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

Agencies: National Marine Fisheries Service (NMFS), with the United States Navy (U.S. Navy) as Action Agency and Applicant for a Federal Authorization

Activities Considered: The U.S. Navy's proposed military readiness activities on the Northwest Training Range Complex from November 2012 through November 2015

The regulations governing the U.S. Navy's "take" of marine mammals incidental to the military readiness activities on the Northwest Training Range from November 2010 to November 2015

NMFS' issuance of a Letter of Authorization for the U.S. Navy to "take" marine mammals incidental to the military readiness activities on the Northwest Training Range Complex from November 2012 to November 2015

Consultation Conducted by: Endangered Species Act Interagency Cooperation Division of the Office of Protected Resources, National Marine Fisheries Service

Approved by: _____ **Date:** OCT 16 2012

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)).

For the actions described in this document, the action agencies are the U.S. Navy, which proposes to undertake research, development, test and evaluation (military readiness) activities at the Northwest Training Range Complex through November 2015 and NMFS' 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 and (2) proposes to issue a Letter of Authorization (LOA) pursuant to the regulations that would authorize the U.S. Navy to "take" marine mammals incidental to those military readiness activities from November 2012 through November 2015.

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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 proposes to undertake military readiness activities at the Northwest Training Range from November 2012 to November 2015 and NMFS Office of Protected Resources – Permits and Conservation Division (Permits Division), which has (1) promulgated regulations under the Marine Mammal Proection Act (MMPA) governing the U.S. Navy's "take" of marine mammals incidential to those military readiness activities through November 2015 and (2) proposes to issue a Letter of Authorization (LOA) pursuant to the regulations, as revised in February 2012, that would authorize the U.S. Navy to "take" marine mammals incidental to those military readiness activities from November 2012 to November 2015. The consulting agency for these proposals is NMFS Office of Protected Resources - Endangered Species Act Interagency Cooperation Division (ESA IC)[1].

The biological opinion and incidental take statement were prepared by NMFS Endangered Species 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' 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 June 15, 2010 Programmatic Biological Opinion described in more detail below, which is incorporated by reference.

[1] In October 2011 NMFS Office of Protected Resources underwent a reorganization that created the Endangered Species Act Interagency Cooperation Division out of the former Endangered Species Division.

1.1 Background

The U.S. Navy began work toward compliance with Federal environmental protection regulations at their Northwest Training Range Complex with the development of an Environmental Impact Statement (EIS) pursuant to the National Environmental Policy Act (NEPA). Since that effort in 2008, the Navy has worked with NMFS on authorizations under the MMPA that include the issuance of Federal regulations that initially allowed NMFS to issue annual Letters of Authorization to the Navy for the incidental "take" of marine mammals. The Navy also sought compliance with the ESA for species protected under its provisions. The general history of the initial and subsequent annual compliance documents are shown in Table 1. In February 2012, NMFS Permits Division amended the Federal regulation under MMPA to allow for the issuance of multi-year Letters of Authorization (77 FR 4917) (Table 1). While the original five-year final rule analyzed annual LOAs, issuance of multi-year LOAs does not change the analyses of marine mammal impacts conducted, nor increase the level of "take" authorized in the original final rule.

NMFS has issued multi-year Letters of Authorization for Navy training activities at the Southern California Range Complex (77 FR 6084, Feb. 7, 2012); Naval Surface Warfare Center Panama City Division (77 FR 9628, Feb. 17, 2012); Hawaii Range Complex (77 FR 11067, Feb. 24, 2012); Gulf of Mexico Range Complex (77 FR 17033, Mar. 23, 2012); Keyport Range Complex (77 FR 30996, May 24, 2012); Cherry Point, Virginia Capes, and Jacksonville Range Complexes (77 FR 31333, May 25, 2012); and Mariana Islands Range Complex (77 FR 46733, Aug 6, 2012). The submission of annual monitoring and exercise reports by the Navy allows NMFS to accurately track the military readiness activities and ensure that the multi-year LOAs issued by NMFS and the impacts of the military readiness activities on marine mammals remain within what was analyzed and authorized under the 5-year regulations. NMFS also requires annual adaptive management meetings with the Navy.

Table 1. Procedural history of U.S. Navy's compliance under the Endangered Species Act (ESA) for training in the Northwest Training Range Complex.

Date	Entity	Item
Jan 2009	U.S. Navy	ESA Biological Evaluation
Jul 2009	U.S. Navy	Draft Environmental Impact Statement/Overseas Environmental (Navy 2009)
Oct 2009	U.S. Navy	Updated ESA Biological Evaluation
13 Jul 2009	NMFS Permits Division	Published proposed Marine Mammal Protection Act (MMPA) regulations
18 Mar 2010	NMFS Permits Division	Published final rule
15 Jun 2010	NMFS ESA IC Division	Issued Biological Opinion on 2010-2015 MMPA regulations (50 CFR § 218.110)
Sep 2010	U.S. Navy	Final Environmental Impact Statement/Overseas Environmental Statement
25 Oct 2010	U.S. Navy	Record of Decision
4 Nov 2010	NMFS Permits Division	Final draft of 1st annual LOA
10 Nov 2010	NMFS Permits Division	Published final MMPA regulations
12 Nov 2010	NMFS ESA IC Division	Issued ESA Biological Opinion on 2010-2011 LOA and Navy's proposed activities
24 Jun 2011	U.S. Navy	Request for renewal of 2011-2012 LOA
5 Aug 2011	NMFS Permits Division	Request for ESA consultation on 2011-2012 LOA
7 Nov 2011	NMFS Permits Division	Final draft of 2011- 2012 LOA
9 Nov 2011	NMFS ESA IC Division	Issued ESA Biological Opinion on 2011-2012 LOA and Navy's proposed activities
1 Feb 2012	NMFS Permits Division	Amended MMPA regulations to allow for multi-year LOA (77 FR 4917)

1.2 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 Northwest Training Range Complex over a five-year period beginning in June 2010 and ending in June 2015; (3) NMFS' Permits, Conservation, and Education Division's (Permits 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 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 Northwest Training Range Complex.[2]

On 10 November 2010, NMFS' Permits Division published final regulations to allow the U.S. Navy to "take" of marine mammals incidental to military readiness activities on the Northwest Training Range Complex from November 2010 through November 2015, 75 FR 69296.

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

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

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

On 3 August 2012, the U.S. Navy submitted a request to NMFS Permits Division for renewal of their LOA for November 2012 through November 2015 which, if issued, would cover the remaining effective period of the five-year "take" regulations for the Northwest Training Range Complex.

On 4 September, 2012, NMFS Permits Division provided NMFS ESA IC Division with a copy of the draft LOA it proposed to issue to the U.S. Navy for military readiness activities on the Northwest Training Range Complex.

On 24 September 2012, NMFS Permits Division provided NMFS ESA IC Division with a copy of the final draft LOA it proposed to issue to the U.S. Navy for military readiness activities on the Northwest Training Range Complex

[2] 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.

On 24 September and 4 October 2012, NMFS ESA IC Division provided a draft of this Opinion to the Permits Division and the U.S. Navy, respectively. Comments were received from the Navy on 5 October 2012.

2 DESCRIPTION OF THE ACTIVITIES CONSIDERED

This Opinion addresses: (1) the U.S. Navy's proposal to continue military readiness activities on the Northwest Training Range Complex from 12 November 2012 through 9 November 2015; (2) the regulations promulgated by NMFS Permits Division under the MMPA governing the U.S. Navy's "take" of marine mammals incidental to those military readiness activities from November 2010 through November 2015; and (3) NMFS Permits Division's proposal to issue a LOA pursuant to the regulations that would authorize the U.S. Navy to "take" marine mammals incidental to military readiness activities on the Northwest Training Range Complex (authorized by 50 CFR § 218.110) through November 2015. This Opinion also updates and supplements the June 15, 2010 Programmatic Biological Opinion on the MMPA rulemaking for the Northwest Training Range Complex, which is incorporated by reference.

The purpose of the activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex 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 Division's proposed LOA is to allow the U.S. Navy to "take" marine mammals incidental to military readiness activities on the Northwest Training Range Complex conducted through November 2015 in a manner that is protective of those marine mammals.

The following narratives summarize the information the U.S. Navy provided on the various military readiness activities it plans to conduct from November 2012 through November 2015 pursuant to the five-year MMPA regulations and the proposed LOA. The Navy is not proposing to conduct any sinking exercises (SINKEX), which is a change from the action as proposed in previous years and a reduction in the scope of activities evaluated in the June 15, 2010 Programmatic Biological Opinion, which anticipated that the Navy would perform two sinking exercises per year. The tempo of training within the Northwest Training Range Complex is subject to variation within the scope of the activities described in the Navy's Northwest Training Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement and this biological 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 Northwest Training Range Complex; 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 Northwest Training Range Complex is not expected to exceed the amount identified in Table 2 during the time period of this authorization. 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 from 2012 to 2015.

2.1 Activities Not Likely to Affect ESA-listed Resources

On 15 June 2010, NMFS issued a Programmatic Biological Opinion that assessed the probable direct and indirect effects of the U.S. Navy's military readiness activities on the Northwest Training Range Complex (the entire list of activities are presented in Table 2). That opinion concluded that several of the activities the U.S. Navy plans to conduct on the Northwest Training Range Complex 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' 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' 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' 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' 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' 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' 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' 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' 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. The best information available leads us to conclude that endangered and threatened species are not likely to be exposed to the technologies associated with these training activities and, if exposed, they are not likely to respond to that exposure.

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 1) 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. The best information available leads us to conclude that endangered and threatened species are not likely to be exposed to the technologies associated with these training activities and, if exposed, they are not likely to respond to that exposure.

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 Areas. The best information available leads us to conclude that endangered and

threatened species are not likely to be exposed to the technologies associated with these training activities and, if exposed, they are not likely to respond to that exposure.

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. The best information available leads us to conclude that endangered and threatened species are not likely to be exposed to the technologies associated with these training activities and, if exposed, they are not likely to respond to that exposure.

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 Northwest Training Range Complex 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. The best information available leads us to conclude that endangered and threatened species are not likely to be exposed to the technologies associated with these training activities and, if exposed, they are not likely to respond to that exposure.

2.2 Activities that are Likely to Adversely Affect Listed Resources

Below we summarize the remaining training operations the U.S. Navy plans to conduct on the Northwest Training Range Complex. Table 2 (which begins on page 15) 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 Northwest Training Range Complex 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 from November 2012 through November 2015 in the Northwest Training Range Complex.

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 Northwest Training Range Complex.

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 Northwest Training Range Complex.

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 Area of the Northwest Training Range Complex. The U.S. Navy plans to conduct about 4 of these training events annually, in the Northwest Training Range Complex.

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 proposes to conduct about 210 events per year. All of these events would occur in the Offshore Area of the Northwest Training Range Complex.

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.

Before 2014, 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 has been delayed until mid-2013. Deployment would begin with east coast squadrons. Deployment in the Northwest Training Range Complex is not expected in 2013, but could 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 proposes to conduct about 12 events per year. All of these events would occur in the Offshore Area of the Northwest Training Range Complex.

2.2.7 Anti-Submarine Warfare Tracking Exercise, Surface Ship

The U.S. Navy proposes to conduct about 26 training events annually involving guided-missile destroyers and 39 training events annually involving guided-missile frigates on the Northwest Training Range Complex. 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 proposes to conduct about 100 of these training events annually from November 2012 through November 2015 on the Northwest Training Range Complex.

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 proposes to conduct about 30 events annually in the Northwest Training Range Complex.

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 proposes to conduct a total of about 3,000 events annually in the Northwest Training Range Complex, 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.

From November 2012 through November 2015, the U.S. Navy does not plan to conduct sinking exercises in the Northwest Training Range Complex. However, because this activity was included in the MMPA rule, we retained the activity description and the analysis in this biological opinion.

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 proposes to conduct about 110 detonations annually on the Explosive Ordnance Disposal ranges in the Northwest Training Range Complex.

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. Specifically, Explosive Ordnance Disposal units conduct underwater detonation training at Crescent Harbor, Indian Island, and Hood Canal. In the two previous LOAs, these units used 2.5-lb charges of C-4 to produce one surface or one subsurface detonation, although only one detonation took place per activity, and only one activity occurred in any one day.

The Navy proposes to change 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 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 would 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 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 Northwest Training Range Complex 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 Northwest Training Range Complex.

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 Northwest Training Range Complex.

2.2.16 Range Enhancements

The U.S. Navy proposes to develop 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 Northwest Training Range Complex 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 places 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 plans to install a fixed, land-based electronic warfare emitter on or near the Pacific Coast of the Northwest Training Range Complex to facilitate electronic

combat training for ships at-sea, submarines, aircraft, and multi-axis threat training for aircraft (when combined with the existing electronics warfare emitter at Outlying Landing Field Coupeville or electronic combat threat simulation requirements of contract air-target or surface-target services). One of the sites the U.S. Navy is considering for one of these emitters is located at Pacific Beach, Washington; we have no information on alternative sites the U.S. Navy might be considering.

The U.S. Navy proposes to install 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 proposed system would temporarily instrument 25-square-mile or smaller areas on the seafloor, and would consist 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 would be either concrete or sand bags, which would be approximately 1.5 ft-by-1.5 ft and would weigh approximately 300 pounds. When training is complete, the U.S. Navy plans to recover the undersea tracking range . No on-shore construction would take place.

Range tracking pingers would be 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 would be in use for 3 hours each during portable undersea tracking range operational days.

Table 2. Activities the U.S. Navy proposes to conduct in the Northwest Training Range each year over the next three years (adapted from Table 2-9, U.S. Navy 2008d).

