area has been confirmed to be visually clear of marine mammals and birds, the charge is detonated manually (with a time-delay fuse) or remotely. These exercises typically last four hours for underwater detonations and one hour for surface detonations. The Explosives detonated underwater introduce loud, impulsive, broadband sounds into the marine environment. At its source, the acoustic energy of an explosive is, generally, much greater than that of a sonar, so careful treatment of them is important, since they have the potential to injure. Three source parameters influence the effect of an explosive: the net effective weight of the explosive, the type of explosive material, and the detonation depth. The net explosive weight accounts for the first two parameters. The net explosive weight 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. 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). Since most of the explosives the Navy uses in the Northwest Range Complex are munitions that detonate essentially upon impact, the effective source depths are very shallow so the surface-image interference effect can be pronounced. In order to limit the cancellation effect (and thereby provide exposure estimates that tend toward the worst case), relatively deep detonation depths are used.

The number of endangered or threatened species that might be exposed to explosions associated with this ordnance treat each in-water explosion as an independent event. The cumulative effect of a series of explosives can often be estimated by addition if the detonations are spaced widely in time and space which would provide marine animals sufficient time to move out of an area affected by an explosion. As a result, we assume that the populations of animals that are exposed to in-water explosions consist of different animals each time.

6.1.5.1 **Explosive Source associated with the Improved Extended Echo Ranging (IEER) System**

One of the systems the U.S. Navy employed on the NWTRC includes explosive charges that provide a sound source. The AN/SSQ-110A Explosive Source Sonobuoy is composed of two sections, an active (explosive) section and a passive section. The lower, explosive section consists of two signal underwater sound explosive payloads of Class A explosive weighing 1.9

kg (4.2 lbs) each. The arming and firing mechanism is hydrostatically armed and detonated. Once in the water, the signal underwater sound charges explode, creating a loud acoustic signal.

The cumulative effect of a series of explosives can often be estimated by addition if the detonations are spaced widely in time and space which would provide marine animals sufficient time to move out of an area affected by an explosion. As a result, the populations of animals that are exposed to in-water explosions are assumed to consist of different animals each time.

6.2 Classification of Impulsive and Non-implusive Acoustic Sources

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

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

There are two primary types of acoustic sources: impulsive and non-impulsive. A description of each source classification is provided in the table below. Impulsive source class bins are based on the Net Explosive Weight (NEW) of the munitions or explosive devices or the source level for air and water guns. Non-impulsive acoustic sources are grouped into source class bins based

on the frequency[13] source level[14], and, when warranted, the application in which the source would be used. The following factors further describe the considerations associated with the development of non-impulsive source bins:

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

6.3 Source Classes Analyzed for Training

Table **16** shows impulsive sources (detonations) associated with Navy training activities that were modeled. Table **17** shows non-impulsive (sonar and other acoustic devices) source classes that were modeled.

Table 16. Training Impulsive (Explosives) Source Classes Analyzed

Source Class	Representative Munitions	Net Explosive Weight (pounds

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

[14] Source decibel levels are expressed in terms of sound pressure level (SPL) and are values given in dB referenced to one micropascal at 1 meter.

		[lb.])
E1	Medium-caliber projectiles	0.1–0.25
E3	Large-caliber projectiles	> 0.5–2.5
E4	Improved Extended Echo Ranging Sonobuoy	> 2.5–5.0
E5	5-inch projectiles	> 5–10
E8	MK-46 torpedo	> 60–100
E10	Air-to-surface missile	> 250–500
E11	MK-48 torpedo	> 500–650
E12	2,000 lb. bomb	> 650–1,000

Table 17. Non-Impulsive Training Source Classes Quantitatively Analyzed

Source Class Category	Representative Munitions	Net Explosive Weight (pounds [lb.])
Mid-Frequency (MF): Tactical and non-tactical sources that produce mid-frequency (1–10 kHz) signals	MF1	Hull-mounted surface ship sonar (e.g., AN/SQS-53C and AN/SQS-60)
	MF3	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	MF4	Helicopter-deployed dipping sonar (e.g., AN/AQS-22 and AN/AQS-13)
	MF5	Active acoustic sonobuoys (e.g., DICASS)
	MF11	Hull-mounted surface ship sonar with an active duty cycle greater than 80%
High-Frequency (HF): Tactical and non-tactical sources that produce high-frequency (greater than 10 kHz but less than 100 kHz) signals	HF1	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)
	HF6	Active sources (equal to 180 dB and up to 200 dB)
Anti-Submarine Warfare (ASW): Tactical sources such as active sonobuoys and acoustic countermeasures systems used during the conduct of ASW testing activities	ASW2	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)
	ASW3	Mid-frequency towed active acoustic countermeasure systems (e.g., AN/SLQ-25)

6.4 Exposure Estimates

Our exposure analyses are designed to determine whether listed resources are likely to co-occur with the direct and indirect beneficial and adverse effects of actions and the nature of that co-occurrence. In this step, we try to identify the number, age (or life stage), and gender of the

individuals that are likely to be exposed to one or more of the stressors produced by or associated with an Action and the populations or subpopulations those individuals represent.

6.4.1 Disturbance from Vessel Traffic

We assume that any individuals of the endangered or threatened species that occur in the Action Area during the military readiness activities in the NWTRC may be exposed to visual and acoustic stimuli associated with vessel traffic and related activities. However, we are not able to quantify those exposures separately from the other potential stressors associated with the Navy's military readiness activities.

6.4.2 Vessel Strike

To estimate the number of times individual animals might have some risk of being struck by a Navy vessel involved in training activities, we considered the speeds (about 10 knots) at which these vessels are likely to move, the Navy's operational orders for ships to prevent collisions between surface vessels participating in naval exercises, and the endangered species that might occur in the action area. The measures, which include marine observers on the bridge of ships, requirements for course and speed adjustments to maintain safe distances from whales, and having any ship that observes whales alert other ships in the area, have historically been effective measures for avoiding collisions between surface vessels and whales in the action area.

Observations for marine mammals are conducted prior to each training event, and activities are postponed if a cetacean is observed within established exclusion zones. For cetaceans the exclusion zones must be as least as large as the area in which the test vehicle may operate in and must extend at least 1,000 yards (914 m) from the intended track of the test vehicle. For pinnipeds, the exclusion zone extends out 100 yards (91 m) from the intended track of the test vehicle. The exclusion zones for cetaceans and pinnipeds would be established prior to an in-water exercise (Navy 2008a).

U.S. Navy vessels that are underway produce engine noise and noise produced by displacement across the bow. Those and other cues would be available to endangered or threatened whales that are in or near a ship's path and would increase the whale's probability of avoiding the ship before a collision occurs (see Ford and Reeves 2008 for the specific anti-predator strategies of different species of baleen whales). Although the number of times endangered or threatened whales are struck by ships in other areas of the world and by U.S. Navy vessels on other range complexes is the strongest evidence that this avoidance does not always occur or is not always effective, the absence of collisions involving U.S. Navy vessels and endangered or threatened

species in the Pacific Northwest despite decades of spatial and temporal overlap suggests that the actual probability of a collision is small.

It is possible, but highly unlikely, that a marine mammal could be struck by a submarine while it is under water. When traveling on the surface, the chances of a strike are probably much the same as for any vessel of the same size moving at the same speed. Smaller animals like pinnipeds and porpoises are expected to be able to detect and avoid boats and ships. The greatest risk is from baleen whales (e.g., blue, fin, and humpback) which are rare within the vicinity of the NWTRC.

There has never been a vessel strike to a whale during any of the training activities in the action area. There has been only one whale strike in the Pacific Northwest by the Navy since such records have been kept (June 1994–present). In August 2012, a San Diego homeported DDG at-sea about 35 nm west of Coos Bay, Oregon struck a whale while transiting to San Diego after visiting Seattle for a Fleet Week celebration. The whale (believed to be a minke whale) was last seen swimming away from the location. The fate of the animal is unknown and although no blood or other obvious indications of injury to the whale were detected, this does not negate the possibility that there may have been serious internal injury to the whale resulting from the encounter.

Based on the small number of training events that occur on the NWTRC, the small number of vessels involved in those training events, and decades of spatial and temporal overlap that have not resulted in a collision, we conclude that the probability of a U.S. Navy vessel striking an endangered whale on the NWTRC is very low in a given year yet possible (though still unlikely) over an extended period of time.

The rarity of ship strikes involving pinnipeds and sea turtles combined with the Navy's established operating policies and procedure intended to reduce interactions of Navy assets and listed species, leads NMFS to conclude that the exposure risk of collision from surface vessels or submarines is also very low.

We could not find any reports regarding collisions with surface vessels or submarines and any species of fish of similar size or characteristics of the ESA-listed species being considered in this Opinion. Therefore we conclude that the risk of collision between surface vessels and submarines and leatherback sea turtles, and ESA-listed fish (bocaccio, eulachon, Chinook, coho, chum, and sockeye salmon, and steelhead) is so small as to be discountable. Therefore, the risk

of collision with surface vessels and submarines with these species will not be discussed further in this Opinion.

6.4.3 Exposure to Projectiles and Expended Materials

The potential for marine mammals to be exposed to projectiles or encounter expended material is low given the density of marine mammals in the NWTRC. The probability is further reduced by Navy mitigation measures, which require the area be clear of marine mammals before most of the equipment would be deployed. The potential for leatherback sea turtles, bocaccio, eulachon, or salmonids to encounter expended material is sufficiently low that it can be considered discountable.

Based on the above information, NMFS does not consider this category of potential stressors further in the analyses.

6.4.4 Overview of Exposure to Active Sonar and Underwater Detonations

The U.S. Navy will continue to implement mitigation measures required under the current MMPA rule to prevent marine mammals from being exposed to mid frequency active sonar at high received levels. The Navy has chosen to exclude mid-frequency active sonar training in Puget Sound from the scope of their action. Therefore, we assume that endangered or threatened species under our jurisdiction would not be exposed to mid-frequency active sonar in Puget Sound.

The other measures the U.S. Navy is required to implement rely primarily on Navy marine species observers, helicopter pilots, and other Navy assets detecting marine mammals visually so that the Navy can take the appropriate action. To the degree that the Navy detects marine mammals visually, these safety zones might reduce the number of marine mammals that are exposed to mid-frequency active sonar or the intensity of their exposure. The other measures the U.S. Navy implements rely primarily on Navy marine species observers, helicopter pilots, and other Navy assets detecting marine mammals visually so that the Navy can take the appropriate action. To the degree that the Navy detects marine mammals visually, these safety zones might reduce the number of marine mammals that are exposed to mid-frequency active sonar or the intensity of their exposure.

However, the effectiveness of visual monitoring is limited to daylight hours, and its effectiveness declines during poor weather conditions (JNCC 2004). In line transect surveys, the range of effective visual sighting (the distance from the ship's track or the effective strip width) varies

with an animal's size, group size, reliability of conspicuous behaviors (blows), pattern of surfacing behavior, and positions of the observers (which includes the observer's height above the water surface). For most large baleen whales, effective strip width can be about 3 km (1.6 nm) up through Beaufort 6 (Buckland and Borchers 1993). For harbor porpoises the effective strip width is about 273 yd (250 m), because they are much smaller and less demonstrative on the surface than baleen whales (Palka 1996).

Further, several studies of interactions between seismic surveys and marine mammals and a proposed low-frequency active sonar system and marine mammals concluded that dedicated marine mammal observers were more effective at detecting marine mammals, were more effective at detecting marine mammals at greater distances than Navy watchstanders (watchstanders of the Navies of other countries), were better at identifying the marine mammal to species, and reported a broader range of behaviors than other personnel (Aicken et al. 2005; Stone 2000; Stone 2001; Stone 2003b). It is not clear, however, how the U.S. Navy's watchstanders and marine species observers, who are specifically trained to identify objects in the water surrounding Navy vessels, compare with observers who are specifically trained to detect and identify marine mammals in marine water. NMFS is working with the Navy to determine the effectiveness of this component of the Navy's monitoring program and the degree to which it is likely to minimize the probability of exposing marine mammals to mid-frequency active sonar.

The percentage of marine animals Navy personnel would not detect, either because they will pass unseen below the surface or because they will not be seen at or near the ocean surface, is difficult to determine. However, for minke whales, Schweder et al. (1992) estimated that visual survey crews did not detect about half of the animals in a strip width. Palka (1996) and Barlow (1988) estimated that visual survey teams did not detect about 25 percent of the harbor porpoises in a strip width.

Given that marine mammals off the coasts of Washington, Oregon, and California are generally free to move and will do so to follow food, temperature gradients, to avoid potential predation or competitive interactions, or as part of their seasonal migrations, the actual location of marine mammals is highly variable; their location and numbers are likely to change over hourly, diurnally, daily, weekly, or monthly intervals. Because the distribution and abundance of marine mammals within an area like the NWTRC will be highly variable as animals enter and leave specific areas while foraging or engaging in social activity, among other reasons, density

estimates that assume that the density of animals in a particular location will reflect their distribution and abundance over the larger area over which they move are more appropriate than density estimates that assume animals do not change their location.

6.4.5 Exposure Estimates for Non-impulsive Acoustic Sources

For this consultation, NMFS considered exposure estimates from the Phase II NAEMO model at several output points for marine mammals and sea turtles. Exposure of fish to acoustic stressors was not modeled due to limited information on species distribution and density in the action area. First, we estimated the total number of ESA-listed species (animats) that would be exposed to acoustic sources prior to the application of a dose-response curve or criteria. We term these the "unprocessed" estimates. This estimate is the number of times individual animats or animals are likely to be exposed to the acoustic environment that is a result of training exercises, regardless of whether they are "taken" as a result of that exposure. In most cases, the number of animals "taken" by an action would be a subset of the number of animals that are exposed to the action because (1) in some circumstances, animals might not respond to an exposure or (2) some responses may be negative for an individual animal without constituting a form of "take" (for example, some physiological stress responses only have fitness consequences when they are sustained and would only constitute a "take" as a result of cumulative exposure).

A second set of exposure estimates ("model-estimated") of listed species were generated and "processed" using dose-response curves and criteria for temporary and permanent threshold shift developed by the Navy and NMFS' Permits Division for the purpose of identifying harassment pursuant to the MMPA. Neither sets of exposure estimates, the unprocessed or processed, consider standard mitigation actions that NMFS' Permits Division requires under the MMPA rule and LOA to avoid marine mammals, nor did the estimates consider any avoidance responses that might be taken by individual animals once they sense the presence of Navy vessels or aircraft. Since the processed exposure estimates represent incidental take for purposes of the ESA, we base our jeopardy analyses and determinations on these estimates. These estimates do not take into account the standard mitigation measures required under the MMPA rule or conducted by the Navy.

Table 19 identifies unprocessed exposure estimates binned into potential exposures above 120 dB and above 150 dB, values derived from literature. We do not rely on these potential exposures for our jeopardy analysis, but include this information to illustrate that the number of

exposures that may result in a take is a small subset of the total estimated exposures. We discuss after the table the difference in these numbers for the listed species.

Unprocessed exposure estimates of marine mammals and sea turtles to non-impulsive sound from active sonar sources at identified decibel levels used in training exercises are summarized in Table **18** below and further described in the following sections.

Table 18. Summary of Navy-modeled Exposure Estimates for Non-Impulsive Acoustic Sources

Training Activity Type by Species	Exposure Levels		% of Total
	>120dB	>150dB	
Maritime Homeland Defense/Security Mine Countermeasures Integrated Exercise	**0.00**	**0.00**	**0**
humpback whale	0.00	0.00	0.00%
killer whale southern resident	0.00	0.00	0.00%
Submarine Mine Exercise	**0.00**	**0.00**	**0.00%**
blue whale	0.00	0.00	0.00%
fin whale	0.00	0.00	0.00%
humpback whale	0.00	0.00	0.00%
leatherback turtle	0.00	0.00	0.00%
sperm whale	0.00	0.00	0.00%
Submarine Sonar Maintenance	**0.00**	**0.00**	**0.00%**
blue whale	0.00	0.00	0.00%
fin whale	0.00	0.00	0.00%
humpback whale	0.00	0.00	0.00%
killer whale southern resident	0.00	0.00	0.00%
leatherback turtle	0.00	0.00	0.00%
sei whale	0.00	0.00	0.00%
sperm whale	0.00	0.00	0.00%
Surface Ship Sonar Maintenance	**0.00**	**0.00**	**0.00%**
blue whale	0.00	0.00	0.00%
fin whale	0.00	0.00	0.00%
humpback whale	0.00	0.00	0.00%
killer whale southern resident	0.00	0.00	0.00%
leatherback turtle	0.00	0.00	0.00%
sei whale	0.00	0.00	0.00%

sperm whale	0.00	0.00	0.00%
TRACKEX - Helo	**0.00**	**0.00**	**0.00%**
blue whale	0.00	0.00	0.00%
fin whale	0.00	0.00	0.00%
humpback whale	0.00	0.00	0.00%
leatherback turtle	0.00	0.00	0.00%
sei whale	0.00	0.00	0.00%
sperm whale	0.00	0.00	0.00%
steller sea lion	0.00	0.00	0.00%
TRACKEX - MPA	**905.62**	**5.99**	**3.47%**
blue whale	5.33	0.02	3.01%
fin whale	36.33	0.18	3.31%
humpback whale	16.53	0.05	1.09%
leatherback turtle	0.00	0.00	0.00%
sei whale	2.37	0.00	3.67%
sperm whale	303.19	0.47	7.80%
TRACKEX - MPA (Multi-Static Active Coherent - MAC)	**18720.40**	**17.96**	**71.74%**
blue whale	132.44	0.15	74.92%
fin whale	872.80	1.28	79.52%
humpback whale	1258.46	0.41	83.05%
leatherback turtle	2409.63	2.23	100%
sei whale	48.80	0.06	75.73%
sperm whale	2671.07	2.31	68.75%
TRACKEX - Sub	**68.66**	**7.40**	**0.26%**
blue whale	0.97	0.14	0.55%
fin whale	2.88	0.28	0.26%
humpback whale	1.05	0.11	0.07%
leatherback turtle	0.00	0.00	0.00%
sei whale	0.16	0.01	0.25%
sperm whale	13.55	1.03	0.35%
TRACKEX - Surface	**6399.72**	**773.34**	**24.53%**
blue whale	38.04	3.04	21.52%
fin whale	185.63	12.76	16.91%
humpback whale	239.20	8.52	15.79%
killer whale southern resident	0.00	0.00	0.00%

leatherback turtle	0.00	0.00	0.00%
sei whale	13.11	0.84	20.35%
sperm whale	897.56	128.60	23.10%

6.4.5.1 **Blue Whale**

The model output estimates that blue whales will be exposed to sonar and other non-impulsive acoustic stressors associated with training activities throughout the year. The NAEMO provided an unprocessed estimate of approximately 177 blue whale exposure events annually to non-impulsive sounds associated with annual training at levels greater than 120dB and approximately four exposures between 150dB and 195 dB SPL with one exposure above 169dB. No exposures to non-impulsive sounds associated with annual training are expected above 195 dB SPL. Approximately 75% of the total sonar exposures to blue whales result from TRACKEX – MPA while approximately 22% of exposures result from TRACKEX – Surface training activities (Table **18**).