Range Operation	Platform	System or Ordnance	Proposed Action	Location
ANTI-AIR WARFARE				
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				
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)		

Range Operation	Platform	System or Ordnance	Proposed Action	Location
ANTI-SURFACE WARFARE				
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	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	

Range Operation	Platform	System or Ordnance	Proposed Action	Location
	Guided missile destroyer		50 events	
	Guided missile frigate		100 events	
	Fast combat support ship		25 events	
	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	Offshore Area
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

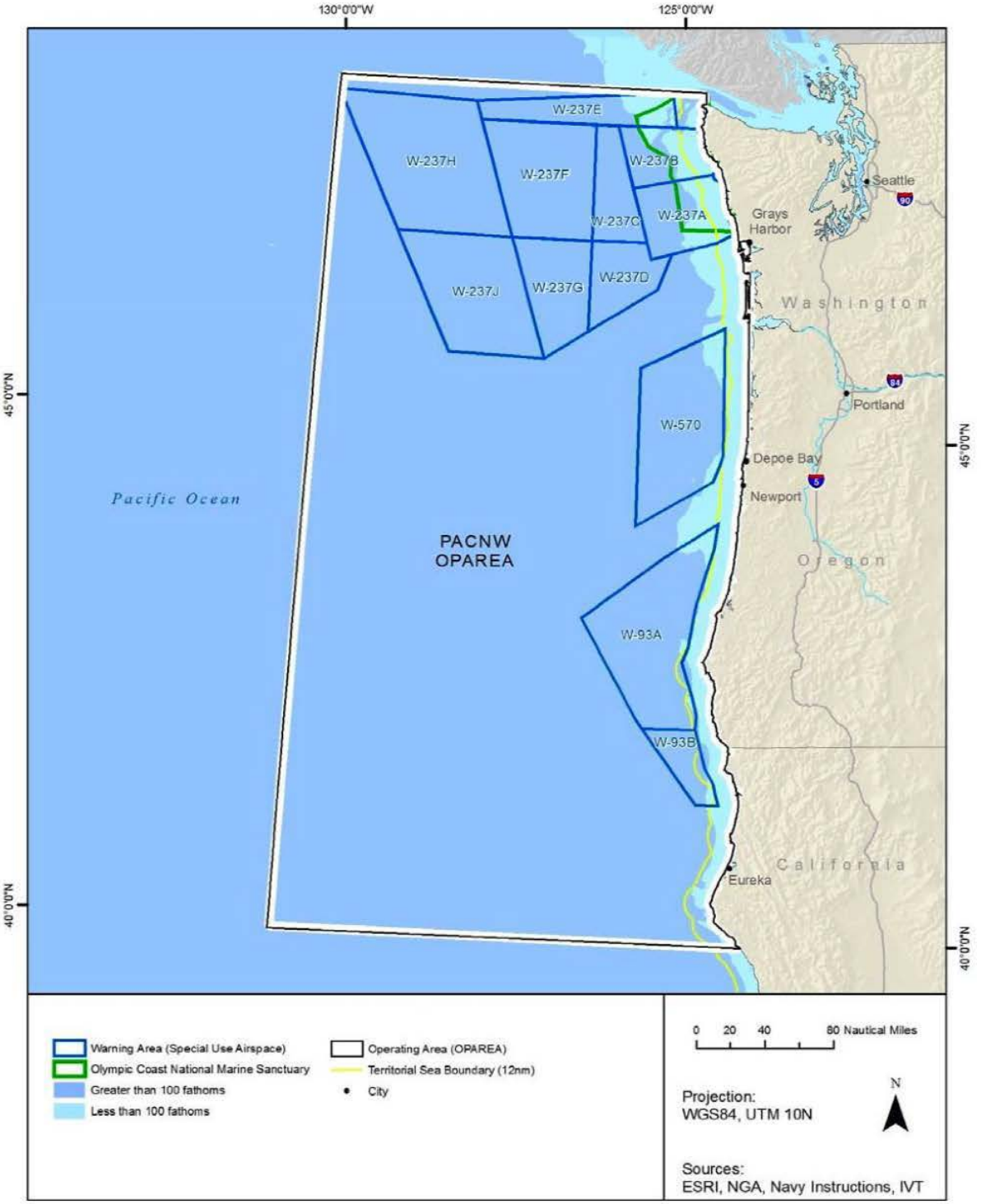

Figure 1. The offshore areas of the Northwest Training Range Complex.

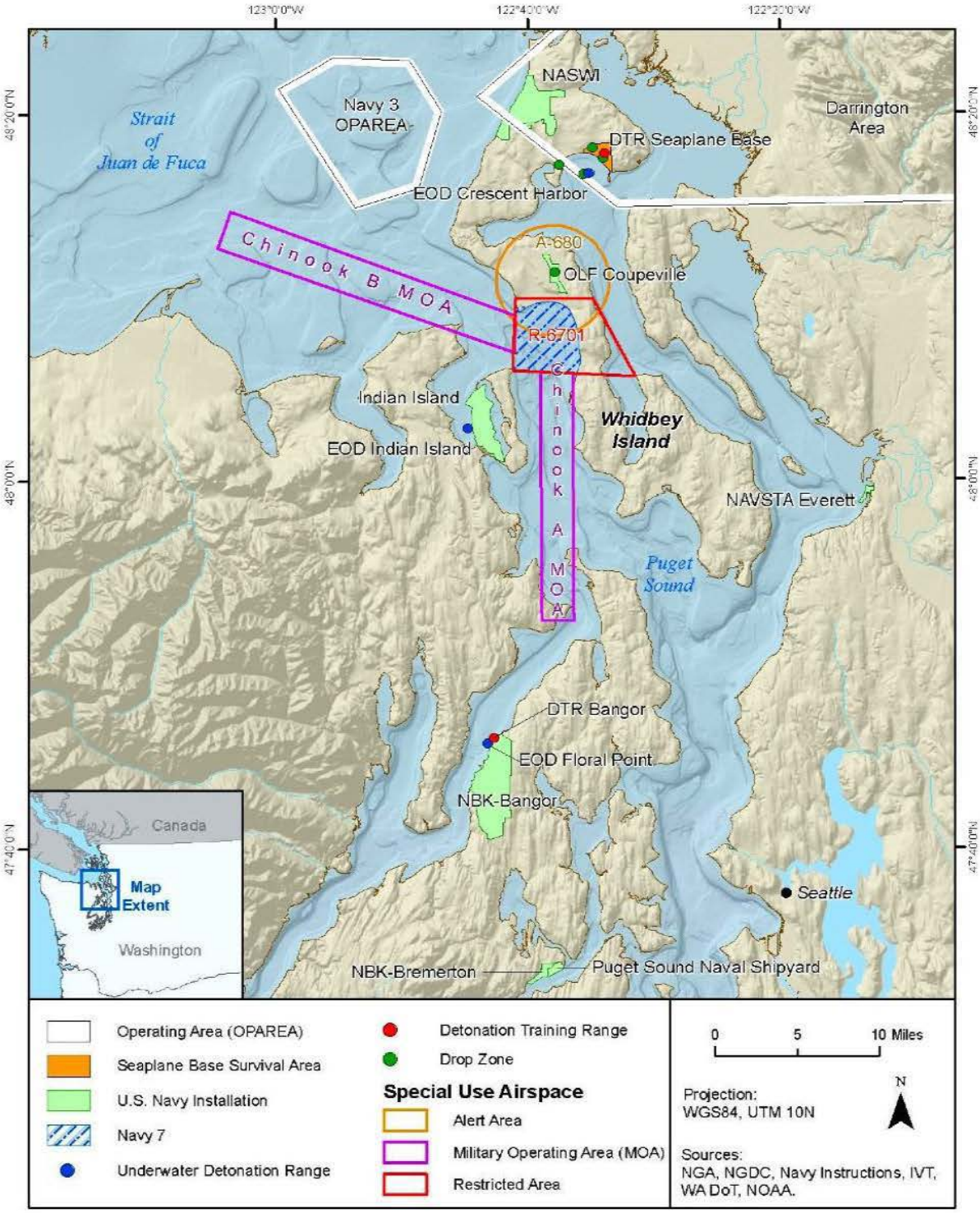

Figure 2. The Puget Sound training areas of the Northwest Training Range Complex.

2.3 Scope of the MMPA Requirements

NMFS' Permits Division finalized regulations (50 CFR § 218.110 et seq.) that authorize the U.S. Navy's "take" of marine mammals (a) within the U.S. Navy's Northwest Training Range Complex, 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 Mitigation Measures Proposed by the U.S. Navy

As required to satisfy the requirements of the MMPA, the U.S. Navy's proposes to implement 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 proposed exercises, readers should refer to the U.S. Navy's request for a LOA to "take" marine mammals incidental to military readiness activities on the Northwest Training Range Complex and the Permit Division's MMPA regulations for those activities.

The U.S. Navy proposes 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.

2.4.1 General Maritime

The following mitigation measures would apply during general maritime activities.

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.

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.

2.4.2 Measures for Specific Training Events

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

Mid-Frequency Active Sonar Training Activities

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.

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.

Operating Procedures

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

2.4.3 Underwater Detonations

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.

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.

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.

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.

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).

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 method.

(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.

2.5 Mitigation Required by NMFS Permits Division

NMFS Permits Division requires that the U.S. Navy, as the holder of the LOA, implement the above proposed 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 Northwest Training Range Complex.

2.6 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 proposed notification measures above.

(d) The Navy must conduct all monitoring and required reporting under the LOA, including abiding by Northwest Training Range Complex 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 Northwest Training Range Complex Monitoring Plan Report – The Navy shall submit a report on July 1, 201x describing the implementation and results (through May 1, 201x of the same year) of the Northwest Training Range Complex 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 Northwest Training Range Complex Monitoring Plan shall, at a minimum, provide the same marine mammal observation data required in 50 CFR § 218.115(g)(1). The Northwest Training Range Complex 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 Northwest Training Range Complex Exercise Report – The Navy shall submit an Annual Northwest Training Range Complex Exercise Report on July 1, 201x (covering data gathered through May 1, 201x). 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 Northwest Training Range Complex. The Navy shall include (in the Northwest Training Range Complex 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 Northwest Training Range Complex

(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 Northwest Training Range Complex Range.

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

(h) Northwest Training Range Complex 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 Northwest Training Range Complex Exercise Reports and Northwest Training Range Complex 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 – By June, 2014, the Navy shall submit 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 Northwest Training Range Complex, and the Gulf of Alaska.

(j) The Navy shall respond to NMFS any comments and/or requests for additional information or clarification on the Northwest Training Range Complex Comprehensive Report, the Comprehensive National ASW report, the Annual Northwest Training Range Complex Exercise Report, or the Annual Northwest Training Range Complex Monitoring Plan Report (or the multi-Range Complex Annual Monitoring Plan Report, if that is how the Navy chooses to submit the information) within 3 months of receipt. 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.

2.7 Activities Under Previous LOAs

Here we provide information regarding the U.S. Navy's activities under the 2010-2011 and 2011-2012 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.

2.7.1 Activities Conducted

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 Northwest Training Range Complex (Navy 2011; Navy 2012b). 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 2012b).

2.7.2 Activities Not Conducted

The Navy did not conduct the following activities under the 2010-2011 or 2011-2012 LOAs and biological opinions (Navy 2011; Navy 2012b):

- Training events involving explosives (Explosive Ordnance Disposal underwater detonation);
- Sinking exercises (SINKEX)
- Installation of the Portable Undersea Tracking Range (PUTR);
- Installation of the underwater training minefield (non-explosive).

2.7.3 Actual Take of ESA-listed Species

Previous biological opinions on the issuance of the annual LOAs (NMFS 2010b; NMFS 2011) included Incidental Take Statements that provided estimates of the "take" of ESA-listed species. In their request package for this ESA consultation (Navy 2012c), the Navy provided a summary of the take estimate from the 2010 and 2011 Incidental Take Statements along with an estimate of actual take of ESA-listed species for each of the two previous LOA periods (Table 3). This post-calculation take estimate is based on the assumption that use of a given sonar system or explosive event as reported in the classified Exercise Report could potentially generate exposures that result in "takes" under the ESA. Model limitations do not factor in small scale animal movement, animal avoidance, regional distribution other than potential presence, or exposure

limiting effects from Navy mitigation measures or location of actual training in one part of the range vice another (Table 3) (Navy 2012c).

Table 3. The U.S. Navy's post-calculation take estimates of ESA-listed species based on actual sonar system usage and explosive events for 2010-2011 and 2011-2012 authorization periods and the number of each species estimated to be taken in each annual Incidental Take Statement (ITS) (Navy 2012c).

Species	2010-2011 ITS	Estimated Actual Take	Percent of Authorized Take	2011-2012 ITS	Estimated Actual Take	Percent of Authorized Take
Blue Whale	17	0	0%	17	2	12%
Fin Whale	62	0	0%	70	8	12%
Humpback Whale	26	0	0%	15	2	13%
Sei Whale	7	0	0%	1	0	0%
Sperm Whale	128	1	1%	128	18	14%
Killer Whale	2	0	0%	14	2	14%
Steller sea lion	117	2	2%	120	17	14%
Puget Sound Chinook Salmon	14	0	0%	25	0	0%
Hood Canal summer-run Chinook Salmon	27	0	0%	108	0	0%

The 2010 Programmatic Biological Opinion and 2010 LOA Biological Opinion estimated that 14 blue whales would be "harassed" as a result of their exposure to mid-frequency active sonar, although 17 blue whales were expected to be "taken" each year. In contrast, the Incidental Take Statement of the 2011 biological opinion estimated that 15 blue whales would be "harassed" as a result of their exposure to mid-frequency active sonar with a total of 17 blue whales "taken" by both mid-frequency active sonar and underwater detonations. These differences resulted from different approaches that were used to round values less than 1.0, which did not affect the total number of blue whales expected to be "taken."

The Incidental Take Statement in our 2011 LOA Biological Opinion estimated that 102 southern resident killer whales would be exposed to mid-frequency active sonar and two southern resident killer whales would be "taken" as a result of their exposure to mid-frequency active sonar.

The estimates contained in the Incidental Take Statement of the 2011 biological opinion were incorrect because they mirrored the "take" of killer whales that was authorized by the 2011 LOA, which did not distinguish between the "take" of southern resident killer whales and the "take" of all other killer whales. The 2010 Programmatic Biological Opinion, the 2010 LOA Biological

Opinion, and the Effects of the Action chapter of the 2011 biological opinion presented the correct estimates of the number of southern resident killer whales that would be "taken" as a result of the exposure to mid-frequency active sonar: two of the 14 killer whales whose "take" was authorized by the 2011 LOA would be southern resident killer whales.

The actual take of listed species during the first two LOAs that addressed activities over the initial two years of the MMPA regulations was substantially below the levels considered in the LOA Biological Opinions. The highest estimated proportion of take over the previous two years was 14 percent of the take estimate of sperm whales and killer whales. The killer whale take estimate in the 2011 Incidental Take Statement were in error as noted above, and based on the Navy's actual take for 2011, the Navy did not exceed the take level analyzed in the Effects of the Action section of the 2011 Biological Opinion (NMFS 2011). Further, the Navy's actual activities from 2010-2012 were well below the take analyzed in the 2010 Programmatic Biological Opinion which covers the full 5-years of the MMPA rule.

Consistent with what was anticipated in the previous biological opinion analysis, there were no Navy ship strikes to any listed species within the Northwest Training Range Complex from 2010 through 2012 (Navy 2012c).

2.7.4 Monitoring

The U.S. Navy provided the following summary of monitoring related to the Northwest Training Range Complex training activities:

Two High-frequency Acoustic Monitoring Packages (HARPs) from the Scripps Institute of Oceanography were deployed and provided continuous monitoring within the offshore marine waters of Washington State.

One HARP was deployed in January 2011 along the central coast of Washington State in the southern part of the Olympic Coast National Marine Sanctuary. Scripps has deployed HARPs in the same approximate location periodically since 2004 (Oleson et al. 2009). A second HARP under the Northwest Training Range Monitoring Plan was deployed in May 2011 near the edge of an underwater canyon west of the Olympic Coast National Marine Sanctuary boundary (Širović et al. 2012). These devices placed on the ocean floor record marine mammal vocalizations and anthropogenic sounds on internal hard drives that must be retrieved during field service calls approximately every 8-9 months. Both HARPs were field serviced in early December 2011. Data was collected from the HARPs and returned to Scripps for analysis, and the HARPs were redeployed at the same locations. Passive acoustic analysis from the two Navy funded Northwest Training Range Complex monitoring HARPs is presented in the Navy's Year 2 Monitoring Report (Navy 2012b) covering the period from January 2011 to November 2011.

Over 10,617 hours of passive acoustic data were recorded (6,552 hours at HARP-QC and 4,065 hours at HARPCE)(Navy 2012c). Subsequent analysis confirmed detection of three baleen whale species to include blue whales, fin whales, and humpback whales; nine toothed whale species; and anthropogenic sounds dominated by shipping noise (Širović et al. 2012).

The Navy reported that they purchased 10 satellite tracking tags for deployment by Cascadia Research Collective on a suite of marine species within the offshore waters of the Northwest Training Range Complex. The tags used were the Andrews-style LIMPET (Low Impact Minimally Percutaneous External Transmitter), in either the location-only Spot5 configuration or the location/dive data Mk10-A configuration (Wildlife Computers, Redmond, Washington) (Navy 2012c). Tags were programmed to species-specific, transmission schedule-based surfacing behavior and transmission data from previous deployments. Tags transmit animal movement data via the Argos satellite system.

The commercial Argos system consists of data acquisition and relay equipment attached to National Oceanic and Atmospheric Administration (NOAA) low-orbiting weather satellites and ground-based receivers and data processing systems.

The Navy purchased these satellite tracking tags as part of the Northwest Training Range Complex monitoring. However, the tags were deployed opportunistically during field efforts associated with a grant from the NMFS' Alaska Regional Office for fin whale research, a collaborative project with the Washington Department of Fish and Wildlife (WDFW) addressing marine mammal distribution and habitat use off Oregon and Washington (Schorr et al. 2012 at appendix in Navy 2012c).

The species of interest in this 3-year joint field project are endangered cetaceans such as blue whales, fin whales, humpback whales, and sperm whales, but may also include high priority cetaceans such as beaked whales, in the event they are encountered in favorable tagging conditions. Other species of interest for tagging could also include seasonal resident gray whales and transient or offshore killer whales (Navy 2012a; Navy 2012c).

Three fin whales and one humpback whale were tagged using Navy funded tags off the Washington coast in 2011. A total of approximately 43 days of animal movement data were obtained. The Navy's Year 2 (2011-2012) Northwest Training Range Complex Monitoring Report shows the tagging results for May 2011 to May 2012 field work (Navy 2012a).

2.8 Action Area

The action area for this Opinion encompasses waters within and adjacent to the U.S. Navy's Northwest Training Range Complex. This consists of two primary components: the Offshore

Area and the Inshore Area (see Figure 1 and Figure 2). 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 Northwest Training Range Complex encompass 122,440 square nautical miles (420,163 square kilometers [km^2]) of surface and subsurface ocean operating areas, 46,048 nm^2 (157,928 km^2) of special use airspace, 367 nm^2 (1,258 km^2) of Restricted Airspace and 875 acres (354 hectares) of land.

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

3 APPROACH TO THE ASSESSMENT

NMFS uses a series of steps to identify and analyze those aspects of proposed actions that are likely to have direct and indirect effect on the physical, chemical, and biotic environment of an action area. The steps include the identification of potential stressors, which includes defining the spatial extent of any potential stressors, including the degree to which the spatial extent of those stressors may change with time (the spatial extent of these stressors is the "action area" for a consultation).

The second step is determining whether endangered species, threatened species, or designated critical habitat are likely to occur in the same space and at the same time as these potential stressors. If such co-occurrence is likely, then the nature of that co-occurrence is estimated (these represent our exposure analyses). 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 an Action's stressors and the populations or subpopulations those individuals represent.

Once we identify which listed resources (endangered and threatened species and designated critical habitat) are likely to be exposed to potential stressors associated with an action and the nature of that exposure, in the third step of our analyses we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our response analyses) (see Section 5). The final steps of our analyses — establishing the risks those responses pose to listed resources — are different for listed species and designated critical habitat (these represent our risk analyses) (see Section 5).

3.1 Potential Stressors

NMFS has identified several aspects of the proposed 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.

3.2 Exposure

Exposure analyses are designed to identify the listed resources that are likely to co-occur with these potential effects in space and time and the nature of that co-occurrence. This exposure analyses was designed to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an Action's effects and the populations or subpopulations (or other sub-divisions of "populations," including demes, runs, or races) those individuals represent.

NMFS generally relies on an action agency's estimates of the number of ESA-listed animals that might be "taken" as a result of their proposed action if an estimate is provided. However, in

some cases we may develop our own estimate of the number of listed animals that might be "taken." In this consultation, the number of marine mammals that might be "taken" (as that term is defined for the purposes of the MMPA) was estimated by the Navy (and that estimate carried forward by NMFS Permits Division). We also independently estimated potential "take" of other listed species, such as sea turtles and salmonid species that may be exposed to the Navy's military readiness activities.

In addition to considering the provided estimate of marine mammals that might be "taken", we used a model based on components of Holling's disc equation (Holling 1959) to independently estimate the number of marine mammals that might be exposed to some of the Navy training activities that satisfied the following conditions; first, the sole or primary stressor was hull-mounted mid-frequency active sonar; and second, data were available on the density of endangered or threatened animals in an action area, the ship's speed, the radial distance at which different received levels would be detected from a source given sound speed profiles, and the duration of specific training exercises.

These conditions have been met in less than one fourth of the consultations NMFS has completed on Navy training since 2002 (for example, opinions on anti-submarine warfare training on the Navy's Hawai'i Range Complex and Southern California Range Complex) so NMFS conducted independent exposure analyses and included the results of those analyses in Biological Opinions on those actions. In the remaining consultations, hull-mounted mid-frequency active sonar was not the primary stressor associated with proposed training or the data for one of the model's variables were not available.

In this Opinion, we considered the following approaches to estimate the number of whales that might interact with sound fields associated with mid-frequency active sonar in the Northwest Training Range Complex:

1. The first method was developed by the U.S. Navy and the NMFS Permits Division to estimate "take" (as that term is defined pursuant to the MMPA) for the application of authorization to "take" marine mammals incidental to training activities pursuant to the MMPA and to analyze potential effects in the Environmental Impact Statement prepared by the U.S. Navy and NMFS' Permits Division for proposed U.S. Navy activities in the Northwest Training Range Complex. NMFS Permits Division's incidental "take" authorizations in the 5-year regulations reflect these "take" estimates.

2. The second method is an exposure model developed by NMFS ESA IC Division using components of an established ecological model (the Hollings' disc equation) to estimate the number of endangered and threatened marine mammals that are likely to be exposed

to active sonar during proposed U.S. Navy activities in the Northwest Training Range Complex (the data necessary to estimate the number of sea turtles and fishes that might be exposed to active sonar was not available).

The first approach was designed to estimate the number of times marine mammals might be "taken" (as that term is defined pursuant to the MMPA) as a result of being exposed to active sonar or underwater detonations during U.S. Navy training, which is a subset of the number of animals that might be exposed to those training activities or respond given exposure. Although the U.S. Navy's modeling efforts and the results of NMFS Permit Division exposure models may produce similar numerical results to our analysis, the U.S. Navy and NMFS Permits Division estimates are based on the number of times marine mammals might be 'taken' given that they have been exposed and respond to that exposure. Our estimates only consider the number of times marine mammals might be exposed to those activities.

3.2.1 U.S. Navy Exposure Estimates for the Proposed Actions

In 2010, the U.S. Navy updated its approach to estimating the number of marine mammals that might be exposed to activities conducted on U.S. Navy training ranges. What follows is a brief summary of the Navy's current approach (for more details, refer to Appendix F of the U.S. Navy's Final Environmental Impact Statement on the Northwest Training Range Complex) (Navy 2010).

The U.S. Navy's updated approach focuses on a suite of representative provinces based on sound velocity profiles, bathymetries, and bottom types. Within each of these provinces, the U.S. Navy modeled transmission losses in 5 meter increments and used the results to build sound fields (based on maximum sound pressure levels). The U.S. Navy then calculates an "impact volume," which is the volume of water in which an acoustic metric exceeds a specified threshold; in this case, the Navy used one of three acoustic metrics: energy flux density (in a limited band or across a full band), peak pressure, or positive impulse. By multiplying these "impact volumes" by estimates of animal densities in three dimensions (densities distributed by area and depth), the U.S. Navy estimated the expected number of animals that might be exposed to an acoustic metric (energy flux density, peak pressure, or positive impulse) at levels that exceed thresholds that had been specified in advance. Specifically, the U.S. Navy calculated impact volumes for sonar operations (using energy flux density to estimate the probability of injury), peak pressure, and a Goertner modified positive impulse (for onset of slight lung injury associated with explosions).

To calculate "impact volumes," the U.S. Navy used a "risk continuum" or a curve that the U.S. Navy and NMFS developed that relates the probability of a behavioral response given exposure to a received level that is generally represented by sound pressure level, but included sound exposure level to deal with threshold shifts. The risk continuum, which the U.S. Navy and

NMFS' Permits Division adapted from a mathematical model presented in Feller (1968), was estimated using three data sources: (1) data from controlled experiments conducted at the U.S. Navy's Space and Naval Warfare Systems Center in San Diego, California (Finneran et al. 2003; Finneran et al. 2001; Finneran et al. 2005; Finneran and Schlundt. 2004; Schlundt et al. 2000), (2) data from a reconstruction of an incident in which killer whales were probably exposed to mid-frequency active sonar (Fromm 2004), and (3) a suite of studies of the response of baleen whales to low-frequency sound sources (Nowacek et al. 2004). The U.S. Navy and NMFS' Permits Division estimated the proportion of a population that is expected to exhibit behavioral responses that NMFS' would classify as "take" (as that term is defined by the MMPA) by multiplying the different "impact volumes" at particular received levels by the "risk continuum."

This approach would also tend to overestimate the number of marine mammals that might be exposed, because marine mammals are highly mobile and are likely to use their mobility to avoid stimuli like active sonar, just as they avoid vessel traffic. Consequently, the results of this approach would be conservative, in the sense that they would tend to overestimate the number of animals that are likely to be "taken" by the activities the U.S. Navy plans to conduct in the Northwest Training Range Complex.

3.2.2 NMFS' Exposure Estimates

Our jeopardy analyses must consider all potential effects of proposed actions, including direct or indirect beneficial and adverse effects that do not necessarily rise to the level of "take." For example, jeopardy analyses must consider the direct beneficial or adverse effects of actions on endangered or threatened individuals as well as indirect effects that result from how competitors, prey, symbionts, or the habitat of those listed individuals respond to an action. We cannot begin those analyses with estimates of the number of individuals that might be "taken" (as that term is defined by the MMPA) because our analyses must consider direct and indirect effects that do not necessarily represent one or more form of "take."

We conduct our jeopardy analyses by first identifying the potential stressors associated with an action, then we determine whether endangered species, threatened species, or designated critical habitat are likely to occur in the same space and at the same time as these potential stressors. If we conclude that such co-occurrence is likely, we then try to estimate the nature of that co-occurrence. These two steps represent our exposure analyses, which are designed to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent.

For our exposure analyses, NMFS developed a model to estimate the number of times endangered or threatened marine mammals might be exposed to active sonar or underwater detonations. The core of this model estimates the number of individuals that might be exposed

(N) as a function of an area (A) and the estimated density of animals (D) in that area. That is, N = D × A (Buckland 2001; Buckland and Borchers 1993), where, for the purposes of our analyses, A is the total area that would be ensonified by active sonar or contained within the pressure wave or sound field produced by an underwater detonation. A complete description of the model was provided in the 2010 Programmatic Biological Opinion (NMFS 2010c) and the biological opinion on the issuance of the 2010 LOA (NMFS 2010b). In applying this model, we relied on published sources of information and information contained in the U.S. Navy's *Northwest Training Range Complex Marine and Terrestrial Species Biological Evaluation* (Navy 2009b) (which itself relies on published sources) to estimate the density of endangered and threatened marine mammals in waters of the Northwest Training Range Complex.

The model was used to develop and simulate a scenario that assumed that marine mammal densities never changed and that animals did not move during the course of an exercise (this is the closest approximation of the U.S. Navy's models).

The exposure model we developed assumed ship speeds of 10 knots (or 18.25 km per hour), which is the same assumption contained in the Navy's models. The "sensory field" in the model represented the U.S. Navy's estimates of the area that would be ensonified at different received levels presented in the U.S. Navy's Northwest Training Range Complex Draft Environmental Impact Statements/Overseas Environmental Impact Statement adjusted to eliminate overlap (Navy 2008b). Our exposure model was also based on the Navy's estimates of the number of hours of the different kinds of active sonar that would be employed in the different exercises.