6.4.5.2 **Fin Whale**

The model output estimates that fin whales will be exposed to sonar and other non-impulsive acoustic stressors associated with training activities throughout the year. The NAEMO provided an unprocessed estimate of approximately 1,097 fin whale exposure events annually to non-impulsive sounds associated with annual training at levels greater than 120dB and approximately 15 exposures between 150dB and 195 dB SPL with three exposures above 169dB. No exposures to non-impulsive sounds associated with annual training are expected above 195 dB SPL. Approximately 80% of the total sonar exposures to fin whales result from TRACKEX – MPA while approximately 17% of exposures result from TRACKEX – Surface training activities (Table **18**).

6.4.5.3 **Humpback Whale**

The model output estimates that humpback whales will be exposed to sonar and other non-impulsive acoustic stressors associated with training activities throughout the year. The NAEMO provided an unprocessed estimate of approximately 1,516 humpback whale exposure events annually to non-impulsive sounds associated with annual training at levels greater than 120dB and approximately ten exposures between 150dB and 195 dB SPL with two above 169dB. No exposures to non-impulsive sounds associated with annual training are expected above 195 dB SPL. Approximately 83% of the total sonar exposures to humpback whales result from

TRACKEX – MPA while approximately 16% of exposures result from TRACKEX – Surface training activities (Table **18**).

6.4.5.4 **Sei Whale**

The model output estimates that sei whales will be exposed to sonar and other non-impulsive acoustic stressors associated with training activities throughout the year. The NAEMO provided an unprocessed estimate of approximately 65 sei whale exposure events annually to non-impulsive sounds associated with annual training at levels greater than 120dB and approximately one exposure between 150dB and 195 dB SPL with one above 169dB. No exposures to non-impulsive sounds associated with annual training are expected above 195 dB SPL. Approximately 76% of the total sonar exposures to sei whales result from TRACKEX – MPA while approximately 20% of exposures result from TRACKEX – Surface training activities (Table **18**).

6.4.5.5 **Sperm Whale**

The model output estimates that sperm whales will be exposed to sonar and other non-impulsive acoustic stressors associated with training activities throughout the year. The NAEMO provided an unprocessed estimate of 3,886 sperm whale exposure events annually to non-impulsive sounds associated with annual training at levels greater than 120dB and approximately 132 exposures between 150dB and 195 dB SPL with eight above 169dB. No exposures to non-impulsive sounds associated with annual training are expected above 195 dB SPL. Approximately 69% of the total sonar exposures to sperm whales result from TRACKEX – MPA while approximately 23% of exposures result from TRACKEX – Surface training activities (Table **18**).

6.4.5.6 **Southern Resident Killer Whale**

The model output estimates that no southern resident killer whales will be exposed to sonar and other non-impulsive acoustic stressors associated with training activities throughout the year. The Navy modeled exposure from Maritime Homeland Defense/Security Mine Countermeasures Integrated Exercises, Submarine Sonar Maintenance, Surface Ship Maintenance, and TRACKEX-Surface activities with zero exposures resulting. Other training activities, not modeled, would not have potential to expose southern resident killer whales to non-impulsive acoustic stressors.

6.4.5.7 **Leatherback Sea Turtle**

The model output estimates that leatherback sea turtles will be exposed to sonar and other non-impulsive acoustic stressors associated with training activities throughout the year. The NAEMO provided an unprocessed estimate of 2,410 leatherback sea turtles exposure events annually to non-impulsive sounds associated with annual training at levels greater than 120dB and approximately three exposures between 150dB and 195 dB SPL with zero above 169dB. No exposures to non-impulsive sounds associated with annual training are expected above 195 dB SPL. 100% of the total sonar exposures to leatherback sea turtles result from TRACKEX – MPA (Table **18**).

6.4.5.8 **Endangered and Threatened Fish Species**

As discussed above, exposure of fish to acoustic stressors was not modeled (NAEMO) due to limited information on species distribution and density in the action area. Therefore, we conducted a qualitative analysis on potential exposure to sonar and other acoustic devices. Non-impulsive acoustic sources include sonar and other active acoustic sources.

6.4.5.8.1 High-Frequency Active Sonar

Only a few species of shad within the Clupeidae family (herrings) are known to be able to detect high-frequency sonar and other active acoustic sources greater than 10,000 Hz. Other marine fish would not detect these sounds and would therefore experience no stress, behavioral disturbance, or auditory masking. Shad species, especially in nearshore and inland areas where mine warfare activities take place that often employ high-frequency sonar systems, could have behavioral reactions and experience auditory masking during these activities. However, mine warfare activities are typically limited in duration and geographic extent. Furthermore, sound from high-frequency systems may only be detectable above ambient noise regimes in these coastal habitats from within a few kilometers. Behavioral reactions and auditory masking, if they occurred for some shad species, are expected to be transient. Long-term consequences for the population would not be expected.

6.4.5.8.2 Mid-Frequency Active Sonar

Most marine fish species are not expected to be able to detect sounds in the mid-frequency range of operational sonar. The fish species that are known to detect mid-frequencies (some sciaenids [drum], most clupeids [herring, sardines], and potentially deep-water fish such as myctophids [lanternfish]) do not have their best sensitivities in the range of operational sonar. Thus, these fish may only detect the most powerful systems, such as hull-mounted sonar, within a few kilometers, and most other, less powerful mid-frequency sonar systems, for a kilometer or less.

Due to the limited time of exposure due to the moving sound sources, most mid-frequency active sonar used in the NWTRC action area would not have the potential to substantially mask key environmental sounds or produce sustained physiological stress or behavioral reactions. Furthermore, although some species may be able to produce sound at higher frequencies (greater than 1 kHz), vocal marine fish, such as sciaenids, largely communicate below the range of mid-frequency levels used by most sonar. Other marine species probably cannot detect mid-frequency sonar (1,500 –10,000 Hz) and therefore impacts are not expected for these fish (Popper 2008). However, any such effects would be temporary and infrequent as a vessel transits an area. Some mid-frequency active sonar use, outside the hearing range of most fish species, conducted while ships are pierside and not transiting. As such, sonar use is unlikely to impact fish species. Long-term consequences for fish populations due to exposure to mid-frequency sonar and other active acoustic sources are not expected.

The ESA-listed salmonid species (steelhead trout, Chinook salmon, Coho salmon, chum salmon, and sockeye salmon), and Pacific eulachon, are anadromous and spend a portion of their lives in both the marine environment as well as in the riverine and estuarine systems throughout the Action Area. These species have the potential to be exposed to non-impulse sound associated with training activities in the coastal areas. Since salmonid species and Pacific eulachon spawn in rivers and the early life stages of the fish occur in riverine and estuarine environments, eggs and larvae would not be exposed to sounds produced from non-impulse sound sources during training activities.

It is believed that salmonid species, which are anatomically similar to Atlantic salmon, are unable to detect the sound produced by mid- or high-frequency sonar and other active acoustic sources. Therefore, acoustic impacts from these sources are not expected.

6.4.5.8.3 Vessel Noise

Training activities include vessel movement that could occur anywhere within the NWTRC; however, it would be concentrated near ports and training ranges. Activities involving vessel movements occur intermittently and are variable in duration, ranging from a few hours up to 2 weeks.

Additionally, a variety of smaller craft would be operated. These small craft types, sizes, and speeds vary, but in general, they will emit higher-frequency noise than larger ships. Training activities typically consist of a single vessel involved in unit-level activity for a few hours, or one

or two small boats. Navy vessels do contribute to the overall ambient noise in inland waters. Vessel noise has the potential to expose fish to sound and general disturbance, which could result in short-term behavioral or physiological responses (e.g., avoidance, stress, increased heart rate). Training activities involving vessel movements occur intermittently and range in duration from a few hours up to a few weeks. These activities are widely dispersed throughout the NWTRC. While vessel movements have the potential to expose fish occupying the water column to sound and general disturbance, potentially resulting in short-term behavioral or physiological responses, such responses would not be expected to compromise the general health or condition of individual fish. In addition, most activities involving vessel movements are infrequent and widely dispersed throughout the action area.

The majority of fish species exposed to non-impulsive sources would likely have no reaction or mild behavioral reactions. Overall, long-term consequences for individual fish are unlikely in most cases because acoustic exposures are intermittent and unlikely to repeat over short periods. Since long-term consequences for most individuals are unlikely, long-term consequences for populations are not expected.

The ESA-listed salmonid species (steelhead trout, Chinook salmon, Coho salmon, chum salmon, and sockeye salmon), and Pacific eulachon are anadromous and spend a portion of their lives in both the marine environment as well as in the riverine and estuarine systems throughout the NWTRC Action Area. These species have the potential to be exposed to non-impulsive sound associated with training activities. Since salmonid species and Pacific eulachon spawn in rivers and the early life stages of the fish occur in riverine and estuarine environments, eggs and larvae would not be exposed to sounds produced from non-impulsive sound sources during training activities.

It is believed that salmonid species, which are anatomically similar to Atlantic salmon, are unable to detect the sound produced by mid- or high-frequency sonar and other active acoustic sources. Therefore, acoustic impacts from these sources are not expected.

6.4.6 Exposure Estimates for Impulsive Acoustic Sources

As with non-impulsive sources, NMFS considered exposure estimates from the Navy Acoustic Effects Model for marine mammals and sea turtles. Exposure of fish to acoustic stressors was not modeled due to limited information on species distribution and density in the action area. First, the total number of ESA-listed species (animats) that would be exposed to acoustic sources prior

to the application of a dose-response curve or criteria. We term these the "unprocessed" estimates. This estimate is the number of times individual animats or animals are likely to be exposed to the acoustic environment that is a result of training exercises, regardless of whether they are "taken" as a result of that exposure. In most cases, the number of animals "taken" by an action would be a subset of the number of animals that are exposed to the action because (1) in some circumstances, animals might not respond to an exposure and (2) some responses may be negative for an individual animal without constituting a form of "take" (for example, some physiological stress responses only have fitness consequences when they are sustained and would only constitute a "take" as a result of cumulative exposure).

A second set of exposure estimates ("model-estimated") of listed species were generated and "processed" using dose-response curves and criteria for temporary and permanent threshold shift developed by the Navy and NMFS' Permits Division for the purpose of identifying harassment pursuant to the MMPA. As above, these are the estimates we use in our jeopardy analysis and determination.

Mitigation measures are effective at reducing instances of injury or mortality, but would not further reduce potential behavioral impacts to lesser impacts due to the potential distance from the source stressor. The Navy states that avoidance and mitigation only reduces those "Level A" (potential to injure or kill) impacts to "Level B" impacts. In this case there are no Level A exposures and thus the estimated amounts are not changed.

Estimated unprocessed exposures of marine mammals and sea turtles to impulsive sound from underwater detonations during training exercises at levels greater than 120 dB and 150 dB are summarized in Table **19** below. As with these estimates for the non-impulsive sources contained in Table 19, NMFS does not rely on these estimates in its jeopardy analysis.

Table 19. Summary of Navy-modeled Exposure Estimates for Impulsive Acoustic Sources

Training Activity Type	Number of Exposures by Exposure Level		% of Exposures by Activity
	>120 dB	>150 dB	
BOMBEX [A-S]	**338.92**	**122.71**	**41.12%**
blue whale	3.88	1.03	42.29%
fin whale	22.34	4.01	38.25%
humpback whale	8.10	2.60	33.03%
leatherback turtle	41.57	12.43	40.36%

sei whale	3.19	1.33	54.35%
sperm whale	29.84	19.19	51.07%
GUNEX [S-S] - Ship	**0.00**	**0.00**	**0.00%**
blue whale	0.00	0.00	0.00%
fin whale	0.00	0.00	0.00%
humpback whale	0.00	0.00	0.00%
leatherback turtle	0.00	0.00	0.00%
sei whale	0.00	0.00	0.00%
sperm whale	0.00	0.00	0.00%
Mine Neutralization - EOD	**0.22**	**0.22**	**0.03%**
killer whale southern resident	0.04	0.04	100%
SINKEX	**338.17**	**173.69**	**41.02%**
blue whale	4.00	2.70	43.53%
fin whale	24.99	9.08	42.79%
humpback whale	13.00	2.27	53.02%
leatherback turtle	43.08	10.79	41.83%
sei whale	2.00	1.71	33.99%
sperm whale	17.99	11.12	30.79%
TRACKEX - MPA (Multi-Static Active Coherent - MAC)	**147.00**	**131.34**	**17.83%**
blue whale	1.30	1.05	14.18%
fin whale	11.08	9.87	18.96%
humpback whale	3.42	3.35	13.94%
leatherback turtle	18.35	15.09	17.82%
sei whale	0.69	0.57	11.76%
sperm whale	10.59	10.37	18.13%

6.4.6.1 **Blue Whale**

The model output estimates that blue whales will be exposed to impulsive acoustic stressors associated with training activities throughout the year. The NAEMO provided an unprocessed estimate of approximately ten blue whale exposure events annually to impulsive sounds associated with annual training at levels greater than 120dB and approximately five exposures between 150dB and 195 dB SPL. No exposures to impulsive sounds associated with annual training are expected above 195 dB SPL. Approximately 42% of the total exposures to blue

whales result from BOMBEX Air-to-Surface training while approximately 44% of exposures result from SINKEX activities and 14% from TRACKEX-MPA (**Table 19**).

6.4.6.2 **Fin Whale**

The model output estimates that fin whales will be exposed to impulsive acoustic stressors associated with training activities throughout the year. The NAEMO provided an unprocessed estimate of approximately 59 fin whale exposure events annually to impulsive sounds associated with annual training at levels greater than 120dB and approximately 23 exposures between 150dB and 195 dB SPL. No exposures to impulsive sounds associated with annual training are expected above 195 dB SPL. Approximately 38% of the total exposures to fin whales result from BOMBEX Air-to-Surface training while approximately 43% of exposures result from SINKEX activities and 19% from TRACKEX-MPA (Table **19**).

6.4.6.3 **Humpback Whale**

The model output estimates that humpback whales will be exposed to impulsive acoustic stressors associated with training activities throughout the year. The NAEMO provided an unprocessed estimate of approximately 25 humpback whale exposure events annually to impulsive sounds associated with annual training at levels greater than 120dB and approximately nine exposures between 150dB and 195 dB SPL. No exposures to impulsive sounds associated with annual training are expected above 195 dB SPL. Approximately 33% of the total exposures to humpback whales result from BOMBEX Air-to-Surface training while approximately 53% of exposures result from SINKEX activities and 14% from TRACKEX-MPA (Table **19**).

6.4.6.4 **Sei Whale**

The model output estimates that sei whales will be exposed to impulsive acoustic stressors associated with training activities throughout the year. The NAEMO provided an unprocessed estimate of approximately six sei whale exposure events annually to impulsive sounds associated with annual training at levels greater than 120dB and approximately four exposures between 150dB and 195 dB SPL. No exposures to impulsive sounds associated with annual training are expected above 195 dB SPL. Approximately 54% of the total exposures to sei whales result from BOMBEX Air-to-Surface training while approximately 34% of exposures result from SINKEX activities and 12% from TRACKEX-MPA (Table **19**).

6.4.6.5 **Sperm Whale**

The model output estimates that sperm whales will be exposed to impulsive acoustic stressors associated with training activities throughout the year. The NAEMO provided an unprocessed

estimate of 59 sperm whale exposure events annually to impulsive sounds associated with annual training at levels greater than 120dB and approximately 41 exposures between 150dB and 195 dB SPL. No exposures to impulsive sounds associated with annual training are expected above 195 dB SPL. Approximately 51% of the total exposures to sperm whale result from BOMBEX Air-to-Surface training while approximately 31% of exposures result from SINKEX activities and 18% from TRACKEX-MPA (Table **19**).