3.2.3 Response Analyses

Once we identified which listed resources were likely to be exposed to active sonar associated with the proposed training activities and the nature of that exposure, we examined the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure. Prior to this consultation, we developed, and then subsequently modified several times, a conceptual model that forms the foundation for our response analyses. Our revised model focuses animal behavior and behavioral decision-making, which incorporates the cognitive processes involved in behavioral decisions; earlier versions of this model ignored critical components of animal behavior and behavioral decision-making. A complete description of our model was provided in the 2010 Programmatic Biological Opinion (NMFS 2010c) and the biological opinion on the issuance of the 2010 LOA (NMFS 2010b).

Our revised model assumes that Navy training activities primarily affect endangered and threatened species by changing their behavior, although we continue to recognize the risks of physical trauma and noise-induced losses in hearing sensitivity (threshold shift). Second, we expanded our concept of "hearing" to include cognitive processing of auditory cues, rather than a

focus solely on the mechanical processes of the ear and auditory nerve. Third, our revised model incorporates the primary mechanisms by which behavioral responses affect the longevity and reproductive success of animals: changing an animal's energy budget, changing an animal's time budget (which is related to changes in an animal's energy budget), forcing animals to make life history trade-offs (for example, engaging in evasive behavior such a deep dives that involve short-term risks while promoting long-term survival), or changes in social interactions among groups of animals (for example, interactions between a cow and her calf).

Based on this model we use Bayesian inference for discrete random variables to estimate the probability of the proximate responses identified in our conceptual model given an exposure event from the data that were available (see Bolstad 2007 for an introduction to Bayesian inference). We employed this method because it allowed us to work with all of the data that are available with a minimum number of assumptions and to readily incorporate new data as it becomes available while providing transparency and analytical rigor. To satisfy the requirements of this method, our response analyses consisted of four steps:

Step A: Create a classification system that encompasses the entire suite of physical, physiological, and behavioral responses that have been reported in the literature.

Bayesian inference requires us to produce a set of variables that are exhaustive and mutually exclusive. To satisfy the first of these criteria, we conducted electronic and manual searches of the published and unpublished literature to identify reports of the physical, physiological, and behavioral responses of marine mammals, sea turtles, anadromous fish, and invertebrates when exposed to high-, mid-, and low-frequency anthropogenic acoustic stimuli. From each report, we recorded the different physical, physiological, behavioral, and social responses that were observed (Table 4, column 2). To satisfy the second of these criteria, we created a classification system that organized these responses into mutually-exclusive categories (see Table 4, column 3).

Table 4. Grouping of proximate responses into categories for response analyses.

	Proximate Response	Grouping for Bayesian Analysis
1	No response	No Response
2	Acoustic resonance	Physical Trauma
3	Noise-induced hearing loss (P)	Not used for formal analyses
4	Noise-induced hearing loss (T)	Not used for formal analyses
5	Reduced auditory field (reduced active space)	Not used for formal analyses
6	Signal masking	Not used for formal analyses
7	Increase call amplitude of vocalizations	Vocal Adjustments
8	Shift frequency structure of vocalizations	
9	Shift call duration of vocalizations	
10	Shift call rate of vocalizations	
11	Shift timing of vocalizations	
12	Physiological stress	Not used for formal analyses
13	Avoid sound field	Avoidance Response
14	Avoid received levels in sound field	
15	Abandon area of exercise	Evasive Response
16	Increase vigilance	Not used for formal analyses
17	Exhibit "disturbance" behavior	Behavioral Disturbance
18	Continue current behavior (coping)	No Response
19	Unspecified behavioral responses (adverse)	Unspecified behavioral responses (adverse)
20	Unspecified behavioral responses (not adverse)	Unspecified behavioral responses (not adverse)
21	Behaviors that cannot be classified	Not used for formal analyses

Step B: Systematically review the published and unpublished studies to identify reports of the response of marine mammals to active sonar exposure

Once we collected sources of data and other information we identified through our searches, we appraised the studies using two filters: study relevance and study quality. Relevance refers to the correspondence between the objectives, methods, and results of a source and the objectives of this systematic review. Study quality refers to the *internal validity*, *external validity*, *statistical conclusion validity*, and *conclusion validity* of the study. *Internal validity* refers to the validity of inferences about whether an experimental treatment or trial caused an outcome observed during a study.

We only included those studies that were relevant and satisfied our criteria for quality in our systematic review. From those studies we recorded the number of instances in which individual animals were reported to have exhibited one or more of these responses (records were entered into a database). For example, Nowacek et al.(2004) reported one instance in which North Atlantic right whales exposed to alarm stimuli did not respond to the stimulus and several instances in which right whales exhibited “disturbance” responses. We coded these two responses (no response and disturbance response) separately.

Step C: Use Bayesian analysis for discrete variables, using the data identified in Step 3, to estimate the probability of particular responses (given exposure).

Using data from the studies that we accepted into our systematic review (in Step B) we needed to estimate the probability that an animal would exhibit a particular response given the data ($R_i|D$). We employed Bayes' rule (Bolstad 2007) to estimate that probability because Bayesian analyses are one of the few methods available that allow investigators to estimate the probability of an hypothesis given data (rather than the probability of the data given an hypothesis, which is the traditional approach to hypothesis testing; (Baron 2008; Bolstad 2007; Hilborn and Mangel 1997):

$$\Pr(R_i \mid D) = \frac{\Pr(D \mid R_i) \times \Pr(R_i)}{\sum\left[\Pr(D \mid R_i) \times \Pr(R_i)\right]}$$

Where R_i represents the set of mutually exclusive and exhaustive physical, physiological, and behavioral responses (candidate responses) to an exposure with probabilities $Pr(R_i)$; D represents the number of times a particular response has been reported in the literature; and Pr(D|R) is the conditional probability of data given a particular response.

In this equation, $\Pr(R_i)$ on the right-hand side of the numerator, is called the *prior probability* of a response which is the probability of the different responses that we would have expected before we began our data analyses. We consider two prior probabilities in our analyses: (1) an uninformed prior, which assumed that responses in each of our response categories (Table 2, column 3) were equally probable, and (2) priors derived from the relative frequency of responses formally or informally reported in the literature, which includes notes, anecdotal reports (for example, reports from newspapers or posted on list servers), etc.

Table 5 illustrates our analyses. Our "data" (Column 3) represent the number of reports of the different categories of responses. Column 4 represents the "prior probabilities" of these data; because we initially assumed the responses are equally probable, these prior probabilities are recorded as 0.1111 (or, more precisely, 1/9). The last column in Table 5 represents the posterior probabilities or the probability that an animal exposed to active sonar (in this case) would exhibit a particular category of response.

Table 5. An Illustration of the Bayesian model that was employed to estimate the probability of specific responses given exposure (in this example) to active sonar. This model assumed that every response was equally probable (uninformed prior probability) which is reflected in Column 4 of the Table.

Response (R_i)		Data (D_i)	$Pr(R_i)$ (Prior Probability)	$Pr(D_i\|R_i)$	$Pr(D_i\|R_i)Pr(R_i)$	$Pr(R_i\|D_i)$ (Posterior Probability)
1	Physical trauma	15	0.1111	0.0350	0.0039	**0.0240**
2	Noise-induced hearing loss	2	0.1111	0.0047	0.0005	**0.0032**
3	Evasive response	218	0.1111	0.5093	0.0566	**0.3490**
4	Behavioral disturbance	25	0.1111	0.1179	0.0131	**0.0808**
5	Avoidance response	8	0.1111	0.0377	0.0042	**0.0259**
6	Vocal adjustment	21	0.1111	0.0991	0.0110	**0.0679**
7	Unspecified response – adverse (not as above)	54	0.1111	0.2547	0.0283	**0.1745**
8	Unspecified response - not adverse	61	0.1111	0.2877	0.0320	**0.1972**
9	No response	24	0.1111	0.1132	0.0126	**0.0776**
Totals		428	1.0000		0.1622	1.0000

Step D: Multiply the estimates of the number of exposure events by the posterior probabilities produced in Step 4 to estimate the proportions of exposure events that are expected to produce specific responses.

To estimate the number of times animals exposed to an acoustic stimulus might exhibit one of these categories of responses, we multiplied the number of exposure events by the posterior probabilities (the values in the last column of Table 5). If, for the sake of illustration, we concluded that 100 southern resident killer whales might be exposed to active sonar, we would have concluded that 2 of these whales would experience physical trauma, none would experience threshold shift, 35 would engage in "evasive" behavior, 8 would experience behavioral disturbance (that is, a shift from one behavioral state to another behavioral state), etc. We would rely on the actual reports to qualitatively describe the particular kinds of responses we would expect. For example, we would qualitatively describe the kinds of avoidance we would expect particular animals to exhibit (such as horizontal avoidance versus vertical avoidance, shifts from resting to active behavioral states, etc.).

For further description of the response analyses conceptual model please see the programmatic consultation on the Northwest Training Range Complex regulations (NMFS 2010c).

3.3 Risk Analysis

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 the proposed actions are likely to pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those risks to individuals to identify consequences to the populations that include those individuals. 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 current or expected future reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable response to stressors produced by an action would reasonably be expected to reduce the individual's current or expected future reproductive success by increasing the individual's likelihood of dying prematurely, having reduced longevity, increasing the age at which individuals become reproductively mature, reducing the age at which individuals stop reproducing, reducing the number of live births individuals produce during any reproductive bout, decreasing the number of times an individual is likely to reproduce over its reproductive lifespan (in animals that reproduce multiple times), or causing an individual's progeny to experience any of these phenomena (Brommer et al. 1998; Coulson et al. 2006; Kotiaho et al. 2005; McGraw and Caswell 1996; Oli and Dobson 2003; Saether et al. 2005; Sterns 1992).

When individual, listed plants or animals are expected to experience reductions in their current or expected future reproductive success, 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 (see Sterns 1992). 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. On the other hand, when listed plants or animals exposed to an Action's effects are *not* expected 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 (for example, see Anderson 2000; Mills and Beatty 1979; Sterns 1992). 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 current or expected future reproductive success, our assessment tries to determine if those 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 *Status of the Species* section of this Opinion) as our point of reference. The primary advantage of this approach is that it considers the consequences of the response of endangered and threatened species in terms of fitness costs, which allows us to assess how particular behavioral decisions are likely to influence individual reproductive success (Bejder et al. 2009). Individual-level effects can then be translated into changes in demographic parameters of populations, thus allowing for an assessment of the biological significance of particular human disturbances.

Biological opinions, then, distinguish among different kinds of "significance" (as that term is commonly used for NEPA analyses). First, we focus on potential physical, chemical, or biotic stressors that are "significant" in the sense of "salient" in the sense of being distinct from ambient or background. We then ask if (a) exposing individuals to those potential stressors is likely to (a) represent a "significant" adverse experience in the life of individuals that have been exposed; (b) exposing individuals to those potential stressors is likely to cause the individuals to experience "significant" physical, chemical, or biotic responses; and (c) any "significant" physical, chemical, or biotic response is likely to have "significant" consequence for the fitness of the individual animal; in the latter two cases, (items (b) and (c)), the term "significant" means "clinically or biotically significant" rather than statistically significant.

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

For "species" (this term refers to the entity that has been listed as endangered or threatened, not the biological species concept commonly referred to as "species"), we are concerned about whether the number of populations that 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 population comprise. Here, again, "significant" also means "clinically or biotically significant" rather than statistically significant.

3.4 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. If an area encompassed in a critical habitat designation is likely to be exposed to the direct or indirect consequences of the proposed action on the natural environment, we ask if primary constituent elements included in the designation (if there are any) or physical, chemical, or biotic phenomena that give the designated area conservation value are likely to respond to that exposure.

In this step of our assessment, we must identify (a) the spatial distribution of stressors produced by an action; (b) the temporal distribution of stressors 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 constituent elements 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.

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, the 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 designated critical habitat has limited current value or potential value for the conservation of listed species, the limited value is our point of reference for our assessment.

3.5 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 (Bowles 1994; Croll et al. 2001b; Frankel and Clark 1998; Gisiner et al. 2006; McCauley and Cato. 2001; Norris 1994; NRC 2000; NRC 2005; Richardson et al. 1995; Southall et al. 2007; Tyack 2007; Tyack and Clark 2000; Wright et al. 2007).

To supplement that body of knowledge, we conducted electronic literature searches using the *Web of Science*, and Cambridge Abstract's *Aquatic Sciences and Fisheries Abstracts* (ASFA) database services. Our searches specifically focus on the *ArticleFirst*, *BasicBiosis*, *Dissertation Abstracts*, *Proceedings* and *ECO* databases, which index the major journals dealing with issues of ecological risk (for example, the journals *Environmental Toxicology and Chemistry*, *Human and Ecological Risk Assessment*), marine mammals (*Journal of Mammalogy*, *Canadian Journal of Zoology*, *Marine Mammal Science*), sea turtles (*Copeia*, *Herpetologia*, *Journal of Herpetology*), ecology (*Ambio*, *Bioscience*, *Journal of Animal Ecology*, *Journal of Applied Ecology*, *Marine Pollution Bulletin*, *Oikos*), bioacoustics (*Bioacoustics*, *Journal of the Acoustical Society of America*), and animal behavior (*Advances in the Study of Behavior*, *Animal Behavior*, *Behavior*, *Ethology*). We manually searched issues of the *Journal of Cetacean Research and Management* and *Reports of the International Whaling Commission*.

To supplement our searches, we examined the literature that was cited in documents and any articles we collected through our electronic searches. If a reference's title did not allow us to eliminate it as irrelevant to this inquiry, we acquired it. We did not conduct hand searches of published journals for this consultation. We organized the results of these searches using commercial bibliographic software.

We ranked the results of these searches based on the quality of their study design, sample sizes, level of scrutiny prior to and during publication, and study results. We ranked carefully-designed field experiments (for example, experiments that control variables, such as other sources of sound in an area, that might produce the same behavioral responses) higher than field experiments that were not designed to control those variables. We ranked carefully-designed field experiments higher than computer simulations. Studies that were based on large sample

sizes with small variances were generally ranked higher than studies with small sample sizes or large variances.

Despite the information that is available, this assessment involved a large amount of uncertainty about the basic hearing capabilities of marine mammals; how marine mammals 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 marine mammals; the mechanisms by which human-generated sounds affect the behavior and physiology (including the non-auditory physiology) of marine mammals, and the circumstances that are likely to produce outcomes that have adverse consequences for individual marine mammals and marine mammal populations (see (NRC 2000) for further discussion of these unknowns).