6.4.6.6 **Southern Resident Killer Whale**

The model output estimates that no southern resident killer whales will be exposed to impulsive acoustic stressors associated with training activities throughout the year. The Navy modeled exposure from Mine Neutralization – Explosive Ordnance Disposal activities with zero exposures resulting. Other training activities, not modeled, would not have potential to expose southern resident killer whales to impulsive acoustic stressors.

6.4.6.7 **Leatherback Sea Turtle**

The model output estimates that leatherback sea turtles will be exposed to impulsive acoustic stressors associated with training activities throughout the year. The NAEMO provided an unprocessed estimate of 103 leatherback sea turtles exposure events annually to impulsive sounds associated with annual training at levels greater than 120dB and approximately 39 exposures between 150dB and 195 dB SPL. No exposures to impulsive sounds associated with annual training are expected above 195 dB SPL Approximately 40% of the total exposures to leatherback sea turtles result from BOMBEX Air-to-Surface training while approximately 42% of exposures result from SINKEX activities and 18% from TRACKEX-MPA (Table **19**).

6.4.6.8 **Endangered and Threatened Fish Species**

Training would use underwater detonations and explosive ordnance. Potential impacts on fish from explosions and impulsive acoustic sources can range from no impact, brief acoustic effects, tactile perception, and physical discomfort; to slight injury to internal organs and the auditory system; to death of the animal (Keevin et al. 1997). Occasional behavioral reactions to intermittent explosions and impulsive acoustic sources are unlikely to cause long-term consequences for individual fish or populations. Fish that experience hearing loss (permanent or temporary threshold shift) as a result of exposure to explosives and impulsive acoustic sources may have a reduced ability to detect relevant sounds such as predators, prey, or social vocalizations.

The ESA-listed salmonid species (steelhead trout, Chinook salmon, chum salmon, coho salmon, and sockeye salmon), and Pacific eulachon are anadromous and spend a portion of their lives in both the marine environment as well as in the riverine and estuarine systems.

Salmonid species and Pacific eulachon species have the potential to be exposed to explosive energy and sound associated with training activities in the offshore portions of the action area. Since the salmonid species and Pacific eulachon spawn in rivers and the early lifestages of the fish occur in riverine and estuarine environments, eggs and larvae would not be exposed to impulsive acoustic sources produced by explosives, weapons firing, launch, and non-explosive ordnance impact with the water's surface during training activities in the offshore portions of the action area.

Training activities involving impulsive acoustic sources in the offshore portions of the action area have the possibility to affect the ESA-listed species present, potentially resulting in short-term behavioral or physiological responses, hearing loss, injury, or mortality. The infrequent nature of training activities involving impulsive acoustic sources reduces the likelihood of these species encountering an explosive activity taking place anywhere within the offshore portions of the action area.

Fish species would be exposed to explosions at or beneath the water during training activities. Noise could be produced by explosions and weapons firing in the Inland Waters of the NWTRC. Explosive events would consist of a single explosion. The detonations would occur in Hood Canal and Crescent Harbor. The infrequent nature of training activities involving impulsive acoustic sources reduces the likelihood of these species encountering an explosive activity taking place in the Inland Waters of NWTRC. Two detonation events are permitted a year at both the Crescent Harbor and Hood Canal range areas. Each event at Crescent Harbor may consist of EITHER a single 2.5 lb charge OR four, 1 ounce charges set off approximately 30 minutes apart. Each event at Hood Canal may consist of EITHER a single 1.5 lb charge OR four, 1 ounce charges set off approximately 30 minutes apart. For impact analysis purposes, we are analyzing a worst case scenario where two 2.5 lb charges are used at Crescent Harbor and two 2.5 lb charges are used at Hood Canal per year, therefore the range to effects of these net explosive weights is assumed in our analysis. Over the past two years only the 1 ounce charges have been used for training.

Green sturgeon, Pacific salmon and steelhead, and the southern population of eulachon are likely to be exposed to the sound field produced by underwater detonations. Since we did not have density estimates for each species to conduct quantitative exposure analysis for impulsive sound exposures, we made the following assumptions:

1. Green sturgeon are likely to be exposed to training activities that occur in coastal areas of the NWTRC (particularly areas W-237A, W-237B, and W-237E). Because of their coastal distribution, southern green sturgeon are not likely to be exposed to training activities that occur on those portions of the NWTRC that occur seaward of state waters. As a result, southern green sturgeon are not likely to be exposed to training activities that occur off the coasts of California (W-93B) or Oregon (W-93A or W-570);

2. Endangered and threatened species of Pacific salmon and steelhead are likely to be exposed to training activities that occur in coastal or nearshore areas of the NWTRC (particularly areas W-237A, W-237B, and W-237E). The number of each ESU or DPS that might be exposed is not quantifiable because we do not have sufficient information on exactly when or where species will be or when or where the Navy's activities will occur;

3. Adult and juvenile Puget Sound Chinook salmon, Hood Canal summer run chum salmon, and Puget Sound steelhead, because of their presence in Puget Sound, are likely to be exposed to shock waves and sound fields associated with underwater detonations on the Northwest Training Range, particularly during explosive ordnance disposal operations at Naval Air Station Whidbey Island in Crescent Harbor and Bangor in northern Hood Canal. We expect each of the surface detonations will expose one adult and one juvenile Puget Sound Chinook salmon at Crescent Harbor; each underwater detonation at Hood Canal will expose six adult Puget Sound Chinook salmon; and each underwater detonation at Hood Canal will exposure 27 adult Hood Canal summer-run chum salmon at levels which may result in mortality (NMFS 2008). As described above, up to two detonations are expected to occur annually at both EOD ranges, thus a total of 16 Puget Sound Chinook salmon and a total of 54 Hood Canal summer-run chum salmon will be exposed annually to underwater detonations at levels which may result in mortality (Table 23).

4. Southern population of eulachon are likely to be exposed to shock waves and sound fields associated with explosive ordnance disposal operations at Crescent Harbor and Bangor in northern Hood Canal.

6.4.7 Summary of Modeled Exposure Estimates for Non-impulsive and Impulsive Sound Sources and Navy, Post-processed Estimates of Take

As we discussed above, NMFS considered exposure estimates from the Navy Acoustic Effects Model for marine mammals and sea turtles. In Table **20**, below, we summarize model-estimated exposure events between 150dB and 195dB to provide a general comparison of the extent of exposure events to which individuals of each species might be exposed.

Table 20. Navy Unprocessed Exposure Estimates Compared to the Post-processed Estimate of Exposures Constituting Behavioral Harassment

ESA Species	Navy Model-Estimated Exposures (Unprocessed) Between 150dB and 195dB	Post-processed, Navy Exposure Estimates Considering MMPA Criteria (Dose Response)
Blue Whale	**14**	**1**
Fin Whale	**38**	**6**
Humpback Whale	**19**	**3**
Sei Whale	**5**	**0**
Sperm Whale	**173**	**26**
Southern Resident Killer Whale	**0**	**0**
Leatherback Turtle	**42**	**0**

6.4.8 Summary of Exposures of Endangered and Threatened Fish Species to Impulsive and Non-impulsive acoustic stressors

Two detonation events are permitted a year at both the Crescent Harbor and Hood Canal range areas. Each event at Crescent Harbor may consist of EITHER a single 2.5 lb charge OR four, 1 ounce charges set off approximately 30 minutes apart. Each event at Hood Canal may consist of EITHER a single 1.5 lb charge OR four, 1 ounce charges set off approximately 30 minutes apart. For impact analysis purposes, we analyzed a worst case scenario where two 2.5 lb charges are used at Crescent Harbor and two 2.5 lb. charges are used at Hood Canal per year. Over the past two years only the 1 ounce charges have been used for training.

6.5 Response Analysis

As discussed in the *Approach to the Assessment* section of this Opinion, response analyses determine how listed resources are likely to respond after being exposed to an Action's effects

on the environment or directly on listed species themselves. For the purposes of consultations on activities involving active sonar, our assessments try to detect the probability of lethal responses, sensory impairment (permanent and temporary threshold shifts and acoustic masking), physiological responses (particular stress responses), behavioral responses, and social responses that might result in reducing the fitness of listed individuals. Our response analyses considered and weighed evidence of adverse consequences, beneficial consequences, or the absence of such consequences.

It is important to acknowledge that there is limited empirical evidence on how endangered or threatened marine animals respond upon being exposed to active sonar and sound pressure waves associated with underwater detonations in natural settings. Therefore, the narratives that follow this introduction summarize the best scientific and commercial data available on the responses of other species to the stressors identified earlier in this Opinion. Based on those data, we identify the probable responses of endangered and threatened marine animals, sea turtles and fish species.

6.5.1 Responses to Disturbance from Vessel Traffic

As of 2014, there are currently seven Navy combatant surface ships homeported within Puget Sound. Activities involving vessel movement associated with training could be widely dispersed throughout the NWTRC action area. As of 2014, there are currently seven Navy combatant surface ships homeported within Puget Sound (two aircraft carriers, two destroyers, and three frigates). Based on hours of operation, vessel use during training would in the majority occur in the offshore portion of the action area throughout the year. The action would not result in any appreciable changes in locations or frequency of activity. The manner in which the Navy has trained would remain consistent with the range of variability observed over the last decade.

6.5.1.1 **Marine Mammals**

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Goodwin and Cotton 2004; Lusseau 2006). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994; Evans et al. 1992; Evans et al. 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

Based on the suite of studies of cetacean behavior to vessel approaches (Au and Green 1990, (Au and Perryman 1982; Bain et al. 2006; Bauer and Herman 1986; Bejder et al. 1999; Bejder et al. 2006a; Bejder et al. 2006c; Bryant et al. 1984; Corkeron 1995; David 2002; Felix 2001; Goodwin and Cotton 2004; Hewitt 1985b; Lusseau 2003; Lusseau 2006; Magalhaes et al. 2002; Nowacek et al. 2001; Richter et al. 2006; Richter et al. 2003b; Scheidat et al. 2004; Simmonds 2005b; Watkins 1986; Williams and Ashe 2007; Williams et al. 2002c; Wursig et al. 1998), the set of variables that help determine whether marine mammals are likely to be disturbed by surface vessels include:

1. *Number of vessels*. The behavioral repertoire marine mammals have used to avoid interactions with surface vessels appears to depend on the number of vessels in their perceptual field (the area within which animals detect acoustic, visual, or other cues) and the animal's assessment of the risks associated with those vessels (the primary index of risk is probably vessel proximity relative to the animal's flight initiation distance).

   Below a threshold number of vessels (which probably varies from one species to another, although groups of marine mammals probably share sets of patterns), studies have shown that whales will attempt to avoid an interaction using horizontal avoidance behavior. Above that threshold, studies have shown that marine mammals will tend to avoid interactions using vertical avoidance behavior, although some marine mammals will combine horizontal avoidance behavior with vertical avoidance behavior (Bryant et al. 1984; David 2002; Kruse 1991b; Lusseau 2003; Nowacek et al. 2001; Stensland and Berggren 2007b; Williams and Ashe 2007);

2. *The distance between vessel and marine mammals* when the animal perceives that an approach has started and during the course of the interaction (Au and Perryman 1982; David 2002; Hewitt 1985b; Kruse 1991b; Lusseau 2003);

3. *The vessel's speed and vector* (David 2002);

4. *The predictability of the vessel's path*. That is, cetaceans are more likely to respond to approaching vessels when vessels stay on a single or predictable path (Acevedo 1991a; Angradi et al. 1993; Browning and Harland. 1999; Lusseau 2003; Lusseau 2006; Williams et al. 2002a) than when it engages in frequent course changes (Evans et al. 1994; Lusseau 2006; Williams et al. 2002a);

5. *Noise associated with the vessel* (particularly engine noise) and the rate at which the engine noise increases (which the animal may treat as evidence of the vessel's speed) (David 2002; Lusseau 2003; Lusseau 2006);

6. *The type of vessel* (displacement versus planing), which marine mammals may be interpret as evidence of a vessel's maneuverability (Goodwin and Cotton 2004);

7. *The behavioral state of the marine mammals* ((David 2002; Lusseau 2003; Lusseau 2006; Wursig et al. 1998). For example, Würsig et al. (Wursig et al. 1998) concluded that whales were more likely to engage in avoidance responses when the whales were milling or resting than during other behavioral states.

Most of the investigations cited earlier reported that animals tended to reduce their visibility at the water's surface and move horizontally away from the source of disturbance or adopt erratic swimming strategies (Corkeron 1995; Lusseau 2003; Lusseau 2004; Nowacek et al. 2001; Van Parijs and Corkeron 2001; Williams et al. 2002a; Williams et al. 2002c). In the process, their dive times increased, vocalizations and jumping were reduced (with the exception of beaked whales), individuals in groups move closer together, swimming speeds increased, and their direction of travel took them away from the source of disturbance (Baker and Herman 1989; Edds and Macfarlane 1987; Evans et al. 1992; Kruse 1991b). Some individuals also dove and remained motionless, waiting until the vessel moved past their location. Most animals finding themselves in confined spaces, such as shallow bays, during vessel approaches tended to move towards more open, deeper waters (Kruse 1991b). We assume that this movement would give them greater opportunities to avoid or evade vessels as conditions warranted.

Although most of these studies focused on small cetaceans (for example, bottlenose dolphins, spinner dolphins, spotted dolphins, harbor porpoises, beluga whales, and killer whales), studies of large whales have reported similar results for fin and sperm whales (David 2002). Baker et al. (1983) reported that humpbacks in Hawai'i responded to vessels at distances of 2 to 4 km. Richardson et al. (1985) reported that bowhead whales (*Balaena mysticetus*) swam in the opposite direction of approaching seismic vessels at distances between 1 and 4 km and engage in evasive behavior at distances under 1 km. Fin whales also responded to vessels at a distance of about 1 km (Edds and Macfarlane 1987).

Some cetaceans detect the approach of vessels at substantial distances. Finley et al. (1990) reported that beluga whales seemed aware of approaching vessels at distances of 85 km and began to avoid the approach at distances of 45-60 km. Au and Perryman (1982) studied the behavioral responses of eight schools of spotted and spinner dolphins (*Stenella attenuata* and *S. longirostris*) to an approaching ship (the NOAA vessel Surveyor: 91.4 meters, steam-powered, moving at speeds between 11 and 13 knots) in the eastern Pacific Ocean (10°15 N lat., 109°10 W long.). They monitored the response of the dolphin schools to the vessel from a Bell 204 helicopter flying a track line ahead of the ship at an altitude of 366 – 549 meters (they also monitored the effect of the helicopter on dolphin movements and concluded that it had no observable effect on the behavior of the dolphin schools). All of the schools continuously adjusted their direction of swimming by small increments to continuously increase the distance between the school and the ship over time. The animals in the eight schools began to flee from the ship at distances ranging from 0.9 to 6.9 nm. When the ship turned toward a school, the individuals in the school increased their swimming speeds (for example, from 2.8 to 8.4 knots) and engaged in sharp changes in direction.

Hewitt (1985b) reported that five of 15 schools of dolphin responded to the approach of one of two ships used in his study and none of four schools of dolphin responded to the approach of the second ship (the first ship was the NOAA vessel David Jordan Starr; the second ship was the Surveyor). Spotted dolphin and spinner dolphins responded at distances between 0.5 to 2.5 nm and maintained distances of 0.5 to 2.0 nm from the ship while striped dolphins allowed much closer approaches. Lemon et al. (2006) reported that bottlenose dolphin began to avoid approaching vessels at distances of about 100 m.

Würsig et al. (1998) studied the behavior of cetaceans in the northern Gulf of Mexico in response to survey vessels and aircraft. They reported that Kogia species and beaked whales (ziphiids) showed the strongest avoidance reactions to approaching ships (avoidance reactions in 11 of 13 approaches) while spinner dolphins, Atlantic spotted dolphins, bottlenose dolphins, false killer whales, and killer whales either did not respond or approached the ship (most commonly to ride the bow). Four of 15 sperm whales avoided the ship while the remainder appeared to ignore its approach.

If behavioral disruptions of whales result from the presence of vessels or submarines, those disruptions are expected to be temporary. Animals are expected to resume their migration, feeding, or other behaviors with minimal threat to their survival or reproduction. Marine

mammals react to vessels in a variety of ways and seem to be generally influenced by the activity the marine mammal is engaged in when a vessel approaches (Richardson et al. 1995b). Some respond negatively by retreating or engaging in antagonistic responses while other animals ignore the stimulus altogether (Terhune and Verboom 1999; Watkins 1986).

The predominant reaction is likely to be neutral or avoidance behavior, rather than attraction behavior. We did not estimate the number of endangered or threatened species that are likely to be exposed to vessel traffic independent of the number of individuals that might be exposed to active sonar associated with those exercises (primarily because the data we would have needed to support those analyses were not available). Nevertheless, we assume that any individuals of the endangered or threatened species that occur in the action area during the activities in the NWTRC are likely to be exposed to visual and acoustic stimuli associated with vessel traffic and related activities. Based on data provided by Douglas et al. (2008) and the latest abundance estimates (Carretta et al. 2013), any strike to a large whale would most likely to be fin whale, grey whale (Eastern North Pacific stock), or humpback whale.