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

Over the past few years, several organizations have argued that several of our previous biological opinions on the 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. In each instance, we have had to explain how section 7 consultations and biological opinions consider "cumulative impacts" (in the NEPA sense of the term). We reiterate that explanation in this sub-section.

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) (CEQ 1997).

By regulation, the Services assess the effects of a proposed action by adding its direct and indirect effects to the *impacts* of the activities we identify in an *Environmental Baseline* (50 CFR §402.02). Although our regulations use the term "adding" the effects of actions to an environmental baseline, we do not assume that the effects of actions are all additive; our assessments consider synergistic effects, multiplicative effects, and antagonistic effects of stressors on endangered species, threatened species, and any critical habitat that has been designated for those species.

In practice we address "cumulative impacts" by focusing on individual organisms, which integrate the environments they occupy or interact with indirectly over the course of their lives. In our assessments, we think in terms of the biotic or ecological "costs" of exposing endangered

and threatened individuals to a single stressor, a sequence of single stressors, or a suite of stressors (or "stress regime"). At the level of individual organisms, these "costs" consist of incremental reductions in the current or expected future reproductive success of the individuals that result from exposing those individuals to one or more stressors. The "costs" of those exposures might be immediately significant for an organism's reproductive success (for example, when an individual dies or loses one of its young) or the "costs" might become significant only over time. The costs of synergistic interactions between two stressors or a sequence of stressors would be expected to be higher than the "costs" incurred without the synergism; the "costs" of antagonistic interactions would be expected to be lower than the "costs" incurred without the antagonism.

We begin our assessments by either qualitatively or quantitatively accumulating the biotic "costs" of exposing endangered or threatened individuals to the threats we identify in the *Status of the Species* and *Environmental Baseline* sections of our biological opinions. Then we estimate the probable additional "costs" associated with the proposed action on those individuals and ask whether or to what degree those "costs" would be expected to translate into reductions in the current and expected future reproductive success of those individuals. If we would expect those "costs" to reduce the current and expected future reproductive success of individuals or an endangered or threatened species, we would assess the consequences of those reductions on the population or populations those individuals represent and the species those populations comprise.

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 Northwest Training Range Complex. It then summarizes the biology and ecology of those species and what is known about their life histories in the Action Area. The species occurring within the action area that may be affected by the Proposed Action are listed in Table 6, along with their ESA listing status.

Table 6. Species listed under the Federal Endangered Species Act (ESA) under NMFS jurisdiction that may occur in the Action Area for the Northwest Training Range Complex.

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	-- --	71 FR 38385
Humpback Whale (*Megaptera novaeangliae*)	E - 35 FR 18319	-- --	55 FR 29646
North Pacific Right Whale (*Eubalaena japonica*)	E - 73 FR 12024	73 FR 19000	-- --
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			
Steller Sea Lion–Eastern (*Eumetopias jubatus*)	T - 55 FR 49204	58 FR 45269	73 FR 11872
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			
Georgia Basin Bocaccio *(Sebastes paucispinus*)	E - 75 FR 22276	-- --	-- --
Georgia Basin Canary rockfish (*Sebastes pinniger*)	T - 75 FR 22276	-- --	-- --
Georgia Basin Yelloweye rockfish *(Sebastes ruberrimus*)	T - 75 FR 22276	-- --	-- --
Green sturgeon (*Acipenser medirostris*)	T - 75 FR 22276	74 FR 52300	-- --
Pacific Eulachon/smelt (*Thaleichthys pacificus*)	T - 75 FR 13012	76 FR 65324	-- --
Chinook Salmon (*Oncorhynchus tshawytscha)* Evolutionarily Significant Units (ESU)			
Puget Sound ESU	T - 70 FR 37160	70 FR 52630	72 FR 2493
Lower Columbia River ESU	T - 70 FR 37160	70 FR 52630	-- --
California Coast ESU	T – 64 FR 50394	70 FR 52488	-- --
Chum Salmon (*Oncorhynchus keta*) ESUs			
Columbia River ESU	T - 70 FR 37160	70 FR 52630	-- --

Species	ESA Status	Critical Habitat	Recovery Plan
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	-- --
So. Oregon Northern California Coast ESU	T- 76 FR 50447	64 FR 24049	-- --
Central California Coast	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
Steelhead Trout (*Oncorhynchus mykiss*) Distinct Population Segments (DPS)			
Lower Columbia River DPS	T - 71 FR 834	70 FR 52630	-- --
Puget Sound DPS	T - 72 FR 26722	-- --	-- --
Northern California DPS	T - 71 FR 834	70 FR 52488	-- --
Central California Coast DPS	T - 71 FR 834	70 FR 52488	-- --

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 proposed 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 Northwest Training Range Complex 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 Northwest Training Range Complex 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 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′33″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 122°44′26″W. longitude.

Critical habitat that has been designated for southern resident killer whales would not be exposed to most of the training activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex. 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 Northwest Training Range Complex 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 proposes to conduct on the Northwest Training Range Complex 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 a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.6 Critical Habitat For the Eastern Population Of Steller Sea Lions

Critical habitat that has been designated for the eastern population of Steller sea lions includes an air zone that extends 3,000 feet (0.9 km) above areas historically occupied by sea lions at each major rookery in California and Oregon, measured vertically from sea level. Critical habitat includes an aquatic zone that extends 3,000 feet (0.9 km) seaward in state and federally managed waters from the baseline or base point of each major rookery in California and Oregon.

In Oregon, the Steller sea lion rookeries included in the critical habitat designation are Pyramid Rock on Rogue Reef (42 26.4N latitude, 124 28.1W longitude) and Long Brown Rock (42 47.3N latitude, 124 36.2W longitude) and Seal Rock (42 47.1N latitude 124 35.4W longitude) on Orford Reef. In California, the Steller sea lion rookeries included in the critical habitat designation are Ano Nuevo Island (37 06.3N latitude, 122 20.3W longitude), southeast Farallon Island (37 41.3N latitude, 123 00.1W longitude), and Sugarloaf Island.- Cape Mendocino (40

26.0N latitude, 124 24.0W longitude). Critical habitat for the eastern population of Steller sea lions has not been designated in the State of Washington.

Designated critical habitat for the eastern population of Steller sea lions does not occur on the Washington State portions of the Northwest Training Range Complex and does not co-occur with the areas that might be ensonified by active sonar or underwater detonations associated with military readiness activities on the Northwest Training Range Complex. Therefore, the activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex are not likely to affect critical habitat that has been designated for the eastern population of Steller sea lions. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

4.1.7 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 proposes to conduct on the Northwest Training Range Complex. 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 proposes to conduct on the Northwest Training Range Complex 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.

4.1.8 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 proposes to conduct on the Northwest Training Range Complex and these stressors are not

likely to exclude green sturgeon from designated critical habitat, so the military readiness activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex 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.

4.1.9 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 proposes to conduct on the Northwest Training Range Complex and these stressors are not likely to exclude Pacific eulachon from designated critical habitat, so the activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex 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.

4.1.10 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 proposes to conduct on the Northwest Training Range Complex 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 proposes to conduct on the Northwest Training Range Complex 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.

4.1.11 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 proposes to conduct on the Northwest Training Range Complex 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 proposes to conduct on the Northwest Training Range Complex 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.

4.1.12 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 proposes to conduct on the Northwest Training Range Complex 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 proposes to conduct on the Northwest Training Range Complex 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.

4.1.13 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 proposes to conduct on the Northwest Training Range Complex 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 proposes to conduct on the Northwest Training Range Complex 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.

4.1.14 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 proposes to conduct on the Northwest Training Range Complex 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 proposes to conduct on the Northwest Training Range Complex 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.

4.1.15 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 proposes to conduct on the Northwest Training Range Complex 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 proposes to conduct on the Northwest Training Range Complex 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.

4.1.16 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 Northwest Training Range Complex, so the military readiness activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex 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.

4.1.17 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' 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 proposes to conduct on the Northwest Training Range Complex 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 proposes to conduct on the Northwest Training Range Complex 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.

4.1.18 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 Northwest Training Range Complex, so the military readiness activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex 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.

4.1.19 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 Northwest Training Range Complex, so the military readiness activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex 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.

4.1.20 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' 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 proposes to conduct on the Northwest Training Range Complex and these stressors are not likely to exclude northern California steelhead from designated critical habitat, so the military readiness activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex 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.

4.1.21 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' 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 proposes to conduct on the Northwest Training Range Complex 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 proposes to conduct on the Northwest Training Range Complex 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.

4.2 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 proposes to conduct in waters on the Northwest Training Range Complex. 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.

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 founda-

tion 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 2010d), fin and sei whale (NMFS 1998a), humpback whale (NMFS 1991), sperm whale (NMFS 2010e), 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. (1995) and Tyack (2000) provide detailed analyses of the functional aspects of cetacean communication and their responses to active sonar. Finally, Croll et al. (1999b), NRC (2000; 2003; 2005), 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.

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. 2009). 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. 2009).

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 Northwest Training Range Complex (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. 2009; Gregr et al. 2000; Mate et al. 1998).

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.

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).

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).

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 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 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.

A lot of uncertainty surrounds estimates of blue whale abundance in the North Pacific Ocean. Barlow (1994) estimated the North Pacific population of blue whales at approximately 1,400 to 1,900. Barlow (1995) estimated the abundance of blue whales off California at 2,200 individuals. Wade and Gerrodette (1993) and Barlow et al. (1997) estimated there were a minimum of 3,300 blue whales in the North Pacific Ocean in the 1990s.

The size of the blue whale population in the North Atlantic is also uncertain. The population has been estimated to number from a few hundred individuals (Allen 1970; Mitchell 1974) to 1,000 to 2,000 individuals (Sigurjónsson 1995). Gambell (1976) estimated there were between 1,100 and 1,500 blue whales in the North Atlantic before whaling began and Braham (1991) estimated there were between 100 and 555 blue whales in the North Atlantic during the late 1980s and early 1990s. Sears et al. (1987) identified over 300 individual blue whales in the Gulf of St. Lawrence, which provides a minimum estimate for their population in the North Atlantic. Sigurjónsson and Gunnlaugson (1990) concluded that the blue whale population had been increasing since the late 1950s and argued that the blue whale population had increased at an annual rate of about 5 percent between 1979 and 1988, although the level of confidence we can place in these estimates is low.

Estimates of the number of blue whales in the Southern Hemisphere range from 5,000 to 6,000 (Yochem and Leatherwood 1985) with an average rate of increase that has been estimated at between 4 and 5 percent per year. Butterworth et al. (1993), however, estimated the Antarctic population at 710 individuals. More recently, Stern (2001) estimated the blue whale population in the Southern Ocean at between 400 and 1,400 animals (CV 0.4). The pygmy blue whale population has been estimated at 6,000 individuals (Yochem and Leatherwood 1985).

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).

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.

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. 1995). Nevertheless, data reported by Melcón et al. (Melcon et al. 2012) 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.

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).

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.

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.

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).

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' 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).

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 2001; 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 and that the North Atlantic population consists of at least 2,000 individuals. 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.

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.

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. (1995) 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 (2000) 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. 1995).

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).

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.

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. 1992). 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. 1992). 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. 1992; 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. 2009; 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. 1992). 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. 1992).

Several authors have reported that humpback whales do not occur off the coasts of Washington and Oregon in the winter (Green et al. 1992). 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.

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.

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. This estimation is not considered reliable. 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.

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. 2009; 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. (2008) 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).

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).

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.

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. 1995; 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 1983). Such sounds can be heard up to 9 km away (Tyack 1983). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also produced in breeding areas (Richardson et al. 1995; Tyack 1983). 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. 1995; Thompson et al. 1986). However, humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995).

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.

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.

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. 1982; 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.

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).

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.

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).

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).

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.

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. 1995).

A general description of the anatomy of the ear for cetaceans is provided in the description of the blue whale.

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.

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.

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. 1992). 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. (1992), 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.

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).

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.

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.

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).

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. 2004; 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).

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).

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.

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 2005b).

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).

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 2008a). 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 2008a). 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 2008a).

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.

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 2008a).

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 2000; 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.

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.

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).

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 Eastern Population of Steller Sea Lion

The Steller sea lion, also known as the northern sea lion, is the largest member of the Otariid (eared seal) family. Steller sea lions exhibit sexual dimorphism, in which adult males are noticeably larger than females and further distinguished by a thick mane of coarse hair. Adult males may be up to 10-11 ft (3-3.4 m) in length and can weigh up to 2,500 lbs (1,120 kg). Females are smaller than males, at 7.5-9.5 ft (2.5-3.0 m) in length and weigh up to 770 lbs (350 kg). The coats of adult males and females are light blonde to reddish brown and slightly darker

on the chest and abdomen. The light coloration is still visible when the body is wet, which is different from many pinniped species. Like other pinnipeds, their coat of fur "molts" every year. Both sexes also have long whitish whiskers, or vibrissae, on their muzzle. The flippers and other hairless parts of the skin are black. The fore-flippers are broader and longer than the hind-flippers and are the primary means of locomotion in water. On land, sea lions, unlike "true" seals, can turn their hind flippers forward for walking.

Steller sea lions "forage" nearshore and pelagic waters. They are capable of traveling long distances in a season and can dive to approximately 1300 ft (400 m) in depth. They also use terrestrial habitat as haul-out sites for periods of rest, molting, and as rookeries for mating and pupping during the breeding season. At sea, they are seen alone or in small groups, but may gather in large "rafts" at the surface near rookeries and haul outs. This species is capable of powerful vocalizations that are accompanied by a vertical head bobbing motion by males. Steller sea lions are opportunistic predators, foraging and feeding primarily at night on a wide variety of fishes (e.g., capelin, cod, herring, mackerel, pollock, rockfish, salmon, sand lance, etc.), bivalves, cephalopods (e.g., squid and octopus) and gastropods. Their diet may vary seasonally depending on the abundance and distribution of prey. They may disperse and range far distances to find prey, but are not known to migrate.

Distribution

Steller sea lions are distributed mainly around the coasts to the outer continental shelf along the North Pacific Ocean rim from northern Hokkaiddo, Japan through the Kuril Islands and Okhotsk Sea, Aleutian Islands and central Bering Sea, southern coast of Alaska and south to California. The population is divided into the Western and the Eastern distinct population segments (DPSs) at 144° West longitude (Cape Suckling, Alaska). The Western DPS includes Steller sea lions that reside in the central and western Gulf of Alaska, Aleutian Islands, as well as those that inhabit the coastal waters and breed in Asia (e.g., Japan and Russia). The Eastern DPS includes sea lions living in southeast Alaska, British Columbia, California, and OregonSteller sea lions do not migrate, but they often disperse widely outside of the breeding season (Loughlin 2002).