The Navy's operational orders for ships that are underway are designed to prevent collisions between surface vessels participating in naval exercises training events and any endangered whales that might occur in the action area. For instance, Navy ships strive to keep at least 500 yd. (460 m) away from any observed whale in the vessel's path and avoid approaching whales head-on, so long as safety of navigation is not imperiled. These measures, which include marine observers on the bridge of ships, requirements for course and speed adjustments to maintain safe distances from whales, and having any ship that observes whales to alert other ships in the area, have historically been effective measures for avoiding collisions between surface vessels and whales in most areas. However, in the action area, history suggests that animals may be struck infrequently. In the absence of speed restrictions that would reduce the likelihood and severity of injury from ship strikes, we assume that Navy vessels could operate over the full range of ship speeds. The disparity in size between a large whale weighing over 150 tons and an aircraft carrier amphibious assault ship weighing 101,196 50,370 tons or a destroyer, the most prevalent type of ship in the U.S. Atlantic Fleet surface force, weighing 10,635 tons leads us to conclude that most ship strikes would result in the death of the struck animal.. Based on this, we expect that if an endangered whale is struck by a Navy vessel that it would die immediately or later due to injuries sustained as a result of the collision.

Because the activities involve few vessels, are of short duration, and occur on a local scale, few endangered and threatened species would be exposed to vessel traffic. Consequently, we do not anticipate vessel strikes would occur within the action area in a given year and over the remainder of the five-year period or into the reasonably forseeable future.

6.5.1.2 **Leatherback Sea Turtle**

The majority of the training activities involve some level of vessel activity. Vessels include ships, submarines, and boats ranging in size from small, 22 ft. (6.7 m) rigid hull inflatable boats to aircraft carriers with lengths up to 1,092 ft. (332.8 m). Large Navy ships generally operate at speeds in the range of 10–15 knots, and submarines generally operate at speeds in the range of 8–13 knots. Small craft (less than 40 ft. [12.2 m] in length) have much more variable speeds (dependent on the mission). While these speeds are representative of most activities, some vessels need to operate outside of these parameters. Conversely, there are other instances, such as launch and recovery of a small rigid hull inflatable boat, vessel boarding, search, and seizure training activities or retrieval of a target, when vessels will be stopped or moving slowly ahead to maintain steerage. Exposure to vessels would be greatest in the areas of highest naval vessel traffic. In an attempt to determine traffic patterns for Navy and non-Navy vessels, a review by the Center for Naval Analysis (Mintz and Parker 2006) was conducted on commercial vessels, coastal shipping patterns, and Navy vessels. Commercial and non-Navy traffic, which included cargo vessels, bulk carriers, passenger vessels, and oil tankers (all over 65 ft. [20 m] in length), was heaviest near the Strait of Juan de Fuca and the Columbia River mouth, and could be seen in the east to west and north to south international shipping lanes. While commercial traffic is relatively steady throughout the year, Navy traffic is episodic in the ocean. The number of Navy vessels in NWTRC at any given time varies, and depends on local training requirements. Most activities include either one or two vessels, and may last from a few hours up to 2 weeks. Vessel movement would be widely dispersed throughout the area, but more concentrated in portions of the NWTRC OPAREA.

Minor strikes may cause temporary reversible impacts, such as diverting the turtle from its previous activity or causing minor injury. Major strikes are those that can cause permanent injury or death from bleeding or other trauma, paralysis and subsequent drowning, infection, or inability to feed. Apart from the severity of the physical strike, the likelihood and rate of a turtle's recovery from a strike may be influenced by its age, reproductive state, and general condition. Much of what is written about recovery from vessel strikes is inferred from observing individuals some time after a strike. Numerous sea turtles have scars that appear to have been

caused by propeller cuts or collisions with vessel hulls (Hazel et al. 2007; Lutcavage et al. 1997), suggesting that not all vessel strikes are lethal. Conversely, fresh wounds on some stranded animals may strongly suggest a vessel strike as the cause of death. The actual incidence of recovery versus death is not known, given available data.

Sea turtles spend a majority of their time submerged (Renaud and Carpenter 1994; Sasso and Witzell 2006). Leatherback turtles are more likely to feed at or near the surface in open ocean areas and are more likely to spend more time at the surface in northern latitudes to bask and help thermoregulate (Casey et al 2014). To assess the risk or probability of a physical strike, the number, size, and speed of Navy vessels were considered, as well as the sensory capability of sea turtles to identify an approaching vessel. Sea turtles can detect approaching vessels, likely by sight rather than by sound (Bartol and Ketten 2006c; Hazel et al. 2007). Sea turtles seem to react more to slower-moving vessels (2.2 knots) than to faster vessels (5.9 knots or greater). Vessel-related injuries to sea turtles are more likely to occur in areas with high boating traffic. Although sea turtles likely hear and see approaching vessels, they may not be able to avoid all collisions.

Within the action area, the vast majority of vessel traffic would be concentrated in the offshore area. Vessel strikes are more likely in nearshore areas than in the open ocean portions of the action area because of the concentration of vessel movements in those areas. Leatherback sea turtles can occur at or near the surface in open-ocean and coastal areas, whether feeding or periodically surfacing to breathe. Given the concentration of Navy vessel movements within the offshore portions of the action area, training activities utilizing vessels could overlap with sea turtles occupying these waters. While the potential for serious injury and mortality of sea turtles from vessel strike exists, it is very difficult to estimate the number and species composition of turtles that could be "taken" in the Action Area in transit zones and range complexes.

Exposure to vessels used in training activities may cause short-term disturbance to an individual turtle because if a turtle were struck, it could lead to injury or death. As demonstrated by scars on all species of sea turtles, they are not always able to avoid being struck; therefore, vessel strikes are a potential cause of mortality for these species. Although the likelihood of being struck is minimal, sea turtles that overlap with Navy exercises are more likely to encounter vessels. Exposure to vessels may change an individual's behavior, growth, survival, annual reproductive success, or lifetime reproductive success (fitness). Exposure to vessels is not expected to result in population-level impacts.

Because of the wide dispersal of large vessels in open ocean areas and the widespread, scattered distribution of turtles at sea, strikes during open-ocean transits of Navy vessels are unlikely. For very large vessels, the bow wave may even preclude a sea turtle strike. The probability of a strike is further reduced by Navy mitigation measures and standard operating procedures to avoid sea turtles. Some vessels associated with training can travel at high speeds, which increase the strike risk to sea turtles (Hazel et al. 2007).

6.5.1.3 **Endangered and Threatened Fish Species**

Training activities include vessel movement. Navy vessel traffic could occur anywhere within the NWTRC; however, it would be concentrated near ports or naval installations and training ranges. Activities involving vessel movements occur intermittently and are variable in duration, ranging from a few hours up to 2 weeks.

Additionally, a variety of smaller craft are operated within the NWTRC. These small craft types, sizes, and speeds vary, but in general, they will emit higher-frequency noise than larger ships. Training activities within NWTRC typically consist of a single vessel involved in unit-level activity for a few hours, or one or two small boats conducting testing. Navy vessels do contribute to the overall ambient noise in inland waters near Navy ports, although their contribution to the overall noise in these environments is minimal because these areas typically have large amounts of commercial and recreational vessel traffic.

Vessel noise has the potential to expose fish to sound and general disturbance, which could result in short-term behavioral or physiological responses (e.g., avoidance, stress, increased heart rate). Training activities involving vessel movements occur intermittently and range in duration from a few hours up to a few weeks. These activities are widely dispersed throughout the NWTRC Action Area. While vessel movements have the potential to expose fish occupying the water column to sound and general disturbance, potentially resulting in short-term behavioral or physiological responses, such responses would not be expected to compromise the general health or condition of individual fish. In addition, most activities involving vessel movements are infrequent and widely dispersed throughout the NWTRC Action Area. The exception is for pierside activities; although these areas are located in the Inland Waters, these are industrialized areas that are already exposed to high levels of anthropogenic noise due to numerous waterfront users (e.g., industrial and marinas). Therefore, impacts from vessel noise would be temporary and localized. Long-term consequences for the population are not expected.

6.5.2 Responses to Non-Impulsive Acoustic Sources

The following sections provide predicted responses to non-impulsive acoustic stressors resulting from training activities.

6.5.2.1 **Blue Whale**

Based on the U.S. Navy's exposure models, each year we would expect one instance annually in which blue whales might be exposed to active sonar associated with training exercises and exhibit a behavioral response as a result of that exposure. We would not expect any exposures leading to injury including permanent threshold shift.

Blue whales exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low frequency calls usually associated with feeding behavior (Melcon et al. 2012a). It is not known whether the lower rates of calling actually indicated a reduction in feeding behavior or social contact since the study used data from remotely deployed, passive acoustic monitoring buoys. In contrast, blue whales increased their likelihood of calling when ship noise was present, and decreased their likelihood of calling in the presence of explosive noise, although this result was not statistically significant (Melcon et al. 2012a).

Additionally, the likelihood of an animal calling decreased with the increased received level of mid-frequency sonar, beginning at a sound pressure level of approximately 110–120 dB re 1 µPa (Melcon et al. 2012a). Preliminary results from the 2010–2011 field season of an ongoing behavioral response study in Southern California waters indicated that in some cases and at low received levels, tagged blue whales responded to mid-frequency sonar but that those responses were mild and there was a quick return to their baseline activity (Southall et al. 2011) Blue whales responded to a mid-frequency sound source, with a source level between 160 and 210 dB re 1 µPa at 1 m and a received sound level up to 160 dB re 1 µPa, by exhibiting generalized avoidance responses and changes to dive behavior during CEEs (Goldbogen et al. 2013). However, reactions were not consistent across individuals based on received sound levels alone, and likely were the result of a complex interaction between sound exposure factors such as proximity to sound source and sound type (mid-frequency sonar simulation vs. pseudo-random noise), environmental conditions, and behavioral state. Surface feeding whales did not show a change in behavior during CEEs, but deep feeding and non-feeding whales showed temporary reactions that quickly abated after sound exposure. Whales were sometimes less than a mile from the sound source during CEEs.

These preliminary findings from Melcón et al. (2012) and Goldbogen et al. 2013 are consistent with the Navy's criteria and thresholds for predicting behavioral effects to mysticetes (including blue whales) from sonar and other active acoustic sources used in the Navy's quantitative acoustic effects analysis. The behavioral response function predicts a probability of a substantive behavioral reaction for individuals exposed to a received sound pressure level of 120 dB re 1 µPa or greater, with an increasing probability of reaction with increased received level as demonstrated in Melcón et al. (2012).

6.5.2.2 **Fin Whale**

Based on the U.S. Navy's exposure models, each year we would expect six instances annually in which fin whales might be exposed to active sonar associated with training exercises and exhibit a behavioral response to the exposure. We would not expect any exposures leading to injury including permanent threshold shift.

Fin whales are not likely to respond to high-frequency sound sources associated with the training activities because of their hearing sensitivities. While we recognize that animal hearing evolved separately from animal vocalizations and, as a result, it may be inappropriate to make inferences about an animal's hearing sensitivity from their vocalizations, we have no data on fin whale hearing so we assume that fin whale vocalizations are partially representative of their hearing sensitivities. Those vocalizations include a variety of sounds described as low frequency moans or long pulses in the 10-100 Hz band (Edds 1988; Thompson and Friedl 1982; Watkins 1981a). The most typical signals are very long, patterned sequences of tonal infrasonic sounds in the 15-40 Hz range. Ketten (1997) reports the frequencies of maximum energy between 12 and 18 Hz. Short sequences of rapid calls in the 30-90 Hz band are associated with animals in social groups (Clark personal observation and McDonald personal communication cited in Ketten 1997). The context for the 30-90 Hz calls suggests that they are used to communicate but do not appear to be related to reproduction. Fin whale moans within the frequency range of 12.5-200 Hz, with pulse duration up to 36 seconds, have been recorded off Chile (Cummings and Thompson 1994). The whale produced a short, 390 Hz pulse during the moan.

6.5.2.3 **Humpback Whale**

Based on the U.S. Navy's exposure models, each year we would expect three instances annually in which humpback whales might be exposed to active sonar associated with training exercises and exhibit a behavioral response to the exposure. We would not expect any exposures leading to injury including permanent threshold shift.

Humpback whales are not likely to respond to high-frequency sound sources associated with the training activities because of their hearing sensitivities. While we recognize that animal hearing evolved separately from animal vocalizations and, as a result, it may be inappropriate to make inferences about an animal's hearing sensitivity from their vocalizations, we have no data on humpback whale hearing so we assume that humpback whale vocalizations are partially representative of their hearing sensitivities. As discussed in the Status of the Species narrative for humpback whales, these whales produce a wide variety of sounds.

Humpback whales produce sounds less frequently in their summer feeding areas. Feeding groups produce distinctive sounds ranging from 20 Hz to 2 kHz, with median durations of 0.2-0.8 seconds and source levels of 175-192 dB (Thompson et al. 1986). These sounds are attractive and appear to rally animals to the feeding activity (D'Vincent et al. 1985; Sharpe and Dill 1997). In summary, humpback whales produce at least three kinds of sounds:

1. Complex songs with components ranging from at least 20Hz – 4 kHz with estimated source levels from 144 – 174 dB; these are mostly sung by males on the breeding grounds (Payne and McVay 1971; Winn et al. 1970)

2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3kHz (Richardson et al. 1995b; Tyack and Whitehead 1983); and

3 Feeding area vocalizations that are less frequent, but tend to be 20Hz – 2 kHz with estimated source levels in excess of 175 dB re 1 uPa-m (Richardson et al. 1995b; Thompson et al. 1986). Sounds often associated with possible aggressive behavior by males (Silber 1986; Tyack 1983b) are quite different from songs, extending from 50 Hz to 10 kHz (or higher), with most energy in components below 3 kHz. These sounds appear to have an effective range of up to 9 km (Tyack and Whitehead 1983).

Au et al. (2006) conducted field investigations of humpback whale songs that led these investigators to conclude that humpback whales have an upper frequency limit reaching as high as 24 kHz. Based on this information, it is reasonable to assume that the active mid-frequency sonar the U.S. Navy would employ during the active sonar training activities the U.S. Navy conducts in the Action Area are within the hearing and vocalization ranges of humpback whales. There is limited information on how humpback whales are likely to respond upon being exposed to mid-frequency active sonar (most of the information available addresses their probable responses to low-frequency active sonar or impulsive sound sources). Humpback whales

responded to sonar in the 3.1–3.6 kHz by swimming away from the sound source or by increasing their velocity (Maybaum 1990; Maybaum 1993). The frequency or duration of their dives or the rate of underwater vocalizations, however, did not change.

Humpback whales have been known to react to low frequency industrial noises at estimated received levels of 115-124 dB (Malme et al. 1985), and to calls of other humpback whales at received levels as low as 102 dB (Frankel et al. 1995). Malme et al. (1985) found no clear response to playbacks of drill ship and oil production platform noises at received levels up to 116 dB re 1 Pa. Studies of reactions to airgun noises were inconclusive (Malme et al. 1985). Humpback whales on the breeding grounds did not stop singing in response to underwater explosions (Payne and McVay 1971). Humpback whales on feeding grounds did not alter short-term behavior or distribution in response to explosions with received levels of about 150 dB re 1 Pa/Hz at 350Hz (Lien et al. 1993; Todd et al. 1996b). However, at least two individuals were probably killed by the high-intensity, impulse blasts and had extensive mechanical injuries in their ears (Ketten et al. 1993; Todd et al. 1996b). The explosions may also have increased the number of humpback whales entangled in fishing nets (Todd et al. 1996b). Frankel and Clark (1998) showed that breeding humpbacks showed only a slight statistical reaction to playbacks of 60-90 Hz sounds with a received level of up to 190 dB. Although these studies have demonstrated that humpback whales will exhibit short-term behavioral reactions to boat traffic and playbacks of industrial noise, the long-term effects of these disturbances on the individuals exposed to them are not known.

6.5.2.4 **Sei Whale**

Based on the U.S. Navy's exposure models, each year we would not expect any instances annually in which sei whales might be exposed to active sonar associated with training exercises at a level that would elicit a behavioral response or potential injury such as permanent threshold shift.

Like blue and fin whales, sei whales are not likely to respond to high-frequency sound sources associated with training activities because of their hearing sensitivities. As discussed in the Status of the Species section of this Opinion, we have no specific information on the sounds produced by sei whales or their sensitivity to sounds in their environment. Based on their anatomical and physiological similarities to both blue and fin whales, we assume that the hearing thresholds of sei whales will be similar as well and will be centered on low-frequencies in the 10-200 Hz.

6.5.2.5 **Southern Resident Killer Whale**

Based on the U.S. Navy's exposure models, each year we would not expect any instances annually in which southern resident killer whales might be exposed to acoustic stressors including active sonar and other acoustic devices.

6.5.2.6 **Sperm Whale**

Based on the U.S. Navy's exposure models, each year we would expect 26 instances annually in which sperm whales might be exposed to active sonar associated with training exercises and would exhibit behavioral responses to the exposures. We would not expect any exposures leading to injury including permanent threshold shift.

Although there is no published audiogram for sperm whales, sperm whales would be expected to have good, high frequency hearing because their inner ear resembles that of most dolphins, and appears tailored for ultrasonic (>20 kHz) reception (Ketten 1994). The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate, which suggest that neonatal sperm whales respond to sounds from 2.5 to 60 kHz. Sperm whales vocalize in high- and mid-frequency ranges; most of the energy of sperm whales clicks is concentrated at 2 to 4 kHz and 10 to 16 kHz. Other studies indicate sperm whales' wide-band clicks contain energy between 0.1 and 20 kHz (Goold and Jones 1995; Weilgart and Whitehead 1993). Ridgway and Carder (Ridgway and Carder 2001) measured low-frequency, high amplitude clicks with peak frequencies at 500 Hz to 3 kHz from a neonate sperm whale.

Based on their hearing sensitivities and vocalizations, the active sonar and sound pressure waves from the underwater detonations (as opposed to the shock waves from underwater detonations) the U.S. Navy conducts at the Naval Surface Warfare Center might mask sperm whale hearing and vocalizations. There is some evidence of disruptions of clicking and behavior from sonars (Goold 1999; Watkins 1985), pingers (Watkins and Schevill 1975), the Heard Island Feasibility Test (Bowles et al. 1994b), and the Acoustic Thermometry of Ocean Climate (Costa et al. 1998). Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders (Watkins and Schevill 1975). Goold (1999) reported six sperm whales that were driven through a narrow channel using ship noise, echosounder, and fish finder emissions from a flotilla of 10 vessels. Watkins and Scheville (Watkins and Schevill 1975) showed that sperm whales interrupted click production in response to pinger (6 to 13 kHz) sounds. They also stopped vocalizing for brief periods when codas were being produced by other

individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995).

Sperm whales have been reported to have reacted to military sonar, apparently produced by a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent and becoming difficult to approach (Watkins 1985). Captive bottlenose dolphins and a white whale exhibited changes in behavior when exposed to 1 sec pulsed sounds at frequencies similar to those emitted by multi-beam sonar that is used in geophysical surveys (Ridgway and Carder 1997; Schlundt et al. 2000b), and to shorter broadband pulsed signals (Finneran et al. 2000a; Finneran et al. 2002). Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al. 2002; Schlundt et al. 2000b). Dolphins exposed to 1-sec intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 Pa_{rms} and belugas did so at received levels of 180 to 196 dB and above. Received levels necessary to elicit such reactions to shorter pulses were higher (Finneran et al. 2000a; Finneran et al. 2002). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran et al. 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway and Carder 1997; Schlundt et al. 2000b). The relevance of these data to free-ranging odontocetes is uncertain. In the wild, cetaceans sometimes avoid sound sources well before they are exposed to the levels listed above, and reactions in the wild may be more subtle than those described by Ridgway et al. (1997) and Schlundt et al. (2000b).

Other studies identify instances in which sperm whales did not respond to anthropogenic sounds. Sperm whales did not alter their vocal activity when exposed to levels of 173 dB re 1 Pa from impulsive sounds produced by 1 g TNT detonators (Madsen and Mohl 2000). Richardson et al. (1995b) citing a personal communication with J. Gordon suggested that sperm whales in the Mediterranean Sea continued calling when exposed to frequent and strong military sonar signals. When Andre et al. (1997) exposed sperm whales to a variety of sounds to determine what sounds may be used to scare whales out of the path of vessels, sperm whales were observed to have startle reactions to 10 kHz pulses (180 dB re 1 Pa at the source), but not to the other sources played to them.

Published reports identify instances in which sperm whales have responded to an acoustic source and other instances in which they did not appear to respond behaviorally when exposed to

seismic surveys. Mate et al. (1994) reported an opportunistic observation of the number of sperm whales to have decreased in an area after the start of airgun seismic testing. However, Davis et al. (2000) noted that sighting frequency did not differ significantly among the different acoustic levels examined in the northern Gulf of Mexico, contrary to what Mate et al. (1994) reported. Sperm whales may also have responded to seismic airgun sounds by ceasing to call during some (but not all) times when seismic pulses were received from an airgun array >300 km away (Bowles et al. 1994b).

A study offshore of northern Norway indicated that sperm whales continued to call when exposed to pulses from a distant seismic vessel. Received levels of the seismic pulses were up to 146 dB re 1 μPa peak-to-peak (Madsen et al. 2002). Similarly, a study conducted off Nova Scotia that analyzed recordings of sperm whale sounds at various distances from an active seismic program did not detect any obvious changes in the distribution or behavior of sperm whales (McCall-Howard 1999). Recent data from vessel-based monitoring programs in United Kingdom waters suggest that sperm whales in that area may have exhibited some changes in behavior in the presence of operating seismic vessels (Stone 1997; Stone 1998; Stone 2000; Stone 2001; Stone 2003a). However, the compilation and analysis of the data led the author to conclude that seismic surveys did not result in observable effects to sperm whales (Stone 2003a). The results from these waters seem to show that some sperm whales tolerate seismic surveys.

These studies suggest that the behavioral responses of sperm whales to anthropogenic sounds are highly variable, but do not appear to result in the death or injury of individual whales or result in reductions in the fitness of individuals involved. Responses of sperm whales to anthropogenic sounds probably depend on the age and sex of animals being exposed, as well as other factors. There is evidence that many individuals respond to certain sound sources, provided the received level is high enough to evoke a response, while other individuals do not.

6.5.2.7 **Leatherback Sea Turtle**

No sea turtles are predicted to experience TTS, which would result in short-term reduced perception of sound within a limited frequency range, lasting from minutes to days, depending on the exposure. Zero sea turtles are predicted to experience PTS due to training with sonar and other active acoustic sources, which would permanently reduce perception of sound within a limited frequency range. This long-term consequence could impact an individual turtle's ability to sense biologically important sounds such as predators or prey, reducing that animal's fitness;

however, because most sounds are broadband, a reduction in sensitivity over a small portion of hearing range may not interfere with perception of most sounds.

Cues preceding the commencement of the event (e.g., vessel presence and movement, aircraft overflight) may result in some animals departing the immediate area, even before active sound sources begin transmitting. Avoidance behavior could reduce the sound exposure level experienced by a sea turtle and therefore reduce the likelihood and degree of TTS predicted near sound sources. In addition, PTS and TTS threshold criteria for sea turtles are conservatively based on criteria developed for mid-frequency marine mammals. Therefore, actual TTS impacts are expected to be substantially less than the predicted quantities.

Sea turtles may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the immediate area around a source, although studies examining sea turtle behavioral responses to sound have used impulsive sources, not non-impulsive sources. Pronounced reactions to acoustic stimuli could lead to a sea turtle expending energy and missing opportunities to forage or breed. In most cases, acoustic exposures are intermittent, allowing time to recover from an incurred energetic cost, resulting in no long-term consequence.

Because model-predicted impacts are conservative and most impacts would be short-term, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts.

6.5.2.8 **Endangered and Threatened Fish Species**

Training activities include activities that produce in-water noise in the offshore portions of the action area from the use of sonar and other active acoustic sources. Sonar and other active acoustic sources used are transient in most locations, as active sonar activities pass through the NWTRC action area. As discussed in Section 3.6.4 of this Opinion, potential acoustic effects to fish from these sources may be considered in four categories: (1) direct injury; (2) hearing loss; (3) auditory masking; and (4) physiological stress and behavioral reactions. Direct injury to fish as a result of exposure to sonar is highly unlikely to occur. Therefore, direct injury as a result of exposure to non-impulsive sources including sonar is not discussed further in this Opinion.

Additionally, research indicates that exposure of fish to transient, non-impulsive stressors is unlikely to result in any hearing loss. Most sonar sources are outside of the hearing and sensitivity range of most marine fish, and noise sources such as vessel movement and aircraft

overflight lack the duration and intensity to cause hearing loss. Furthermore, permanent hearing loss has not been demonstrated in fish as they have been shown to regenerate lost sensory hair cells. Therefore, hearing loss as a result of exposure to sonar and other active acoustic sources is not discussed further in this Opinion.

The majority of fish species exposed to non-impulsive sources would likely have no reaction or mild behavioral reactions. Overall, long-term consequences for individual fish are unlikely in most cases because acoustic exposures are intermittent and unlikely to repeat over short periods. Since long-term consequences for most individuals are unlikely, long-term consequences for populations are not expected.

The ESA-listed salmonid species (steelhead trout, Chinook salmon, Coho salmon, chum salmon, and sockeye salmon), green sturgeon, and Pacific eulachon are anadromous and spend a portion of their lives in both the marine environment as well as in the riverine and estuarine systems throughout the NWTRC. These species have the potential to be exposed to non-impulsive sound associated with training activities in the coastal areas. Since salmonid species and Pacific eulachon spawn in rivers and the early life stages of the fish occur in riverine and estuarine environments, eggs and larvae would not be exposed to sounds produced from non-impulsive sound sources during training activities.

It is believed that salmonid species, which are anatomically similar to Atlantic salmon, are unable to detect the sound produced by mid- or high-frequency sonar and other active acoustic sources. Therefore, acoustic impacts from these sources are not expected.

The primary exposure to vessel noise would occur around the Navy ranges and ports. Vessel noise have the potential to expose steelhead trout to sound and general disturbance, potentially resulting in short-term behavioral responses. However, any short-term behavioral reactions, physiological stress, or auditory masking are unlikely to lead to long-term consequences for individuals. Therefore, long-term consequences for populations are not expected.

A few activities involving sonar and other active acoustic sources occur in inshore water (within bays and estuaries), specifically at pierside locations. The salmonid species are anadromous and spend a portion of their lives in both the marine environment as well as in the riverine and estuarine systems. Similarly, the Pacific Eulachon and green sturgeon may occur in the Inland Waters.

Based on the evidence available, if they were exposed. to transmissions associated with mid-frequency active sonar training activities on the NWTRC, we would expect the endangered and threatened fish we consider in this Opinion to be able to detect those sounds. If juvenile fish, larvae, or eggs occurred close to a sound source, we would expect some of those life-stages to be killed or injured (which, in those life stages, would probably result in individuals being eaten by predators). Because green sturgeon, Pacific salmon, steelhead, and eulachon are anadromous, the juveniles, larvae, and eggs of southern are not likely to occur in the NWTRC so such exposure is highly improbable. In the case of southern eulachon, this spatial separation between sensitive life stages and active sonar would protect them from the small, but potentially-significant mortality rates reported by Jørgensen and his co-workers (Jørgensen et al. 2005)

If Pacific salmon, steelhead, green sturgeon, or eulachon are exposed to mid-frequency active sonar associated with the military readiness activities on the NWTRC, they might experience startle responses or minor changes in their behavioral state, but those responses are likely to be brief and have no immediate or cumulative consequence for the reproductive success of the fish that might be exposed. Such minor responses would not rise to the level of "take" under the ESA.

6.5.3 Responses to Impulsive Acoustic Sources

The following sections provide predicted responses to impulsive acoustic stressors resulting from training activities.

6.5.3.1 **Blue Whale**

Training activities involving explosions would mainly be conducted throughout the offshore portions of the action area, but also at historically used locations in the Inland Waters portion of the action area.

6.5.3.2 **Fin Whale**

Training activities involving explosions would mainly be conducted throughout the offshore portions of the action area, but also at historically used locations in the Inland Waters portion of the action area. Whales would not be exposed to explosive (impulsive) sources associated with training activities exceeding thresholds known to result in injury.

6.5.3.3 **Humpback Whale**

Training activities involving explosions would mainly be conducted throughout the offshore portions of the action area, but also at historically used locations in the Inland Waters portion of the action area.

6.5.3.4 **Sei Whale**

Training activities involving explosions would mainly be conducted throughout the offshore portions of the action area, but also at historically used locations in the Inland Waters portion of the action area. Sei whales would not be exposed to explosive (impulsive) sources associated with training activities, which would exceed the current impact thresholds.

6.5.3.5 **Southern Resident Killer Whale**

Based on Navy modeling, no southern resident killer whales would be exposed to impulsive acoustic stressors from training activities in the NWTRC.

6.5.3.6 **Sperm Whale**

Training activities involving explosions would mainly be conducted throughout the offshore portions of the action area, but also at historically used locations in the Inland Waters portion of the action area. Sperm whales would not be exposed to explosive (impulsive) sources associated with training activities, which would exceed the current impact thresholds.

6.5.3.7 **Leatherback Sea Turtle**

Up to 378 training activities under the No Action Alternative would use explosives at or beneath the water surface which would expose sea turtles to underwater impulse sound. The largest source class used during training would be E12 (> 650–1,000 pounds [lb.] NEW), which would be used 16 times in the Operating Area (OPAREA). Explosions associated with torpedoes and explosive sonobuoys would occur in the water column; mines and demolition charges could occur near the surface, in the water column, or the ocean bottom. Most detonations would occur in waters greater than 200 ft. (61 m) in depth, and greater than 3 nautical miles (nm) from shore, although mine warfare could occur in shallow water close to shore. Detonations associated with anti-submarine warfare would typically occur in waters greater than 600 ft. (182.9 m) depth.

The ranges of impacts from in-water explosions are listed in Table **7**. While the number of leatherback turtles anticipated in the NWTRC is low, if a leatherback turtle was within the ranges listed in Table **7**, the respective impact would be anticipated. Results from Navy modeling indicate no leatherback sea turtles are predicted to be exposed to impulse levels associated with

the onset of mortality and gastrointestinal tract injury over any training year for explosives use in open ocean habitats. Further, zero sea turtles were modeled to experience TTS or PTS from the use of explosives in the offshore area.

Some sea turtles beyond the ranges of the above impacts may behaviorally react if they hear a detonation. Activities consisting of single detonations, such as bombing and missile exercise, are expected to only elicit short-term startle reactions. If a sea turtle hears multiple detonations in a short period, such as during gunnery, firing, or sonobuoy exercises, it may react by avoiding the area. Any significant behavioral reactions could lead to a sea turtle expending energy and missing opportunities to secure resources. However, because most activities would consist of a limited number of detonations and exposures would not occur over long durations, there would be an opportunity to recover from an incurred energetic cost. Behavioral responses of sea turtles to impulsive and non-impulsive sound stressors is not well studied and cannot be quantified in this Opinion.

6.5.3.8 **Endangered and Threatened Fish**

Training activities would use underwater detonations and explosive ordnance. Potential impacts on fish from explosions and impulsive acoustic sources can range from no impact, brief acoustic effects, tactile perception, and physical discomfort; to slight injury to internal organs and the auditory system; to death of the animal (Keevin et al. 1997). Occasional behavioral reactions to intermittent explosions and impulsive acoustic sources are unlikely to cause long-term consequences for individual fish or populations.

Fish that experience hearing loss (permanent or temporary threshold shift) as a result of exposure to explosives and impulsive acoustic sources may have a reduced ability to detect relevant sounds such as predators, prey, or social vocalizations. It is uncertain whether some permanent hearing loss over a part of a fish's hearing range would have long-term consequences for that individual. If this did affect the fitness of a few individuals, it is unlikely to have long-term consequences for the population. It is possible for fish to be injured or killed by explosives; however, long-term consequences from a loss of a few individuals is unlikely to have measureable effects on overall stocks or populations.

The ESA-listed salmonid species (steelhead trout, Chinook salmon, chum salmon, coho salmon, and sockeye salmon), green sturgeon, and Pacific eulachon are anadromous and spend a portion of their lives in both the marine environment as well as in the riverine and estuarine systems.

Salmonid species and Pacific Eulachon have the potential to be exposed to explosive energy and sound associated with training activities in the offshore area. Since the salmonid species and Pacific eulachon spawn in rivers and the early lifestages of the fish occur in riverine and estuarine environments, eggs and larvae would not be exposed to impulsive acoustic sources produced by explosives, weapons firing, launch, and non-explosive ordnance impact with the water's surface during training activities in the offshore portions of the action area.

Training activities involving impulsive acoustic sources in the offshore portions of the action area have the possibility to affect the ESA-listed species present, potentially resulting in short-term behavioral or physiological responses, hearing loss, injury, or mortality. However, given the infrequent nature of training activities involving impulsive acoustic sources, the likelihood of these species encountering an explosive activity taking place anywhere within offshore portions of the action area is remote.

Fish species would be exposed to explosions at or beneath the water during training activities. Noise could be produced by explosions and weapons firing in the Inland Waters of the NWTRC. Explosive events would consist of a single explosion. Some marine fish close to a detonation would likely be killed, injured, damaged, or displaced. The detonations would occur in Hood Canal and Crescent Harbor. Training activities involving impulsive acoustic sources in the Inland Waters have the possibility to affect the ESA-listed species present, potentially resulting in short-term behavioral or physiological responses, hearing loss, injury, or mortality. However, given the infrequent nature of training activities involving impulsive acoustic sources, the likelihood of these species encountering an explosive activity taking place in the Inland Waters is remote.

As in our 30 June 2008 biological opinion on U.S. Navy explosive ordnance disposal operations at Crescent Harbor, Port Townsend Bay, and Bangor in northern Hood Canal, we assume that adult and juvenile Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, and Puget Sound steelhead are likely to be exposed to shock waves and sound fields associated with underwater detonations in the NWTRC. Specifically, the Crescent Harbor Underwater Explosive Ordnance Disposal Range is outside the major migration corridor for river systems in the area while the Indian Island Underwater Explosive Ordnance Disposal Range is within a migratory corridor for Chinook, chum, and other salmon species.

Our 2010 Programmatic Biological Opinion on the U.S. Navy's activities on the NWTRC used a similar approach to the one we applied in our 2008 biological opinion on U.S. Navy explosive ordnance disposal operations at Crescent Harbor, Port Townsend Bay, and Bangor in northern Hood Canal. Our 2010 Programmatic Biological Opinion expected each of the four surface detonations to result in the death or injury of one adult and one juvenile Puget Sound Chinook salmon at the Crescent Harbor EOD Range; six adult Puget Sound Chinook salmon deaths during each underwater detonation at the Hood Canal EOD Range; and 27 dead adult Hood Canal summer-run Chum salmon during each underwater detonation at the Hood Canal EOD Range.