Population Structure

Steller sea lions are gregarious animals that often travel or haul out in large groups of up to 45 individuals (Keple 2002). At sea, groups usually consist of females and subadult males; adult males are usually solitary while at sea (Loughlin 2002). An area of high occurrence extends from the shore to the 273-fathom (500-m) depth.

Eastern Steller sea lions are distributed from California to Alaska and the population includes all rookeries east of Cape Suckling, Alaska south to Año Nuevo Island, which is the southernmost extant rookery. Most adult Steller sea lions occupy rookeries during the pupping and breeding

season, which extends from late May to early July (Pitcher and Calkins 1981). During the breeding season some juveniles and non-breeding adults occur at or near the rookeries, but most are on haulouts.

Natural Threats

Reproductive failure and neonate, juvenile, and adult mortality resulting from disease probably occur in both DPSs of Steller sea lions. Antibodies to two types of bacteria (Leptospira and Chlamydiia), one marine calicivirus (San lilipel Sea Lion Virus), and seal herpes virus (SeHV), which could produce such effects, were present in blood taken from Steller sea lions in Alaska (Barlough et al. 1987; Calkins and Goodwin 1988; Vedder et al. 1987).

Causes of pup mortality include drowning, starvation caused by separation from the mother, crushing by larger animals, disease, predation, and biting by females other than the mother (Edie 1977; Orr and Poulter 1967). Pup mortality on rookeries has not been thoroughly studied.

Steller sea lions are probably eaten by killer whales and sharks, but the possible impact of these predators is unknown. The occurrence of shark predation on other North Pacific pinnipeds has been documented, but not well quantified (Ainley et al. 1985).

Parasites of Steller sea lions include intestinal cestodes; trematodes in the intestine and bile duct of the liver; nematodes in the stomach, intestine, and lungs; acainthocephalans in the intestine; acarian mites in the nasopharynx and lungs; and an anopluran skin louse (Dailey and Brownell 1972; Dailey and Hill 1970).

Anthropogenic Threats

Historically, the Eastern DPS of Steller sea lions was subjected to substantial mortality by humans, primarily due to commercial exploitation and both sanctioned and unsanctioned predator control (NMFS 2008b). Commercial exploitation occurred primarily in the 1800s and early 1900s while unsanctioned predator control probably persisted into the 1970s in some locations. State sanctioned commercial harvest of Steller sea lions ended in 1972 with the advent of the MMPA.

Although not well documented, there is little doubt that numbers of Steller sea lions were greatly reduced in many locations by these activities (NMFS 2008b). Commercial hunting and predator control activities have been discontinued and no longer affect this DPS. In contrast to the Western DPS, which is experiencing potential human-related threats from competition with fisheries (potentially high), incidental “take” by fisheries (low), and toxic substances (medium) no threats to continued recovery were identified for the Eastern DPS. Although several factors affecting the Western DPS also affect the Eastern DPS (e.g., environmental variability, killer

whale predation, toxic substances, disturbance, shooting), these threats do not appear to be at a level sufficient to keep the Eastern DPS from continuing to recover, given the long term sustained growth of the population as a whole (NMFS 2008b).

Steller sea lions are also harassed during research targeting sea lions and incidental to research on other marine mammals. NMFS' Permits Division issued nine permits that authorized the incidental disturbance of 33,050 individuals from the eastern population of Steller sea lions during research on killer whales and other cetaceans in Alaska, California, Washington, California, and Oregon.

Status and Trend

The Steller sea lion was initially listed as a threatened species under the ESA on April 5, 1990 (55 FR 12645). The Eastern DPS includes animals east of Cape Suckling (Angliss and Outlaw 2005; Loughlin 2002; NMFS 2008b) that extend into southeastern Alaska, and Canada.

Rookeries of the eastern population of Steller sea lions occur in British Columbia, Oregon, and northern California; but there are no rookeries in Washington (Angliss and Outlaw 2008). However, Steller sea lion occur regularly throughout the year in the Pacific Northwest and several haul outs for these sea lions occur along the coast from the Columbia River to Cape Flattery and on the southern coast of Vancouver Island near the Strait of Juan de Fuca (Jeffries et al. 2000). When they are not resting on haul outs, Steller sea lions primarily occur from the shore to the 500 meter (1,640 foot) isobath; they occur in waters deeper than this isobath, but their occurrence becomes increasingly rare. Steller sea lions also occur in the Strait of Juan de Fuca, around San Juan and Whidbey islands, and through the Strait of Georgia with some observations in the southern portion of Puget Sound. They are rare in Hood Canal. A final revised species recovery plan addresses both the Western and Eastern DPSs (NMFS 2008b). The Steller sea lion is designated as depleted under MMPA.

On December 13, 2010 NMFS published a 90-day finding on petitions to delist the Eastern DPS of the Steller sea lion. The finding stated that substantial scientific or commercial information is available such that a status review is warranted.

Diving

Steller sea lions tend to make shallow dives of less than 820 ft (250 m) but are capable of deeper dives (NMFS 2008b).

Social Behavior

Steller sea lions are colonial breeders. Adult males, also known as bulls, establish and defend territories on rookeries to mate with females. Bulls become sexually mature between 3 and 8

years of age, but typically are not large enough to hold territory successfully until 9 or 10 years old. Mature males may go without eating for 1-2 months while they are aggressively defending their territory. Females typically reproduce for the first time at 4 to 6 years of age, usually giving birth to a single pup each year. At birth, pups are about 3.3 ft (1 m) in length and weigh 35-50 lbs (16-22.5 kg). Adult females, also known as cows, stay with their pups for a few days after birth before beginning a regular routine of alternating foraging trips at sea with nursing their pups on land. Female Steller sea lions use smell and distinct vocalizations to recognize and create strong social bonds with their newborn pups. Pups have a dark brown to black "lanugo" coat until 4 to 6 months old, when they molt to a lighter brown. By the end of their second year, pups are the same color as adults. Females usually mate again with males within 2 weeks after giving birth. Males can live to be up to 20 years old, while females can live to be 30.

Vocalization and Hearing

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

Underwater sounds are similar to those produced on land (Loughlin et al. 1987). When the underwater hearing sensitivity of two Steller sea lions was tested, the hearing threshold of the male was significantly different from that of the female. The range of best hearing for the male was from 1 to 16 kHz, with maximum sensitivity (77 dB re 1 μPa - 1 m) at 1 kHz. The range of best hearing for the female was from 16 kHz to above 25 kHz, with maximum sensitivity (73 dB re 1 μPa - 1 m) at 25 kHz. However, because of the small number of animals tested, the findings could not be attributed to individual differences in sensitivity or sexual dimorphism (Kastelein et al. 2005).

Critical Habitat

In 1993, NMFS published a final rule to designate critical habitat for Steller sea lions (58 FR 45269). For the Eastern DPS, the Critical Habitat aquatic zones (located east of 144°W longitude) extend 3,000 ft (0.9 km) seaward in state and federally managed waters from the baseline or base point of each major rookery.

4.2.8 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.

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).

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.

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.

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 2010f).

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 2010f).

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 2010f).

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 2010f).

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.

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).

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).

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).

4.2.9 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.

Natural Threats

Chinook salmon, terns, and harbor seals are known predators of smaller bocaccio (Love et al. 2002). The main predators of adult bocaccio are marine mammals (COSEWIC 2002). 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 (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 (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.

Anthropogenic Threats

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.

Listing status

Georgia Basin bocaccio were listed as an endangered "species" on 28 April 2010 (75 Federal Register 22276).

Population status and trends

From 1975 through 1979, bocaccio were reported as representing an average of 4.63 percent of the total rockfish catch. From 1980–1989, they represented about 0.24 percent of the rockfish identified, and from 1996 to 2007, bocaccio were not reported in a sample of 2,238 rockfish captured in recreational fisheries (in a sample of that size, there was a 99.5 percent probability of observing at least one bocaccio, assuming their relative frequency was the same as it had been in the 1980s). Bocaccio have always been rare in recreational fisheries that occur in North Puget Sound and the Strait of Georgia; however, there have been no confirmed reports of bocaccio in Georgia Basin for about seven years.

Although their abundance cannot be estimated directly, NMFS' Biological Review Team estimated that the populations of bocaccio, canary rockfish, and yelloweye rockfish are small in size, probably numbering fewer than 10,000 individuals in Georgia Basin and fewer than 1,000 in Puget Sound (74 Federal Register 18532).

Hearing

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 Proposed 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 Northwest Training Range Complex 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).

4.2.10 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.

Natural Threats

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.

Anthropogenic Threats

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.

Listing status

Georgia Basin canary rockfish were listed as a threatened "species" on 28 April 2010 (75 Federal Register 22276).

Population Status and Trends

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.

Although their abundance cannot be estimated directly, NMFS' Biological Review Team estimated that the populations of bocaccio, canary rockfish, and yelloweye rockfish are small in size, probably numbering fewer than 10,000 individuals in Georgia Basin and fewer than 1,000 in Puget Sound (74 FR 18532).

Hearing

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).

4.2.11 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.

Natural Threats

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.

Anthropogenic Threats

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.

Listing Status

Georgia Basin yelloweye rockfish were listed as a threatened “species” on 28 April 2010 (75 FR 22276).

Population Status and Trends

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.

Although their abundance cannot be estimated directly, NMFS' Biological Review Team estimated that the populations of bocaccio, yelloweye rockfish, and canary rockfish are small in size, probably numbering fewer than 10,000 individuals in Georgia Basin and fewer than 1,000 in Puget Sound (74 FR 18532).

Hearing

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).

4.2.12 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).

Distribution

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.

The species is divided into two genetically distinct but physically indistinguishable clades: a Northern DPS whose populations are relatively healthy, and a Southern DPS that has undergone significant decline (Adams et al. 2007). Only the Southern DPS of green sturgeon is listed under the ESA.

Population Structure

Southern green sturgeon currently consist of a single population that occurs in San Francisco Bay and the river systems associated with the bay (Adams et al. 2007). Southern green sturgeon are known to spawn in the Sacramento River and have been reported to spawn in the Feather River (Adams et al. 2007).

Natural Threats

Green sturgeon eggs and larvae are likely preyed upon by a variety of larger fish and animals, while sub-adult and adult sturgeon may occasionally be preyed upon by shark sea lions, or other large body predators. Physical barriers, changes in water flow and temperatures may also affect freshwater survival.

Anthropogenic Threats

Southern green sturgeon are primarily threatened by reductions in the area of spawning habitat associated with the construction of dams in the Sacramento River system (e.g., Oroville, Shasta and Keswick dams). Southern green sturgeon are also threatened by elevated temperatures in freshwater river systems, harvests, entrainment by water projects, exposure to toxic chemicals, and invasive species (Adams et al. 2007; Erickson and Webb 2007).

Climate change has the potential to affect sturgeon in similar, if not more significant ways it affects salmonids. Elevated air temperatures could lead to precipitation falling as rain instead of snow. Additionally, snow would likely melt sooner and more rapidly, potentially leading to greater flooding during melting and lower water levels at other times, as well as warmer river temperatures. Although sturgeon can spawn over varied benthic habitat, they prefer localized depressions in riverbeds (Moyle et al. 1992; Moyle et al. 1995). Increased extremes in river flow (i.e., periods of flooding and low flow) can alternatively disrupt and fill in spawning habitat that sturgeon rely upon (ISAB 2007). If water flow is low during migration events, it is likely that new obstacles can impede or block sturgeon movement. As with other anadromous fishes, sturgeon are uniquely evolved to the environments that they live in. Because of this specificity,

broad scale changes in environment can be difficult to adapt to, including changes in water temperature (Cech Jr. et al. 2000). Sturgeon are also sensitive to elevated water temperatures. Temperature triggers spawning behavior. Warmer water temperatures can initial spawning earlier in a season for salmon and the same can be true for sturgeon (ISAB 2007). If river and lake temperatures become anomalously warm, juvenile sturgeon may experience elevated mortality due to lack of cooler water refuges in freshwater habitats. Apart from direct changes to sturgeon survival, altered water temperatures may disrupt habitat, including the availability of prey (ISAB 2007). Warmer temperatures may also have the effect of increasing water use in agriculture, both for existing fields and the establishment of new ones in once unprofitable areas (ISAB 2007). This means that streams, rivers, and lakes will experience additional withdrawal of water for irrigation and increasing contaminant loads from returning effluent. Overall, it is likely that global warming will increase pressures on sturgeon survival and recovery.

Green sturgeon are targeted by a subsistence tribal fishery in the Klamath River as well as a small commercial fishery and some sport fisheries along the Pacific Coast. The majority of harvests since 1985 have taken place in the lower Columbia River; although this fishery has declined because of increasingly restrictive fishing regulations (Adams et al. 2002). Mixed stock fisheries along the Pacific coast annually harvested an average of approximately 1,350 green sturgeon during 1994–2001 (Adams et al. 2002). We do not know whether or to what degree these fisheries harvested southern green sturgeon, but the distribution of southern green sturgeon would expose them to these fisheries.

Sturgeon species generally accumulate contaminants in their tissues. White sturgeon from the Kootenai River have been found to contain aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, zinc, DDE, DDT, PCBs, and other organochlorines (Kruse and Scarnecchia 2002). Mercury has also been identified from white sturgeon of the lower Columbia River (Webb et al. 2006). Numerous organochlorines, including DDT, DDD, DDE, chlordane, and dieldrin have also been identified in these fish (Foster et al. 2001). Observed concentrations are likely sufficient to influence reproductive physiology.