The U.S. Navy made changes to Explosive Ordnance Disposal underwater detonation training events for the action through 2015 to add the option of dividing the authorized explosive charge into several smaller charges. As currently described, two underwater demolition events are conducted annually at each of the two training sites; Crescent Harbor and Hood Canal EOD ranges. The Crescent Harbor EOD Range is currently authorized for up to 2.5 pound explosive weight charges and the Hood Canal EOD Range is authorized for up to 1.5 pound charges. The Navy proposed to allow the unit conducting the training to have the option of utilizing up to four, one ounce explosive charges in lieu of one 2.5 or 1.5 pound charge. The four small charges would be initiated individually with an approximately 15 minute interval between charge initiations. The Navy notes that the overall quantity of explosive material utilized in four, one ounce events would be significantly less than quantities utilized in either the 2.5 or 1.5 pound charges. Therefore the worst-case scenario would be use of 2.5 or 1.5 lb. charges in two detonations at each range.

It is difficult to determine the number of each salmon or steelhead species that might be exposed to the underwater explosions under the scenario of reduced charge weights. If we assume the worst case scenario of no reduction in charge weight, since that option was not eliminated, then we would again estimate that each of the surface detonations at the Crescent Harbor EOD Range would result in the death or injury of one adult and one juvenile Puget Sound Chinook salmon from; each underwater detonation at the Hood Canal EOD Range would result in six adult Puget Sound Chinook salmon deaths; and each underwater detonation at the Hood Canal EOD Range would result in 27 dead adult Hood Canal summer-run chum salmon.

6.6 Effects Resulting from Interaction of the Potential Stressors

Exposing living organisms to individual stressors or a suite of stressors that are associated with a specific action may be insignificant or minor when considered in isolation, but may have significant adverse consequences when they are added to other stressors, operate synergistically in combination with other stressors, or magnify or multiply the effects of other stressors. Further, the effects of life events, natural phenomena, and anthropogenic phenomena on an individual's performance will depend on the individual's phenotypic state when the individual is exposed to these phenomena. Disease, dietary stress, body burden of toxic chemicals, energetic stress, percentage body fat, age, reproductive state, and social position, among many other phenomena can "accumulate" to have substantial influence on an organism's response to subsequent exposure to a stressor. That is, exposing animals to individual stressors associated with a specific action can interact with the animal's prior condition (can "accumulate" and have additive, synergistic, magnifying, and multiplicative effect) and produce significant, adverse consequences that would not occur if the animal's prior condition had been different.

An illustrative example of how a combination of stressors interact was provided by Relyea (Relyea 2009) who demonstrated that exposing several different amphibians to a combination of pesticides and chemical cues of natural predators, which induced stress, increased the mortality rates of the amphibians (Sih et al. 2004). For some species, exposing the amphibians to the combination of stressors produced mortality rates that were twice as high as the mortality rates associated with each individual stressor. This section considers the evidence available to determine if interactions associated with mid-frequency active sonar are likely to produce responses we have not considered already or if interactions are likely to increase the severity and, therefore, the consequences of the responses we have already considered.

The activities the U.S. Navy conducts in the NWTRC will continue to introduce a suite of stressors into the marine and coastal ecosystems: mid and high-frequency active sonar from surface vessels, torpedoes, and dipping sonar; shock waves and sound fields associated with underwater detonations, acoustic and visual cues from surface vessels as they move through the ocean's surface, and sounds transferred into the water column from fixed-wing aircraft, and helicopters. Exposing endangered and threatened marine animals to each of these individual stressors could pose additional risks as the exposures accumulate over time. Also, exposing endangered and threatened marine animals to this suite of stressors could pose additional risks as the stressors interact with one another or with other stressors that already occur in those areas. More importantly, endangered and threatened marine animals that occur in the NWTRC would

be exposed to combinations of stressors produced by the Navy's activities at the same time they are exposed to stressors from other human activities and natural phenomena.

We recognize these interactions might have effects on endangered and threatened species that we have not considered thus far; however, the data available do not allow us to do more than acknowledge the possibility. Consider the stressor that has received the most attention thus far: mid-frequency active sonar. The activities would add mid-frequency sound to ambient oceanic noise levels, which, in turn, could have cumulative impacts on the ocean environment, including listed species. During transmissions, mid-frequency sonar will add to regional noise levels produced by commercial shipping, recreational boating, and construction activities occurring along the coastlines, among others. However, there are no reliable methods for assessing potential interactions between these sound sources. The Navy conducted computer simulations to assess the potential cumulative impacts of mid-frequency active sonar. That assessment concluded that the "cumulative impacts" of mid-frequency sonar would be "extremely small" because the exercises would occur for relatively short periods of time, for relatively short periods of time in any given area; the sources of active sonar would not be stationary; and the effects of any mid-frequency exposure would stop when transmissions stop.

A greater cumulative impact is likely to result from an interaction between the number of times endangered or threatened species might be exposed to active sonar and explosions in association with the activities considered in this Opinion and other activities the Navy and other agencies plan to conduct in the NWTRC during the same time interval.

Richardson et al. (Richardson et al. 1995b) provided extensive information and arguments about the potential cumulative effects of man-made noise on marine mammals. Those effects included masking, physiological effects and stress, habituation, and sensitization. Those concerns were echoed by Clark and Fristrup (Clark and Fristrup 2001b), National Research Council (NRC 2003b), and others. Although all of these responses have been measured in terrestrial animals reacting to airborne, man-made noises, those studies are counterbalanced by studies of other terrestrial mammals that did not exhibit these responses to similar acoustic stimuli.

The evidence available does not allow us to reach any conclusions about cumulative effects of the activities considered in this opinion and other activities that are occurring or are designed to occur in the NWTRC. While the increasing abundance of humpback whales over the past 30 years supports an inference that the status of these whales has improved despite the combination

of natural and anthropogenic stressors in those waters, the inference does not suffice to draw a conclusion as to the absence of effects. The inference is less supported for those species that appear to be declining.

6.7 Cumulative Effects

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

During this consultation, we searched for information on future state, tribal, local, or private actions reasonable certain to occur in the action area. Activities that are likely to occur in the NWTRC Action Area during the remaining period of the five-year rule and into the reasonably foreseeable future include continually increasing watershed development and water demand. Anthropogenic effects also include commercial and recreational exploitation, vessel traffic, ocean noise, fisheries interactions, and those from habitat degradation due to pollution, discharged contaminants, and coastal development.

West coast states are considering a variety of legislative actions pertinent to the marine environment and the listed species therein. Oregon is considering legislation to control invasive species and ballast water discharge, prohibit release of hazardous material/sewage into the Pacific, ease restrictions on wave energy power generation, develop and implement a marine aquaculture program, evaluate nearshore resources, territorial sea mapping, regulate fishing gear to reduce bycatch, redefine "native" in regards to salmon and trout enhancement programs, evaluate the economic impact of salmon harvests, reform hatcheries, improve passageways for fish in streams and rivers at obstructions, regulate stream flow to maintain stream morphology/ecology, prohibit salmon and sturgeon capture by net in the Columbia River, evaluate improving fish habitat in rivers, increase hatchery output of salmon smolts, and limit gillnet use in the Columbia river. Washington is considering legislation to protect conservation areas from petroleum extraction, strengthen ocean management policies, establish an aquatic reserve system, prepare a Puget Sound marine managed areas plan, further regulate salmon fishing, modify commercial salmon fishing and recovery actions/regulations, and incentivize construction of fish passageways. California is considering legislation to limit taking sturgeon by nets, limit commercial salmon harvests, evaluate the needs for salmon recovery, sponsor activities to recovery salmon stocks, reduce marine debris and derelict fishing gear, regulate sea

water intake to reduce fish killed in the process, mitigate invasive species, place additional training and preparatory requirements on industry relating to oil spill control and response, regulate ballast water discharge, address climate change, and regulate fisheries so as to be sustainable.

An increase in these activities could result in an increased effect on ESA-listed species; however, the magnitude and significance of any anticipated effects remain unknown at this time.

6.8 Potential for Long-Term or Additive Impacts

In order to address the Court's ruling that we take a long-term view of the "action," we assumed for purposes of this Opinion that the Navy's activities in the NWTRC and associated impacts will continue into the reasonably foreseeable future at the levels set forth in the 2010 EIS/OEIS and MMPA rule.[15] This assumption raises the question of whether the Navy's activities are reasonably certain to cause any aggregate or long-term impacts over time, beyond the effects of individual takes that could occur in a given year discussed in Section 7.0 below. This issue was addressed in general terms in Section 3.6.3.8. Further information is provided below.

To address the likelihood of long-term additive or accumulative impacts, we first considered (1) impacts or effects that accumulate in the environment in the form of stressors or reservoirs of stressors and (2) impacts or effects that represent either the response of individuals, populations, or species to that accumulation of stressors in the environment or the accumulated responses of individuals, populations, and species to sequences of exposure to stressors.

In regards to Item 1, which captures the normal usage of "cumulative impacts," we concluded that phenomena like sound do not accumulate like other phenomena, such as acreage of habitat destroyed and concentrations of toxic chemicals, sediment, and other pollutants, tend to accumulate[16]. In regards to Item 2, we considered phenomena that accumulate in individuals and individually contribute or collectively determine the probable fitness of the individuals that comprise a population. These include: the passage of time and its corollary, the loss of time (specifically, the loss of time to reproduce, to forage, and to migrate, etc.); reproductive success; longevity; energy debt, including allostatic loading; body burdens of toxic chemicals; the fitness

[15] Any change in the level of activity in the action area resulting from the ongoing NEPA and MMPA processes for NWTT will be evaluated in the separate consultation relating to the NWTT.

[16] These example phenomena are not a concern in this Opinion.

costs of behavioral decisions (canonical costs); injuries and tissue damage; and overstimulation of sensory organs (which would include noise-induced losses of hearing sensitivity).

Based on our consideration of these phenomena, we concluded that one of the three primary stressors — the probability of a ship strike — accumulated, in the sense that the probabilities of collisions associated with multiple transits are higher than the probabilities associated with a single transit. We factored those considerations into our estimation of the probability of a collision associated with multiple transits. Even with the consideration that the probability of ship strike accumulated over time, based on the relatively low density of animals and the low number of training exercises, in combination with the information that no ship strikes involving Naval vessels have occurred in the action area, we concluded that this stressor remains discountable.

Otherwise, we concluded that two of the three primary stressors associated with the U.S. Navy training, active sonar and underwater detonations, do not accumulate in either of the two ways discussed earlier in this section. Specifically, we concluded that the effects of multiple exposures to active sonar or underwater detonations were not likely to accumulate through altered energy budgets caused by avoidance behavior (reducing the amount of time available to forage), physiological stress responses (mobilizing glucocorticosteroids, which increases an animal's energy demand), or the canonical costs of changing behavioral states (small decrements in the current and expected reproductive success of individuals exposed to the stressors). In particular, we concluded that the species would be exposed on foraging areas and would experience trivial increases in feeding duration, effectiveness, or both, that would not accumulate in a manner that is likely to result in avoidance behavior or altered energy budgets. In short, the vast majority of impacts expected from sonar exposure and underwater detonations are behavioral in nature, temporary and comparatively short in duration, relatively infrequent, and not of the type or severity that would be expected to be additive for the small portion of the stocks and species likely to be exposed either annually or over the remaining period of the five-year MMPA regulations or in the reasonably foreseeable future.

Under certain conditions, chronic exposure to acoustic sources or other stimuli that can cause individual stress or behavioral responses can also lead to additional long-term adverse impacts. For example, investigators concluded that gray whales and humpback whales abandoned some of their coastal habitat in California and Hawai‘i, respectively, because of persistent underwater noise associated with extensive vessel traffic (Gard 1974, Reeves 1977, Salden 1988). Another

study of terrestrial mammals suggests that while short-term stress responses are often beneficial, conditions of chronic or long-term stress can lead to adverse physiological effects (Romero, et al., 2007). However, the Navy activities on the NWTRC involving active sonar or underwater detonations are infrequent, short-term, and generally unit level. Unit level events occur over a small spatial scale (one to a few 10s of square miles) and with few participants (usually one or two). Single-unit unit level training would typically involve a few hours of sonar use, with a typical nominal ping of every 50 seconds (duty cycle). Even though an animal's exposure to active sonar may be more than one time, the intermittent nature of the sonar signal, its low duty cycle, and the fact that both the vessel and animal are moving provide a very small chance that exposure to active sonar for individual animals and stocks would be repeated over extended periods of time. Consequently, the Navy's activities on the NWTRC do not create conditions of chronic, continuous underwater noise and are unlikely to lead to habitat abandonment or long-term hormonal or physiological stress responses in marine mammals.

As documented above, the vast majority of impacts from sonar exposure and underwater detonations are expected to be behavioral in nature, temporary and comparatively short in duration, relatively infrequent, and not of the type or severity that would be expected to be additive for the small portion of the stocks and species likely to be exposed annually, into the reasonably foreseeable future. Thus, while the number of individuals "taken" by active sonar or underwater detonations increases over time, the effect of each "take" on the survival or reproductive success of the animals themselves would not accumulate in the same way. As a result, for example, we do not expect that exposing one blue whale to mid-frequency active sonar per year at a level that we would consider a take in the form of behavioral harassment, as predicted by the Navy's NAEMO modeling described above, would result in effects over the long-term that would be greater than what we would expect from a single exposure event. To the contrary, we do not expect the effects of that "take" to have any additive, interactive, or synergistic effect on the individual animals, the population(s) those individuals represent, or the species those population(s) comprise.

The preliminary findings from Melcón et al. (2012) and Goldbogen et al. 2013, discussed above, are also consistent with our determination that behavioral responses of mysticetes to active sonar and other active acoustic sources used on the NWTRC are unlikely to have any measurable adverse impact on the long-term fitness or reproductive success of individual animals or long-term adverse population-level effects. Although Goldbogen et al. 2013 speculates that "frequent exposures to mid-frequency anthropogenic sounds may pose significant risk to the recovery rates

of endangered blue whale populations," the authors acknowlege that the actual responses of individual blue whales to simulated mid-frequency sonar documented in the study "typically involves temporary avoidance responses that appear to abate quickly after sound exposure." Moreover, the most significant response documented in the study (figure 1(b)) occurred not as a result of exposure to simulated mid-frequency sonar but as a result of exposure to pseudo-random noise. Therefore, the overall weight of scientific evidence indicates that substantive behavioral responses by mysticetes, if any, from exposure to mid-frequency active sonar and other active acoustic sources evaluated in this Opinion are likely to be temporary and are unlikely to have any long-term adverse impact on individual animals or affected populations.

Also as discussed above, while the New et al. (2013) model provides a test case for future researching the potential for long-term impacts, this pilot study has very little of the critical data necessary to form any conclusions applicable to current management decisions

With respect to threatened and endangered marine mammals, our conclusion that the annual predicted behavioral takes resulting from exposure to active sonar and impulsive acoustic sources, continuing into the reasonably foreseeable future, are unlikely to result in accumulated adverse impacts is consistent with the negligible impact determination contained in the MMPA rulemaking, which is incorporated by reference. See 75 FR 69317-18; 74 FR 33828, 33884-92.

Our assessment that the continuation of the Navy's activities into the reasonably foreseeable future is unlikely to have any adverse additive or long-term impacts on the affected threatened or endangered species (assuming current levels of activity and no significant changes in the status of species or to the environmental baseline) is also consistent with the absence of any documented population-level or adverse aggregate impacts resulting from Navy activities to date, despite decades of Navy training in the NWTRC using many of the same systems. Most of the training activities the Navy conducts on the NWTRC are similar, if not identical, to activities that have been occurring in the same locations for decades. For example, the mid-frequency sonar system on the destroyers and frigates that conduct unit-level ASW training in the NWTRC have the same sonar system components in the water as was first deployed in the 1970s. While the signal analysis and computing processes onboard these ships have been upgraded with modern technology, the power and output of the sonar transducer, which puts signals into the water, have not changed.

The best assessment of long-term consequences from training activities will be to monitor the populations over time within a given Navy range complex. A U.S. workshop on Marine Mammals and Sound (Fitch et al. 2011) indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival. The Navy has developed monitoring plans for protected marine mammals and sea turtles occurring on Navy ranges with the goal of assessing the impacts of training activities on marine species and the effectiveness of the Navy's current mitigation practices. For example, results from 2 years (2009–2010) of intensive monitoring by independent scientists and Navy observers in Southern California Range Complex and Hawaii Range Complex have recorded an estimated 161,894 marine mammals with no evidence of distress or unusual behavior observed during Navy activities. Continued monitoring efforts over time will be necessary to completely evaluate the long-term consequences of exposure to noise sources.

Our regulations require us to consider, using the best available scientific data, effects of the action that are "likely" and "reasonably certain" to occur rather than effects that are speculative or uncertain. See 50 C.F.R. § 402.02 (defining to "jeopardize the continued existence of" and "effects of the action"). For the reasons set forth above, and taking into consideration the best available scientific evidence documented throughout this Opinion, we conclude that the continuation of the Navy's activities in the NWTRC into the reasonable foreseeable future, at the levels described in the current five-year MMPA rule (and assuming no change in the status of species or the environmental baseline), are unlikely to lead to any adverse, long-term additive or cumulative impacts on individuals or affected populations, and that such long-term impacts are not reasonably certain to occur based on the information that is currently available. Furthermore, our analysis and conclusions in this Opinion are based on modeled estimates of exposures and take assuming that the Navy conducts the maximum number of authorized training activities for the maximum number of authorized hours. Therefore, our assumption that the Navy's activities will continue into the reasonably foreseeable future does not alter our conclusion, documented in Section 7.0 below, that the Navy's activites are unlikely to jeopardize the continued existence of any ESA-listed species or destroy or adversely modify critical habitat that has been designated for such species.

7 INTEGRATION AND SYNTHESIS OF EFFECTS

In the *Assessment Approach* section of this Opinion, our analyses begin by identifying the probable actions that pose risk or act as stressors to listed individuals that are likely to be exposed to the action. We measure risks to individuals of endangered or threatened species using changes in the individuals' "fitness" or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When we do not expect listed plants or animals exposed to an action's effects to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (Anderson 2000b; Brandon 1978; Mills and Beatty 1979; Stearns 1977; Stearns 1992b). As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment. If, however, we conclude that listed plants or animals are likely to experience reductions in their fitness, we would assess the potential consequences of those fitness reductions for the population or populations the individuals in an action area represent.

As part of our risk analyses, we consider the consequences of exposing endangered or threatened species to the stressors associated with the actions, individually and cumulatively, given that the individuals in the action areas for this consultation are also exposed to other stressors in the action area and elsewhere in their geographic range. These stressors or the response of individual animals to those stressors can produce consequences — or "cumulative impacts" (in the NEPA sense of the term) — that would not occur if animals were only exposed to a single stressor.

Our analyses led us to conclude, first, whether endangered or threatened individuals are likely to be exposed to the U.S. Navy's training exercises in the NWTRC during the remainder of the five year period of the MMPA rule and LOAs and continuing for the reasonably foreseeable future. We then assessed whether or not those individuals exposed to training and/or activities are likely to experience reductions in the fitness during this period and continuing into the reasonably foreseeable future as training activities likely to continue at similar levels. We assumed that the activities conducted for the remainder of the five-year rules would continue into the foreseeable future at levels similar to that assessed in this Opinion, and we considered the direct and indirect effects of those assumed future activities, together with the effects of all interrelated and interdependent actions. We also assume that there would be no significant changes to the status of the species or Environmental Baseline that further reduce ability for survival and recovery of species during this period.

7.1 Summary of Changes in Take Estimates due to Navy Modeling

As discussed in Section 3.6.1.3, the Navy's 2014 NAEMO model results were lower than the 2008 SAIC model (NWTRC) for 6 of 6 species affected (blue whale, fin whale, humpback whale, sei whale, sperm whale, southern resident killer whale). All NAEMO modeled results for the NWTT draft EIS/OEIS no action alternative were also lower than NMFS' 2010 model carried forward through the 2012 biological opinion.

Table 21. Navy Modeled "Take" in the form of Behavioral Harrassment and Harm (Injury, Mortality) Showing Differences Between Phase I and Phase II Modeling Results

Species	Navy modeled values in NWTRC Final EIS/OEIS (2010)		Navy Modeled values in NWTT No Action Alternative Draft EIS/OEIS (2014)	
	Harrass	***Harm***	***Harrass***	***Harm***
Blue Whale	19	0	1	0
Fin Whale	143	1	6	0
Humpback Whale	13	0	3	0
Killer Whale, Southern Resident DPS*	13	0	0	0
Sei Whale, Eastern North Pacific	1	0	0	0
Sperm Whale	127	2	26	0

***Southern resident killer whale were modeled for exposure to biennial civilian port defense events only in the Phase II No Action Alternative for NWTT. No exposures to surface ship mid-frequency active sonar are expected.**

7.2 Blue Whale

Blue whales are only present in the offshore portion of the NWTRC action area. Blue whales may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. Blue whales found in offshore portion of the NWTRC Action Area are recognized as part of the Eastern North Pacific stock and the acoustic analysis predicts that they may be exposed to sonar and other active acoustic sources associated with training activities that may result in one behavioral reaction annually. Long-term consequences for individuals or to the survival or recovery of populations would not be expected.

Training activities involving explosions would mainly be conducted throughout the offshore portions of the action area, but also at historically used locations in the Inland Waters portion of the NWTRC action area. The Navy's acoustic analysis predicts that blue whales would not be exposed to explosive (impulse) sources associated with training activities, which would exceed the current criteria adopted for our analysis.

Goldbogen et al. (2013) reported on the results of an ongoing Navy-funded behavioral response study in the waters of Southern California (see Southall et al. 2012a for additional details on the behavioral response study). Goldbogen et al. (2013) suggested that "frequent exposure to mid-frequency anthropogenic sounds may pose significant risks to the recovery rates of endangered blue whale populations." While there are no data indicating any trend in the entire Eastern North Pacific population toward recovery since the end of whaling (e.g., Barlow and Forney 2007), research along the U.S. west coast and Baja California reported by Calambokidis et al. (2009b) and based on mark-recapture estimates "indicated a significant upward trend in abundance of blue whales" at a rate of increase just under 3 percent per year for the portion of the blue whale population in the Pacific that includes Southern California as part of its range. The Eastern North Pacific stock (population), which is occasionally present in Southern California, is known to migrate from the northern Gulf of Alaska to the eastern tropical Pacific at least as far south as the Costa Rica Dome (Carretta et al. 2013). Given this population's vast range and absent discussion of any other documented impacts, such as commercial ship strikes (Berman-Kowalewski et al. 2010), the suggestion by Goldbogen et al. (2013) that since the end of commercial whaling, sonar use (in the fraction of time and area represented by Navy's training in the SOCAL Range Complex) may be of significant risk to the blue whale's recovery in the Pacific is speculative at this stage. Furthermore, the suggestion is contradicted by the upward trend in abundance and counts (Calambokidis et al. 2009b; Berman-Kowalewski et al. 2010) of blue whales in the area where sonar use has been occurring for decades."

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that impulsive and non-impulsive acoustic stressors resulting from training activities the U.S. Navy plans to conduct in the NWTRC Action Area on an annual basis, or cumulatively over the remainder of the five year period through November 2015, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline that further reduce ability for survival and recovery of species), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual blue whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations).

7.3 Fin Whale

Fin whales could be present in all portions of the NWTRC and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. Fin whales found in the offshore portions of the action area and the Inland Waters of Puget Sound area are recognized as part of the California, Oregon, Washington stock. The acoustic analysis predicts that fin whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with training activities in the offshore portions of the action area that may result in two TTS and four behavioral reactions annually. Long-term consequences for individuals or populations would not be expected. The Northeast Pacific stock of fin whales would not be exposed to sound that would exceed the current impact thresholds.

Training activities involving explosions would mainly be conducted throughout the offshore portions of the action area, but also at historically used locations in the Inland Waters portion of the NWTRC action area. The Navy's acoustic analysis predicts that fin whales would not be exposed to explosive (impulsive) sources associated with training activities, which would exceed the current impact thresholds.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that impulsive and non-impulsive acoustic stressors resulting from training activities the U.S. Navy plans to conduct in the NWTRC Action Area on an annual basis, or cumulatively over the remainder of the five year period through November 2015, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline that further reduce ability for survival and recovery of species), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual fin whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). Long-term consequences for individuals or to the survival or recovery of populations would not be expected

7.4 Humpback Whale

Humpback whales could be in all portions of the NWTRC and may be exposed to sonar and other active acoustic sources associated with training activities throughout the year. Humpback whales found in the offshore portions of the action area and the Inland Waters of Puget Sound

area are recognized as part of the California, Oregon, Washington stock. The acoustic analysis predicts that humpback whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with training activities in the offshore portions of the action area that may result in one TTS and two behavioral reactions annually. The Central North Pacific stock of humpback whales would not be exposed to sound that would exceed the current impact thresholds.

Training activities involving explosions would mainly be conducted throughout the offshore portions of the action area, but also at historically used locations in the Inland Waters portion of the NWTRC action area. The Navy's acoustic analysis predicts that humpback whales would not be exposed to explosive (impulse) sources associated with training activities, which would exceed the current impact thresholds.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that impulsive and non-impulsive acoustic stressors resulting from training activities the U.S. Navy plans to conduct in the NWTRC Action Area on an annual basis, or cumulatively over the remainder of the five year period through November 2015, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline that further reduce ability for survival and recovery of species), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual humpback whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability or potential for recovery of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, distribution, or recovery potential of those populations). Long-term consequences for individuals or to the survival or recovery of populations would not be expected.

7.5 Sei Whale

Sei whales may be exposed to sonar and other active acoustic sources associated with training activities throughout the year in the offshore portions of the action area. The acoustic analysis predicts that sei whales would not be exposed to sonar and other active acoustic sources associated with training activities in the offshore portions of the action area at levels which would exceed the current impact thresholds. Long-term consequences for individuals or populations would not be expected.

Training activities involving explosions would mainly be conducted throughout the offshore portions of the action area, but also at historically used locations in the Inland Waters portion of the NWTRC action area. The Navy's acoustic analysis predicts that sei whales would not be exposed to explosive (impulse) sources associated with training activities, which would exceed the current impact thresholds.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that impulsive and non-impulsive acoustic stressors resulting from training activities the U.S. Navy plans to conduct in the NWTRC Action Area on an annual basis, or cumulatively over the remainder of the five year period through November 2015, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline that further reduce ability for survival and recovery of species), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual sei whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability or potential for recovery of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, distribution, or recovery potential of those populations). Long-term consequences for individuals or to the survival or recovery of populations would not be expected.

7.6 Southern Resident Killer Whale

During the first two LOA periods, the Navy reported that there were two instances in which Southern Resident killer whales were "taken." This "taking" was from the exposure to active sonar and vessel movements associated with the sonar training exercises. As a result, we expect that the Southern Resident killer whales made short-term behavioral adjustments that did not appreciably reduce their likelihood of surviving and recovering in the wild. No takes of Southern Resident killer whales are predicted for the NWTRC activities expected to occur during the remainder of the current five-year MMPA rule based on the NAEMO modeling results used in this Opinion.

Training activities involving explosions would mainly be conducted throughout the offshore portions of the action area, but also at historically used locations in the Inland Waters portion of the NWTRC action area. The Navy's acoustic analysis predicts that southern resident killer whales would not be exposed to explosive (impulse) sources associated with training activities, which would exceed the current impact thresholds.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that impulsive and non-impulsive acoustic stressors resulting from training activities the U.S. Navy plans to conduct in the NWTRC Action Area on an annual basis, or cumulatively over the remainder of the five year period through November 2015, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline that further reduce ability for survival and recovery of species), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual southern resident killer whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability or potential for recovery of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, distribution, or recovery potential of those populations). Long-term consequences for individuals or to the survival or recovery of populations would not be expected.

7.7 Sperm Whale

Sperm whales are classified as mid-frequency cetaceans. Sperm whales are likely only in the offshore portion of the NWTRC Action Area. Sperm whales found in the offshore portions of the action area are recognized as part of the California, Oregon, Washington stock. The acoustic analysis predicts that sperm whales of the California, Oregon, Washington stock may be exposed to sonar and other active acoustic sources associated with training activities in the offshore portions of the action area that may result in 26 behavioral reactions annually with no instances of TTS. These behavioral reactions are unlikely to cause long-term consequences for individual animals or populations.

Training activities involving explosions would mainly be conducted throughout the offshore portions of the action area, but also at historically used locations in the Inland Waters portion of the NWTRC action area. The Navy's acoustic analysis predicts that sperm whales would not be exposed to explosive (impulse) sources associated with training activities, which would exceed the current impact thresholds.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that impulsive and non-impulsive acoustic stressors resulting from training activities the U.S. Navy plans to conduct in the NWTRC Action Area on an annual basis, or cumulatively over the remainder of the five year period through November 2015, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to

the status of the species or Environmental Baseline that further reduce ability for survival and recovery of species), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual sperm whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability or potential for recovery of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, distribution, or recovery potential of those populations). Long-term consequences for individuals or to the survival or recovery of populations would not be expected.

7.8 Leatherback Sea Turtles

Up to 378 training activities would use explosives at or beneath the water surface which would expose leatherback sea turtles to underwater impulsive sound. The largest source class used during training would be E12 (> 650–1,000 pounds [lb.] net explosive weigh (NEW)), which would be used 16 times in the Operating Area (OPAREA). Explosions associated with torpedoes and explosive sonobuoys would occur in the water column; mines and demolition charges could occur near the surface, in the water column, or the ocean bottom. Most detonations would occur in waters greater than 200 ft. (61 m) in depth, and greater than 3 nautical miles (nm) from shore, although mine warfare could occur in shallow water close to shore. Detonations associated with ASW would typically occur in waters greater than 600 ft. (182.9 m) depth.

The ranges of impacts from in-water explosions are listed in Table **7**. While the number of leatherback turtles anticipated in the NWTRC is low, if a leatherback turtle was within the ranges listed in Table **7**, the respective impact would be anticipated. Results from Navy modeling indicate no leatherback sea turtles are predicted to be exposed to impulse levels associated with the onset of mortality and gastrointestinal tract injury over any training year for explosives use in open ocean habitats. Further, zero sea turtles were modeled to experience TTS or PTS from the use of explosives in the offshore area.

Some sea turtles beyond the ranges of the above impacts may behaviorally react if they hear a detonation. Activities consisting of single detonations, such as bombing and missile exercise, are expected to only elicit short-term startle reactions. If a sea turtle hears multiple detonations in a short period, such as during gunnery, firing, or sonobuoy exercises, it may react by avoiding the area. Any significant behavioral reactions could lead to a sea turtle expending energy and missing opportunities to secure resources. However, because most activities would consist of a limited number of detonations and exposures would not occur over long durations, there would

be an opportunity to recover from an incurred energetic cost. Five leatherback sea turtles were modeled to experience minor behavioral-level impacts from the use of explosives in the offshore portions of the action area. However, behavioral responses of sea turtles to impulsive and non-impulsive sound stressors is not well studied and cannot be quantified in this Opinion.

Because model-predicted impacts are negligible and most impacts would be short-term, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment. Sea turtles may exhibit short-term behavioral reactions, such as swimming away or diving to avoid the immediate area around a source, although studies examining sea turtle behavioral responses to sound have used impulsive sources, not non-impulsive sources. Pronounced reactions to acoustic stimuli could lead to a sea turtle expending energy and missing opportunities to forage or breed. In most cases, acoustic exposures are intermittent, allowing time to recover from an incurred energetic cost, resulting in no long-term consequence. Because model-predicted impacts are conservative and any impacts would be short-term, potential impacts are not expected to result in substantial changes to behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts.

While the potential for serious injury and mortality of sea turtles from vessel strike exists, we believe the potential is discountable for the reasons stated above. Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that impulsive and non-impulsive acoustic stressors resulting from training activities the U.S. Navy plans to conduct in the NWTRC Action Area on an annual basis, or cumulatively over the remainder of the five year period through November 2015, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline that further reduce ability for survival and recovery of species), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual leatherback sea turtles in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability or potential for recovery of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, distribution, or recovery potential of those populations). Long-term consequences for individuals or to the survival or recovery of populations would not be expected.

7.9 Threatened and Endangered Fishes

The majority of fish species exposed to non-impulsive sources would likely have no reaction or mild behavioral reactions. Overall, long-term consequences for individual fish are unlikely in most cases because acoustic exposures are intermittent and unlikely to repeat over short periods. Since long-term consequences for most individuals are unlikely, long-term consequences for populations are not expected.

The ESA-listed salmonid species (steelhead trout, Chinook salmon, coho salmon, chum salmon, and sockeye salmon), green sturgeon, and Pacific eulachon are anadromous and spend a portion of their lives in both the marine environment as well as in the riverine and estuarine systems throughout the NWTRC. These species have the potential to be exposed to non-impulsive sound associated with training activities in the coastal areas. Since salmonid species and Pacific eulachon spawn in rivers and the early life stages of the fish occur in riverine and estuarine environments, eggs and larvae would not be exposed to sounds produced from non-impulsive sound sources during training activities.

It is believed that salmonid species, which are anatomically similar to Atlantic salmon, are unable to detect the sound produced by mid- or high-frequency sonar and other active acoustic sources. Therefore, acoustic impacts from these sources are not expected.

Long-term consequences for the populations would not be expected. The primary exposure to vessel noise would occur in the NWTRC and around ports. Vessel noise has the potential to expose steelhead trout to sound and general disturbance, potentially resulting in short-term behavioral responses. However, any short-term behavioral reactions, physiological stress, or auditory masking are unlikely to lead to long-term consequences for individuals. Therefore, long-term consequences for populations are not expected.

Training activities include activities that produce in-water noise from the use of sonar and other active acoustic sources, and could occur throughout the NWTRC. Sonar and other active acoustic sources are transient in most locations as active sonar activities pass through the NWTRC action area. A few activities involving sonar and other active acoustic sources occur in inshore water (within bays and estuaries), specifically at pierside locations.

The salmonid species are anadromous and spend a portion of their lives in both the marine environment as well as in the riverine and estuarine systems. Similarly, the Pacific Eulachon and green sturgeon may occur in the Inland Waters.

Non-impulsive sound sources in the action area include sonar and other active acoustic sources. Potential effects to fish from these sources may be considered in four categories (as detailed in the Navy's Background and Framework for Fish starting on page 116 of this Opinion): (1) direct injury; (2) hearing loss; (3) auditory masking; and (4) physiological stress and behavioral reactions.

Direct injury to adult fish as a result of exposure to sonar is highly unlikely to occur. Therefore, direct injury as a result of exposure to sonar sources is not discussed further in this Opinion. Research indicates that exposure of fish to transient, non-impulsive sources is unlikely to result in any hearing loss. Most sonar sources are outside of the hearing and sensitivity range of most marine fish, and noise sources such as vessel movement lack the duration and intensity to cause hearing loss. Furthermore, permanent hearing loss has not been demonstrated in fish as they have been shown to regenerate lost sensory hair cells.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that impulsive and non-impulsive acoustic stressors resulting from training activities the U.S. Navy plans to conduct in the NWTRC Action Area on an annual basis, or cumulatively over the remainder of the five year period through November 2015, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or environmental baseline that further reduce ability for survival and recovery of species), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of endangered and threatened fish species in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual fish would not be likely to reduce the viability of the populations those individual fish represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations).