Status and Trend

The southern population of green sturgeon was listed as threatened on April 7, 2006 (70 FR 17757). Critical habitat for this species was designated on October 9, 2009 (74 FR 52300). Data on the demographic status and trend of southern green sturgeon are very limited. Available information comes from two predominant sources, fisheries and tagging. Only three data sets were considered useful for the population time series analyses by NMFS' biological review team: the Klamath Yurok Tribal fishery catch, a San Pablo sport fishery tag returns, and Columbia River commercial landings (BRT 2005). Using San Pablo sport fishery tag recovery

data, the California Department of Fish and Game produced a population time series estimate for the southern DPS. San Pablo data suggest that green sturgeon abundance may be increasing, but the data showed no significant trend. The data set is not particularly convincing, however, as it suffers from inconsistent effort and since it is unclear whether summer concentrations of green sturgeon provide a strong indicator of population performance (BRT 2005). Although there is not sufficient information available to estimate the current population size of southern green sturgeon, catch of juveniles during state and federal salvage operations in the Sacramento delta are low in comparison to catch levels before the mid-1980s.

Vocalizations and Hearing

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.

4.2.13 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.

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).

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).

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).

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).

Status

The southern population of eulachon was listed as threatened on 18 March 2010 (75 FR 13012).

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).

4.2.14 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.

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.

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.

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).

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 2005c). Of these ESUs, two are endangered (Sacramento River winter-run and Upper Columbia River spring-run), seven are threatened (Snake River spring/summer-run, Snake River fall-run, Central Valley spring-run, California coastal, Puget Sound, Lower Columbia River, and Upper Willamette River), and one is listed as a species of concern (Central Valley fall-and late fall-run)(70 FR 37160). The remaining seven ESUs were found to not warrant listing under the ESA (NMFS 2005c). The ESUs of concern in this Opinion are summarized below.

4.2.15 Puget Sound Chinook Salmon

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.

4.2.16 Lower Columbia River Chinook Salmon

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).

4.2.17 California Coast Chinook Salmon

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.

4.2.18 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.

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 175° 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.

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).

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 2005c). 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 2005c).

4.2.19 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.

4.2.20 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.

4.2.21 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.

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 46° 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.

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).

Status and Trends

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

4.2.22 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.

4.2.23 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.

4.2.24 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).

4.2.25 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.

4.2.26 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.

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.

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).

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).

4.2.27 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.

4.2.28 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

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).

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).

4.2.29 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.

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).

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).

4.2.30 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.

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.

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.

4.2.31 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.

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).

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.

4.2.32 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.

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).

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.

4.3 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.

4.3.1 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 Northwest Training Range Complex 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' 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.

4.3.2 Climate Change

There is now widespread consensus within the scientific community that atmospheric temperatures on earth are increasing (warming) and that this will continue for at least the next several decades (IPCC 2001; Oreskes 2004). 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. Because of this commonality, we present this narrative here rather than in each of the species-specific narratives that follow.

The IPCC 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. 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). The IPCC 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 IPCC 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). 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 7).

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 foreseeable future (Houghton 2001; IPCC 2001; Parry et al. 2007). The direct effects of climate change would result in increases in atmospheric temperatures, changes in sea surface temperatures, changes in patterns of precipitation, and changes in 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.

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. Although the IPCC (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.

Table 7. Phenomena associated with projections of global climate change including levels of confidence associated with projections (adapted from IPCC 2001 and Campbell-Lendrum Woodruff 2007).

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 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.

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.

The response of North Atlantic right whales to changes in the North Atlantic Oscillation also provides insight into the potential consequences of a changing climate on large whales. Changes in the climate of the North Atlantic have been directly linked to the North Atlantic Oscillation, which results from variability in pressure differences between a low pressure system that lies over Iceland and a high pressure system that lies over the Azore Islands. As these pressure systems shift from east to west, they control the strength of westerly winds and storm tracks across the North Atlantic Ocean. The North Atlantic Oscillation Index, which is positive when both systems are strong (producing increased differences in pressure that produce more and stronger winter storms) and negative when both systems are weak (producing decreased differences in pressure resulting in fewer and weaker winter storms), varies from year to year, but also exhibits a tendency to remain in one phase for intervals lasting several years.

Sea surface temperatures in the North Atlantic Ocean are closely related to this oscillation which influences the abundance of marine mammal prey such as zooplankton and fish. In the 1970s and 1980s, the North Atlantic Oscillation Index has been positive and sea surface temperatures increased. These increased are believed to have produced conditions that were favorable for the copepod (*Calanus finmarchicus*), which is the principal prey of North Atlantic right whales (Conversi et al. 2001) and may have increased calving rates of these whales (we cannot verify this association because systematic data on North Atlantic right whale was not collected until 1982) (Greene et al. 2003a). In the late 1980s and 1990s, the North Atlantic Oscillation Index was mainly positive but exhibited two substantial, multi-year reversals to negative values. This was followed by two major, multi-year declines in copepod prey abundance (Drinkwater et al. 2003; Pershing et al. 2010). Calving rates for North Atlantic right whales followed the declining trend in copepod abundance, although there was a time lag between the two (Greene et al. 2003b).

Although the North Atlantic Oscillation Index has been positive for the past 25 years, atmospheric models suggest that increases in ocean temperature associated with climate change forecasts may produce more severe fluctuations in the North Atlantic Oscillation. Such fluctuations would be expected to cause dramatic shifts in the reproductive rate of critically endangered North Atlantic right whales (Drinkwater et al. 2003; Greene et al. 2003b) and possibly a northward shift in the location of right whale calving areas (Kenney 2007).

Changes in global climatic patterns are also projected to have profound effect on the coastlines of every continent by increasing sea levels and increasing the intensity, if not the frequency, of hurricanes and tropical storms. 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 that are

destroyed by tropical storms and hurricanes. Further, the combination of increasing sea levels, changes in patterns of coastal erosion and accretion, and changes in rainfall patterns are likely to affect coastal estuaries, submerged aquatic vegetation, and reef ecosystems that provide foraging and rearing habitat for several species of sea turtles. Finally, changes in ocean currents associated with climate change projections would affect the migratory patterns of sea turtles. The loss of nesting beaches, by itself, would have catastrophic effect on sea turtles populations globally if they are unable to colonize any new beaches that form of if the beaches that form do not provide the sand depths, grain patterns, elevations above high tides, or temperature regimes necessary to allow turtle eggs to survive. When combined with changes in coastal habitats and ocean currents, the future climates that are forecast place sea turtles at substantially greater risk of extinction than they already face.

4.3.3 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 2002). 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).

4.3.4 Human-Induced Mortality

Large whale population numbers in the proposed 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 proposed 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. 1995).

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 2003; NRC 2005; Richardson et al. 1995). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003). 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 2003). 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. 1995). 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.

Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans (Simmonds and Hutchinson 1996). The radiated noise spectrum of merchant ships ranges from 20 to 500 Hz and peaks at approximately 60 Hz. Ross (1976) has estimated that between 1950 and 1975 shipping had caused a rise in ambient ocean noise levels of 10 dB. He predicted that this would increase by another 5 dB by the beginning of the 21st century.

Commercial shipping traffic is a major source of low frequency (5 to 500 Hz) human generated sound in the world's oceans (NRC 2003; 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) has estimated that between 1950 and 1975 shipping had caused a rise in ambient ocean noise levels of 10 dB. 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 2008a citing Mintz and Filadelfo 2004a, 2004b)).

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.

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).

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.

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.

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.

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. 1995).

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 2003; NRC 2005; Richardson et al. 1995). 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 2003). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003). 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 2003). 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. 1995). 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.

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.

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 proposed 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 2000; 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, 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.

4.3.5 Military Activities

The Navy has been conducting training exercises in the Northwest Training Range Complex for over 60 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 Northwest Training Range Complex. Stranding data has been collected by researchers in the Northwest Training Range Complex for approximately 30 years as well as by NMFS for

roughtly 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 Northwest Training Range Complex with any regularity, more evidence would have been detected over the 30-year period.

On May 5, 2003, the U.S. Navy guided missile destroyer *USS Shoup* passed through the Haro Strait during a training exercise and while operating its mid-frequency sonar. Members of the J pod of southern resident killer whales were in Haro Strait at the same time and exhibited unusual behavior in response to being exposed to sonar. Variability in the estimated sound exposure level (SEL) values resulted from the use of several integration procedures (based on exposure duty cycle – provided by NMFS), as well as assumptions about the relationship between *in situ* measurements and their relation to modeled mean and maximum received noise estimates. The most probable received SEL values for J-pod were from 169.1 to 187.4 dB re: 1µPa^2-s; worst-case estimates ranged from 177.7 to 195.8 dB re: 1µPa^2-s (NMFS 2005a). Based on the estimated duration and received levels, and the levels known to cause behavioral reactions in other cetaceans, NMFS concluded that J pod had been exposed to mid-frequency sonar at received levels that were likely to cause behavioral disturbance, but not temporary or permanent hearing loss (NMFS 2005a). These findings were consistent with the reports generated from eyewitness accounts of the event.

The Navy's Northwest Training Range Complex Annual Exercise Reports for the first two years of the MMPA rule indicated that no individual category of authorized system(s) or training event(s) exceeded authorized quantities (to include sonar and explosives) within the Northwest Training Range Complex. The reported take of ESA-listed species were well below those authorized in 2010-2011 annual Biological Opinion and the 2011-2012 annual Biological Opinion. In addition, there were no Navy ship strikes to any listed species (none to non-listed species as well) within the Northwest Training Range Complex from 2010 through 2012.

4.3.6 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 Northwest Training Range Complex 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.

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 the Navy's training activities on the Northwest Training Range Complex have resulted in an estimated take of ESA-listed species well below levels evaluated in the 2010 Programmatic Biological Opinion or the two annual LOA Biological Opinions. The Navy has not had any ship strikes of any species occur in the Northwest Training Range Complex. Thus far, since 2010 the Navy had no discernible adverse effect on the overall status of any of the potentially affected species.

5 EFFECTS OF THE PROPOSED 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 proposed 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' 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 proposed action poses to endangered and threatened species.

5.1 Stressors Associated with the Proposed Action

The potential stressors we expect to result from the military readiness activities the U.S. Navy plans to conduct at the Northwest Training Range Complex are:

1. disturbance produced by surface vessels and aircraft involved in training activities;
2. surface vessels and submarines involved in training activities and the associated risk of collisions;
3. ordnance and projectiles associated with firing operations;
4. sound fields produced by the active sonar systems the U.S. Navy would employ;
5. sound fields and pressure waves from underwater detonations.

5.1.1 Disturbance from Vessels

The U.S. Navy plans to conduct anti-submarine warfare training events on the Northwest Training Range Complex. 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 proposes to conduct about 210 events per year in the Offshore Area of the Northwest Training Range Complex. The U.S. Navy also proposes to conduct about 26 training events involving guide-missile destroyers and 39 training events involving guided-missile frigates (59 hours of active sonar) on the Northwest Training Range Complex annually from November 2012 through November 2015.

The presence and movement of vessels 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.

5.1.2 Collisions with Vessels

The movement of surface and subsurface vessels in waters that also might be occupied by endangered or threatened marine species pose collision or ship strike hazards to those species.

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. These training events usually last for two to four hours and do not involve firing torpedoes. The U.S. Navy proposes to conduct about 210 events per year in the Offshore Area of the Northwest Training Range Complex. The U.S. Navy also proposes to conduct about 26 training events involving guide-missile destroyers and 39 training events involving guided-missile frigates (59 hours of active sonar) on the Northwest Training Range Complex from November 2012 through November 2015.

5.1.3 Projectiles and Expended Materials

Many of the activities the U.S. Navy plans to conduct on the Northwest Training Range Complex 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 2). 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.

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 proposes to employ 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).

Cannon and Small Arms Ammunition

Naval gun fire within the Northwest Training Range Complex 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.

Missiles

Missiles would be fired by aircraft, ships, and naval special warfare operatives at a variety of airborne and surface targets within the Northwest Training Range Complex. 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).

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 Northwest Training Range Complex 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.

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.

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 Northwest Training Range Complex. 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 Northwest Training Range Complex 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.

Parachutes and Sonobuoys

The U.S. Navy proposes to deploy several sonobuoys, including passive acoustic DIFAR and VLAD sonobuoys, active acoustic DICASS sonobuoys, and sonobuoys with explosive sources (see Table 2). 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.

5.1.4 Sonar Sound Fields

The Navy plans to employ mid-and high-frequency sonar systems during several of the training events it proposes to conduct in the Northwest Training Range Complex. 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 Northwest Training Range Complex include:

Mid-frequency Sonar

The U.S. Navy proposes to conduct 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 Northwest Training Range Complex from November 2012 through November 2015. As proposed, 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).

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.

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 Airborne Low-Frequency Sonar (ALFS) – 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.

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.

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 Northwest Training Range Complex 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.

5.1.5 Sound Fields and Pressure Waves from Underwater Detonations

The U.S. Navy plans to continue to employ several kinds of explosive ordnance on the Northwest Training Range Complex. 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.

During mine countermeasures training, Explosive Ordnance Disposal units conduct underwater detonation training at Crescent Harbor, Indian Island, and Hood Canal. These units use 2.5-lb charges of C-4 to produce one surface or one subsurface detonation, although only one detonation takes place per activity, and only one activity occurs in any one day. 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 would be 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 U.S. Navy plans to conduct about 4 mine countermeasures training events from November 2012 through November 2015, with four detonations per training event.

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.

Explosive Source associated with the Improved Extended Echo Ranging (IEER) System

One of the systems the U.S. Navy proposes to employ on the Northwest Training Range Complex 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.

5.2 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.

5.2.1 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 Northwest Training Range Complex 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.

5.2.2 Collision with a Vessel or Submarine

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 Northwest Training Range Complex.

Based on the small number of training events that occur on the Northwest Training Range Complex, 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 Northwest Training Range Complex is sufficiently small to be discountable and will not be discussed further in this Opinion.

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 assume that the exposure risk of collision from surface vessels or submarines is small enough to be discountable and will not be discussed further in this Opinion.

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, Steller sea lions, and ESA-listed fish (bocaccio, canary and yelloweye rockfish, green sturgeon, 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.

5.2.3 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 Northwest Training Range Complex. 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, rockfish, green sturgeon, 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.

5.2.4 Exposure to Active Sonar and Underwater Detonations

The U.S. Navy proposes to implement mitigation measures 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 proposed 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 proposes 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. 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 Navy 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. The information available leads us to conclude that the combinations of safety zones triggered by visual observations would still allow most marine mammals and sea turtles to be exposed to mid-frequency active sonar transmissions because most marine animals will not be detected at the ocean's surface.