Based on the estimated annual take, the estimated take that could occur over the remaining period of the action through November 2015 as a result of underwater detonations would be approximately 21 Puget Sound Chinook salmon and 72 Hood Canal summer-run chum salmon.

As a result, the activities the U.S. Navy plans to conduct in the NWTRC through November 2015 would not appreciably reduce the likelihood of Pacific salmon, steelhead, or southern eulachon surviving and recovering in the wild. Long-term consequences for individuals or to the survival or recovery of populations would not be expected

7.10 Comparison of Previously-modeled Take Estimates for Marine Mammals to This Opinion

In this section we summarize the take estimated by the Phase II NAEMO model in 2014 as compared to the results of the Phase I modeling results that were used in the Navy's application for an MMPA letter of authorization for the 2012-2015 period of the five-year rule. For marine mammal species, the estimated take values are below the annual total for each species estimated in Phase I and allowed for in the 2010-2015 MMPA Rule and LOAs.

Table 22. Comparison of Incidental Take in Previous Navy Analysis and NMFS Biological Opinions on NWTRC and the Navy's 2014 Modeling Effort

	NMFS NWTRC BO and LOA authorization (2012-2015)		**Navy modeled values in 2014**	
NWTRC species	***Harrass***	***Harm***	***Harrass***	***Harm***
Blue Whale	11	0	1	0
Fin Whale	40	1	6	0
Humpback Whale	15	0	3	0
Killer Whale (Southern resident)	14	0	0	0
Sei Whale	1	0	0	0
Sperm Whale	84	1	26	0

8 CONCLUSION

For this Opinion, we reviewed the current status of blue whales, fin whales, humpback whales, sei whales, Southern resident killer whales, sperm whales, leatherback sea turtles, Georgia Basin bocaccio, eulachon, Puget Sound Chinook salmon, lower Columbia river Chinook salmon, California coastal Chinook salmon, Columbia river chum salmon, Hood Canal chum salmon, central California coast coho salmon, Southern Oregon/Northern Coastal California coho salmon, lower Columbia River coho salmon, Oregon Coast coho salmon, Ozette Lake sockeye salmon, lower Columbia River steelhead, Northern California steelhead, central California coastal steelhead, and Puget Sound steelhead and the environmental baseline for the action area. We also assessed the effects of the military readiness activities the U.S. Navy plans to conduct on the NWTRC and the potential cumulative effects.

To comply with the Court's order, we used the results of the Navy's Phase II NAEMO modeling which are based, in part, on the 2010 and 2011 Finneran dolphin studies referenced by the Court.

We also assumed for purposes of this Opinion that the Navy's activities in the NWTRC and associated impacts will continue into the reasonably foreseeable future at the levels set forth in the 2010 EIS/OEIS. This assumption raised the question of whether the Navy's activities are reasonably certain to cause any aggregate or long-term impacts over time, beyond the effects of individual takes that could occur in a given year. For the reasons stated above, we concluded that aggregate or long-term impacts on listed species are unlikely to occur.

Therefore, it is NMFS' opinion that these training activities are likely to adversely affect but are not likely to jeopardize the continued existence of these threatened and endangered species under NMFS' jurisdiction and are not likely to affect critical habitat that has been designated for endangered or threatened species in the NWTRC action area during the remainder of the 5-year period or in the reasonably foreseeable future beyond the five-year period, assuming that the type, amount and extent of training do not exceed levels assessed in this Opinion and assuming there are no significant changes to the status of the species or Environmental Baseline that further reduce ability for survival and recovery of species. Any increase in activity levels above what was assessed or significant change in the status of species would require immediate reinitiation of consultation.

This Opinion also concludes that the NMFS' issuance of an LOA pursuant to the MMPA rule as assessed in this Opinion for training activities to take marine mammals through November 2015, incidental to the U.S. Navy's training activities are likely to adversely affect but are not likely to jeopardize the continued existence of these threatened and endangered species under NMFS' jurisdiction and are not likely to result in the destruction or adverse modification of critical habitat that has been designated for endangered or threatened species in the NWTRC action area.

9 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibits the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2) of the ESA, taking that is

incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of an Incidental Take Statement.

9.1 Amount or Extent of Take Anticipated

The section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 CFR § 402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions while the extent of take or "the extent of land or marine area that may be affected by an action" may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (51 FR 19953).

The effects analysis contained in this Opinion concluded that individual blue whales, fin whales, humpback whales, sei whales, sperm whales, Southern Resident killer whales, leatherback sea turtles, and listed fish species have small probabilities of being exposed to the active sonar, sound fields associated with underwater detonations, or noise and other environmental cues associated with the movement of surface vessels. In some instances, we concluded that this exposure was likely to result in evasive behavior or changes in behavioral state, which we would consider "harassment" for the purposes of this Incidental Take Statement.

The instances of harassment identified in Table 23 would generally represent changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures and, therefore, would represent minor disruptions of the normal behavioral patterns of the animals that have been exposed from which individuals would recover from quickly. As discussed throughout this Opinion, these disruptions are expected to be temporary and the animals are expected to fully recover. However, because the possibility remains that some takes in the form of harassment could occur as a result of exposures, we specify a level of take by harassment that is exempted from the take prohibitions. No whales or sea turtles are likely to die or be wounded or injured as a result of their exposure to the training activities the U.S. Navy plans to conduct on the NWTRC. Therefore, for the purposes of this Biological Opinion and Incidental Take Statement, we assume that the training activities the U.S. Navy conducts on the NWTRC is likely to result in incidental "take" shown in Table 23. These numeric take estimates should not be viewed as absolute numbers; rather they are estimates based on the use of models that in turn

are often dependent on estimated input variables. Minor differences between take statements through the years are due to different approaches to rounding model input or output values.

Table 23. The number of threatened or endangered species that are likely to be "taken" in the form of behavioral harassment or harm (injury or death) as a result of their exposure to U.S. Navy military readiness activities conducted on the NWTRC on an Annual Basis through November 2015.

Species		Annual Estimated Take					
		Non-Impulsive Sound (Sonar)		Impulsive Sound (Detonations)		Vessel Strike	Total
		Harrass (Behavioral & TTS)	Harm (PTS, Injury, Mortality)	Harrass (Behavioral & TTS)	Harm (PTS, Injury, Mortality)	Harm (Injury, Mortality)	
Marine Mammals - Cetaceans							
Blue Whale		**1**	0	0	0	0	**1**
Fin Whale		**6**	0	0	0	0	**6**
Humpback Whale		**3**	0	0	0	0	**3**
Sei Whale		0	0	0	0	0	0
Killer Whale – Southern Resident DPS		0	0	0	0	0	0
Sperm Whale		**26**	0	0	0	0	**26**
Sea Turtles							
Leatherback Sea Turtle		0	0	*	0	0	*
Fish							
Green Sturgeon		0	0	0	0	0	0
Pacific Eulachon, Southern DPS		0	0	0	0	0	0
Chinook Salmon	**Puget Sound ESU**	0	0	**	**16**	0	**16**
	Lower Columbia ESU	0	0	0	0	0	0
	California Coast ESU	0	0	0	0	0	0
Chum	Columbia River ESU	0	0	0	0	0	0

Salmon	**Hood Canal Summer-run ESU**	0	0	**	**54**	0	**54**
Coho Salmon	Lower Columbia River ESU	0	0	0	0	0	0
	Oregon Coast ESU	0	0	0	0	0	0
	Central California ESU	0	0	0	0	0	0
Sockeye Salmon	Ozette Lake ESU	0	0	0	0	0	0
Steelhead	Lower Columbia River DPS	0	0	0	0	0	0
	Puget Sound DPS	0	0	0	0	0	0
	Northern California DPS	0	0	0	0	0	0
	Central California Coast DPS	0	0	0	0	0	0

*** Behavioral responses of sea turtles to impulsive and non-impulsive sound and vessel strike stressors are not well studied and cannot be quantified in this Opinion. The number of turtles predicted by the Navy to be taken by impulsive sources in the form of harrassment includes zero from TTS. However, for this Incidental Take Statement, behavioral take will be exceeded if activity levels are exceeded and if post-calculations of take indicate instances of TTS, injury or mortality of turtles from active sonar or detonations is observed during training.**
**** Behavioral responses of Puget Sound chinook salmon and Hood Canal Summer Run chum salmon to impulsive sound stressors are not well studied and cannot be quantified in this Opinion. Take in the form of behavioral harassment from impulsive sources will be exceeded if activity levels are exceeded during a given year. Mortality from impulsive stressors was estimated and is provided in the table.**

As a result of the underwater detonations the U.S. Navy conducts (Table 2), we expect one adult and one juvenile Puget Sound Chinook salmon to die or be injured during each of the surface detonations at Crescent Harbor; six adult Puget Sound Chinook salmon to die during each underwater detonation at Hood Canal; and 27 adult Hood Canal summer-run chum salmon to die during each underwater detonation at Hood Canal. Up to two detonations are expected to occur annually at both EOD ranges, thus a total of 16 Puget Sound Chinook salmon and a total of 54 Hood Canal summer-run chum salmon will be exposed annually to underwater detonations at levels which may result in mortality (Table 23).

"Take" of these species will have been exceeded if the number of detonations, the location of the detonations, or the Net Explosive Weight of the detonations are greater than we expected in our analyses or if the monitoring program associated with the training activities detects greater number of adult salmon than are identified in the preceding paragraph.

9.1.1 Activity Levels Indicator of Take for Fish and Sea Turtles

Detection of behavioral responses, injury or mortality of larval, juvenile or adult individuals of fish or juvenile or adult sea turtles in coastal waters or at-sea during Navy training activities would be extremely difficult. Most forms of behavioral responses would not be detected. Also, monitoring techniques to calculate actual take of larval or adult fish including detection and collection of individuals and assessment of injuries or death is not feasible for fish and sea turtles at the scale of Navy training activities. Therefore, we must rely on predicted take associated with levels of activities and any opportunistic observations of potential behavioral responses or injured or dead adult fish or juvenile or adult sea turtles during training as measurements of take and a trigger for reinitiation of consultation. In the absence of observations of unanticipated levels of behavioral responses, injury or mortality, exceedance of an activity level will require the Navy to reinitiate consultation. Exceedances at the activity level (e.g., anti-submarine warfare, number of detonations, etc.) or in other planned training events must be reported to NMFS prior to carrying out or immediately following, if reporting would interrupt Navy training activities.

9.2 Effect of the Take

In the accompanying Opinion, NMFS determined that the above level of take, considered either on an annual basis or in the aggregate either over the entire five-year course of the applicable MMPA regulations or continuing into the reasonably foreseeable future, is not likely to jeopardize the continued existence of the endangered or threatened species for which "take"

would be exempted by this Incidental Take Statement. Studies of marine mammals and active sonar transmissions have shown behavioral responses by blue whales, fin whales, and humpback whales to active sonar transmissions. Although the biological significance of the animal's behavioral responses remains uncertain, the best scientific and commercial data available leads us to conclude that exposing these endangered and threatened species to active sonar transmissions might disrupt one or more behavioral patterns that are essential to an individual animal's life history or to the animal's contribution to a population. For the proposed action, behavioral responses that result from active sonar transmissions and any associated disruptions are expected to be temporary and would not affect the reproduction, survival, or recovery of these species.

9.3 Reasonable and Prudent Measures

NMFS believes the following reasonable and prudent measures are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

1. The U.S. Navy shall employ the mitigation measures included as part of its action and the mitigation measures required by the NMFS's Permits and Conservation Division 2012 LOA for the NWTRC.

2. NMFS's Permits and Conservation Division shall ensure that the U.S. Navy adheres to the mitigation and measures required by the 2012 LOA and any subsequent LOAs or amendments.

3. The U.S. Navy shall report all exceedences of activity levels (Table **1**) immediately upon determining that a planned activity level may be or has been exceeded.

9.4 Terms and Conditions

In order to be exempt from the prohibitions of Section 9 of the Endangered Species Act of 1973, as amended, NMFS's Permits and Conservation Division and the U.S. Navy must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outlining reporting and monitoring requirements, as required by the section 7 regulations (50 CFR §402.14(i))

1. The U.S. Navy shall carry out all the mitigation, monitoring, and reporting requirements as described in the proposed action section of this Opinion and contained in the LOA

issued under section 101(a)(5)(A) of the Marine Mammal Protection Act. Reports shall be submitted to the following NMFS offices: (1) Chief, Permits and Conservation Division, 1315 East-West Highway, Silver Spring, MD 20910; and (2) Chief, Endangered Species Act Interagency Cooperation Division, 1315 East-West Highway, Silver Spring, MD 20910.

2. NWTRC five-year Comprehensive Report - The Navy shall submit to NMFS a draft report that analyzes and summarizes all of the multi-year marine mammal information gathered during exercises that use active sonar or explosives for which annual reports are required (Annual NWTRC Exercise Reports and NWTRC Monitoring Plan Reports). This report will be submitted at the end of the fourth year of the rule. - COMPLETED

3. Comprehensive National ASW Report - By June 2014, the Navy shall submit a draft National Report that analyzes, compares, and summarizes the active sonar data gathered (through 1 January 2014) from the watchstanders and pursuant to the implementation of the Monitoring Plans for the Southern California Range Complex, the Atlantic Fleet Active Sonar Training, the Hawaii Range Complex, the Mariana Islands Range Complex, the NWTRC, and the Gulf of Alaska. - COMPLETED

    a. The Navy shall respond to NMFS comments and requests for additional information or clarification on the NWTRC Comprehensive Report, the Comprehensive National Anti-Submarine Warfare report, the Annual NWTRC Exercise Report, or the Annual NWTRC Monitoring Plan Report (or the multi-Range Complex Annual Monitoring Plan Report, if that is how the Navy chooses to submit the information) if submitted within three months of receipt. These reports will be considered final after the Navy has addressed NMFS's comments or provided the requested information, or three months after the submittal of the draft if NMFS does not comment by then.

4. If dead or injured marine mammals are observed during the studies and monitoring, the U.S. Navy shall contact NMFS and marine mammal stranding networks immediately (if available and as appropriate). The U.S. navy shall coordinate with marine mammal stranding networks to help determine any potential relationship of any stranding sonar transmissions and to detect long-term trends in stranding.

5. NMFS's Permits and Conservation Division shall provide NMFS's Endangered Species Act Interagency Conservation Division with an annual summary of steps taken to ensure that the U.S. Navy was compliant with the MMPA Letter of Authorization and the

preceding ESA Biological Opinion. This summary shall be submitted by 30 September each year addressing activities that occurred through 1 May of the same year.

6. In the absence of observations of unanticipated levels of behavioral responses, injury or mortality of fish or sea turtles, exceedance of an activity level will require the Navy to reinitiate consultation. Exceedances at the activity level (e.g., anti-submarine warfare, Number of detonations, etc.) or in other planned training events must be reported to NMFS prior to carrying out or immediately following the event.

10 CONSERVATION RECOMMENDATIONS

Section 7(a) (1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a 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 whales as well as reduce harassment related to research activities:

> ***Cumulative Impact Analysis.*** The U.S. Navy should work with NMFS Endangered Species Act Interagency Cooperation Division and other relevant stakeholders (the Marine Mammal Commission, International Whaling Commission, and the marine mammal research community) to develop a method for assessing the cumulative impacts of anthropogenic noise on cetaceans, pinnipeds, sea turtles, and other marine animals. This includes the cumulative impacts on the distribution, abundance, and the physiological, behavioral and social ecology of these species.

In order to keep NMFS's ESA Interagency Cooperation Division informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Permits and Conservation Division should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

11 REINITIATION NOTICE

This concludes formal consultation on military readiness activities the U.S. Navy plans to conduct on the NWTRC through November 2015 and NMFS Permits and Conservation Division's issuance of a Letter of Authorization to allow the U.S. Navy to "take" marine mammals incidental to these activities. As provided in 50 CFR 402.16, reinitiation of formal consultation is normally required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, Action Agencies are normally required to reinitiate Section 7 consultation immediately.

12 DATA QUALITY ACT

Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (Public Law 106-554, AKA the Data Quality Act or Information Quality Act) directed the Office of Management and Budget (OMB) to issue government-wide guidelines that "provide policy and procedural guidance to federal agencies for ensuring and maximizing the quality, objectivity, utility, and integrity of information (including statistical information) disseminated by federal agencies." OMB complied by issuing guidelines which direct each federal agency to 1) issue its own guidelines; 2) establish administrative mechanisms allowing affected persons to seek and obtain correction of information that does not comply with the OMB 515 Guidelines or the agency guidelines; and 3) report periodically to OMB on the number and nature of complaints received by the agency and how the complaints were handled. The OMB Guidelines can be found at:

http://www.whitehouse.gov/omb/fedreg/reproducible2.pdf

The Department of Commerce Guidelines can be found at:
http://ocio.os.doc.gov/ITPolicyandPrograms/Information_Quality/index.htm

The NOAA Section 515 Information Quality Guidelines, created with input and reviews from each of the components of NOAA Fisheries, went into effect on October 1, 2002. The NOAA Information Quality Guidelines are posted on the NOAA Office of the Chief Information Officer Webpage. http://www.cio.noaa.gov/Policy_Programs/info_quality.html

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