To estimate the number of times endangered or threatened species might be exposed to mid-frequency active sonar, we considered the results of an exposure model we developed specifically for that purpose as well as the results of analyses the U.S. Navy conducted to estimate the number of marine mammals that might be "taken" (as that term is defined pursuant to the MMPA) as a result of active sonar training on the range complex. Both of these approaches required estimates of species' densities in the action area and, each method is sensitive to those density estimates. During our programmatic consultation on this action, we had to reconcile differences in estimates of marine mammals densities in the offshore portions of the Northwest Training Range Complex presented in the U.S. Navy's EIS/OEIS for the Keyport Range Complex Extension (Navy 2010), draft EIS/OEIS for the Northwest Training Range Complex (Navy 2008b), and the reports of the surveys that produced those density estimates (Barlow and Forney 2007; Forney 2007). We carry the reconciled estimates forward in this consultation. For more information on the reconciliation process, see the 2010 Programmatic Biological Opinion (NMFS 2010c).

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 Northwest Training Range Complex 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. To reflect this variability, we conducted exposure analyses using the density estimates presented in Forney (2007) for waters off Oregon and Washington as well as the upper and lower 95-percent confidence intervals for those density estimates, where those confidence intervals were available (NMFS 2010c).

Blue Whale

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. 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 Northwest Training Range Complex (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. 2007; Gregr et al. 2000; Mate et al. 1999; Stafford et al. 1999; Stafford et al. 2001). Because of this migratory habit, we assumed that blue whales might be exposed to stressors on the Northwest Training Range Complex only during the summer season, but they would be exposed to stressors associated with military readiness activities in the Southern California Range Complex during all or portions of the winter season.

Our analyses led us to reach the following conclusions about the potential stressors blue whales might be exposed to on the Northwest Training Range Complex and the number of instances, on an annual basis, in which blue whales might be exposed:

1. The mid-frequency active sonar training the U.S. Navy proposes to conduct on the Northwest Training Range Complex was likely to result in about 228 instances annually in which blue whales would be exposed to sound fields produced by this sonar.

   About 143 of these exposure events would occur at received levels of lower than 140 dB, when blue whales would be between 51 and 130 kilometers from the source of a sonar ping; another 71 of these exposure events would occur at received levels between 140 and 160 dB or distances between 10 and 51 kilometers from the source of a sonar ping;

and about 15 of the 228 exposure events would occur at received levels between 160 and 180 dB, when blue whales would occur between 0.56 and 10 kilometers of the source of a sonar ping. As a comparison, the U.S. Navy estimated that annually 17 blue whales might be exposed to active sonar associated with the training activities it proposes to conduct on the Northwest Training Range Complex and exhibit behavioral responses that would qualify as "take," in the form of behavioral harassment, as a result of that exposure.

2. In the biological opinions on the issuance of previous LOAs for the Navy's Northwest Training Range Complex we expected one instance in which blue whales might be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in "take" in the form of behavioral harassment. We also expected another instance in which blue whales would be exposed to underwater detonations and experience temporary threshold shifts as a result of their exposure to shock waves or sound fields associated with those detonations. We did not expect any blue whales to be exposed to received levels of 205 dB or 13 psi-ms associated with underwater detonations and experience 50 percent tympanic membrane rupture or slight lung injury as a result of their exposure. Because the Navy is not proposing to conduct any sinking exercises during next three years, we expect the exposure of blue whales to detonations to be reduced. Over the next three years, we expect only one blue whale each year would be exposed to detonations that would result in "take" in the form of behavioral harassment.

Fin Whale

Like blue whales, 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, although 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. Therefore, we assumed that fin whales might be exposed to stressors on the Northwest Training Range Complex throughout the year.

Our analyses led us to reach the following conclusions about the potential stressors fin whales might be exposed to on the Northwest Training Range Complex and the number of instances annually in which fin whales might be exposed:

1. The mid-frequency active sonar training the U.S. Navy proposes to conduct on the Northwest Training Range Complex was likely to result in about 790 instances in which fin whales would be exposed to sound fields produced by this sonar.

About 495 of these exposure events would occur at received levels of lower than 140 dB, when fin whales would be between 51 and 130 kilometers from the source of a sonar ping. Another 245 of these exposure events would occur at received levels between 140 and 160 dB or distances between 10 and 51 kilometers from the source of a sonar ping. About 50 of the 790 exposure events would occur at received levels between 160 and 180 dB, when fin whales would occur between 0.56 and 10 kilometers (between 0.35 and about 6.2 miles) of the source of a sonar ping. As a comparison, the Navy estimated that 122 fin whales would exhibit behavioral responses to sonar that would be considered harassment under the MMPA.

2. In the biological opinions on previous LOAs for the Northwest Training Range Complex we expected 12 instances annually in which fin whales might be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in behavioral harassment. We also expected another 7 instances annually in which fin whales would be exposed to underwater detonations and experience temporary threshold shifts as a result of their exposure to shock waves or sound fields associated with those detonations and one instance in which a fin whale might be exposed to received levels of 205 dB or 13 psi-ms associated with underwater detonations and experience 50 percent tympanic membrane rupture or slight lung injury as a result of that exposure. Because the Navy is not going to conduct any sinking exercises during the next three years, the number of fin whales exposed to underwater detonations is reduced by 12 whales each year and the one fin whale we expected to be exposed to levels sufficient to cause an injury is not expected to occur. Therefore, our fin whale exposure estimate is that 7 fin whales annually will experience shock waves or sound fields that would result in a behavioral changes or temporary threshold shift.

Humpback Whale

Historically, humpback whales occurred in Puget Sound (Calambokidis and Steiger 1990). 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 and Steiger 1990; Everitt et al. 1980; Osborne et al. 1988). Because of their contemporary rarity in Puget Sound, we assume that humpback whales would not be exposed to U.S. Navy training activities within the sound itself, but would be exposed in waters offshore of Washington, Oregon, or California.

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 and Steiger 1990; 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 and declines substantially from September onward (Calambokidis and Steiger 1990; Calambokidis et al. 2004; Calambokidis et al. 2001; Calambokidis et al. 1997; Green et al. 1992). 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. 1992).

Several authors have reported that humpback whales do not occur off the coasts of Washington and Oregon in the winter (for example, see Green et al. 1992). However, 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. Our analyses led us to reach the following conclusions about the potential stressors humpback whales might be exposed to on the Northwest Training Range Complex and the number of instances in which humpback whales might be exposed:

1. The mid-frequency active sonar training the U.S. Navy proposes to conduct on the Northwest Training Range Complex was likely to result in about 416 instances annually in which humpback whales would be exposed to sound fields produced by this sonar.

About 260 of these exposure events would occur at received levels of lower than 140 dB, when humpback whales would be between 51 and 130 kilometers from the source of a sonar ping. Another 129 of these exposure events would occur at received levels between 140 and 160 dB or distances between 10 and 51 kilometers from the source of a sonar ping. About 26 of the 416 exposure events would occur at received levels between 160 and 180 dB, when humpback whales would occur between 0.56 and 10 kilometers of the source of a sonar ping. The Navy estimated that each year 13 humpback whales would exhibit behavioral responses that would be considered harassment under the MMPA.

2. We do not expect humpback whales to be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in behavioral harassment, temporary threshold shifts, or 50 percent tympanic membrane rupture or slight lung injury.

The MMPA rule limits the take of humpback whales to 15 whales annually, which is lower than our exposure estimate. Potential exposures may be reduced because of the Navy's mitigation activities to monitor for marine mammals prior to initiating active sonar military readiness activities.

Sei Whale

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 (Kenney and Winn 1987) (Best and Lockyer 2002; Gregr and Trites 2001), 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 (Douglas et al. 2008) 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.

Outside of their foraging areas, we have only limited information on the migratory patterns, distribution, and abundance of sei whales; that information is too limited to allow us to determine whether sei whales would only be exposed to stressors on the Northwest Training Range Complex during the summer season or if the sei whales that occur in the action area for this consultation would also be exposed to stressors associated with military readiness activities in the Southern California Range Complex.

Our analyses led us to reach the following conclusions about the potential stressors sei whales might be exposed to on the Northwest Training Range Complex and the annual number of instances in which sei whales might be exposed:

1. The mid-frequency active sonar training the U.S. Navy proposes to conduct on the Northwest Training Range Complex was likely to result in about 113 instances each year in which sei whales would be exposed to sound fields produced by this sonar.

About 71 these exposure events would occur at received levels of lower than 140 dB, when sei whales would be between 51 and 130 kilometers from the source of a sonar ping. Another 35 these exposure events would occur at received levels between 140 and 160 dB or distances between 10 and 51 kilometers from the source of a sonar ping. About 7 the 113 exposure events would occur at received levels between 160 and 180 dB, when sei whales would occur between 0.56 and 10 kilometers of the source of a sonar ping. The Navy estimated that one sei whale each year would exhibit behavioral responses that would be considered harassment under the MMPA.

2. We do not expect any instances in which sei whales might be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in behavioral harassment, temporary threshold shifts, or 50 percent tympanic membrane rupture or slight lung injury.

The MMPA rule limits the take of sei whales to 1 sei whale annually, which is less than our exposure estimate. Potential exposures may be reduced because of the Navy's mitigation activities to monitor for marine mammals prior to initiating active sonar military readiness activities.

Sperm Whale

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. (1992), 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.

Our analyses led us to the following conclusions about the potential stressors sperm whales might be exposed to on the Northwest Training Range Complex and the number of instances in which sperm whales might be exposed each year:

1. The mid-frequency active sonar training the U.S. Navy proposes to conduct on the Northwest Training Range Complex was likely to result in about 1,664 instances annually in which sperm whales would be exposed to sound fields produced by this sonar.

About 1,043 these exposure events would occur at received levels of lower than 140 dB, when sperm whales would be between 51 and 130 kilometers from the source of a sonar ping. Another 516 these exposure events would occur at received levels between 140 and 160 dB or distances between 10 and 51 kilometers from the source of a sonar ping. About 105 the 1,664 exposure events would occur at received levels between 160 and 180 dB, when sperm whales would occur between 0.56 and 10 kilometers of the source of a sonar ping. The Navy estimated that each year 101 sperm whales would exhibit behavioral responses that would be considered harassment under the MMPA.

2. In previous biological opinions on the Navy's activities in the Northwest Training Range complex we expected 13 instances each year in which sperm whales might be exposed to underwater detonations at received levels that would result in behavioral harassment. We also expected another 10 instances each year in which sperm whales would be exposed to underwater detonations and experience temporary threshold shifts as a result and one instance each year in which a sperm whale might be exposed to received levels of 205 dB or 13 psi-ms associated with underwater detonations and experience 50 percent tympanic membrane rupture or slight lung injury as a result of that exposure. These exposure numbers are reduced because the Navy is not going to conduct any sinking exercises during the next three years. On an annual basis we expect 6 sperm whales to be exposed to underwater detonations that would result in behavior harassment or temporary threshold shift and no sperm whales to experience shock waves or sound levels that would result in injury.

Southern Resident Killer Whale

Southern resident killer whales are the only marine mammal that begin and end their lives almost entirely within the action area. 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 2008a). 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).

Much 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 (Krahn et al. 2004). 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. (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 2008a).

The incidental take statement in our 2011 LOA Biological Opinion estimated that 12 southern resident killer whales would be "harassed" as a result of their exposure to mid-frequency active sonar and two southern resident killer whales would be "taken" as a result of their exposure to underwater detonations. The estimates mirrored the "take" of killer whales that was authorized by the 2011 LOA, which did not distinguish between the "take" of southern resident killer whales and the "take" of all other killer whales. Given that killer whales are likely to be visible to watchstanders and that individuals from the southern resident killer whale populations are more likely to be found in Puget Sound rather than off shore areas, we assume that only about 10 percent of the Navy's estimate of killer whales exposed to active sonar would be from the southern resident killer whale DPS. The 2010 Programmatic Biological Opinion, the 2010 LOA Biological Opinion, and the *Effects of the Action* chapter of the 2011 Biological Opinion presented the correct estimates of the number of southern resident killer whales that would be "taken" as a result of the exposure to the Navy's training activities: two of the 14 killer whales whose "take" was authorized by the 2011 LOA would be southern resident killer whales.

Steller Seal Lion- Eastern Population

Rookeries of the eastern population of Steller sea lions occur in British Columbia, Oregon, and northern California; but there are no rookeries in Washington (Angliss and Outlaw 2008). However, Steller sea lion occur regularly throughout the year in the Pacific Northwest and several haul outs for these sea lions occur along the coast from the Columbia River to Cape Flattery and on the southern coast of Vancouver Island near the Strait of Juan de Fuca (Jeffries et al. 2000). When they are not resting on haul outs, Steller sea lions primarily occur from the shore to the 500 meter (1,640 foot) isobath; they occur in waters deeper than this isobath, but their occurrence becomes increasingly rare. Steller sea lions also occur in the Strait of Juan de Fuca,

around San Juan and Whidbey islands, and through the Strait of Georgia with some observations in the southern portion of Puget Sound.

Our analyses led us to reach the following conclusions about the potential stressors Steller sea lions might be exposed to on the Northwest Training Range Complex and the number of instances in which Steller sea lions might be exposed:

1. The mid-frequency active sonar training the U.S. Navy proposes to conduct on the Northwest Training Range Complex was likely to result in about 6,100 instances annually in which Steller sea lions would be exposed to sound fields produced by this sonar.

About 3,800 of these exposure events would occur at received levels of lower than 140 dB, when Steller sea lions would be between 51 and 130 kilometers from the source of a sonar ping. Another 1,900 these exposure events would occur at received levels between 140 and 160 dB or distances between 10 and 51 kilometers from the source of a sonar ping. About 370 of the exposure events would occur at received levels between 160 and 180 dB, when Steller sea lions would occur between 0.56 and 10 kilometers of the source of a sonar ping, and about 30 Steller sea lions each year would be exposed at received levels above 180 dB. The Navy estimated that each year 113 Steller sea lions would exhibit behaviors that would be classified as harassment under the MMPA.

2. In the previous biological opinions on the issuance of LOAs we expected 3 instances each year in which Steller sea lions might be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in behavioral harassment, and another 3 instances in which Steller sea lions would be exposed to underwater detonations and experience temporary threshold shifts as a result. We did not expect any instances in which Steller sea lions might be exposed to received levels of 205 dB or 13 psi-ms associated with underwater detonations and experience 50 percent tympanic membrane rupture or slight lung injury as a result of that exposure. Because the Navy will not be conducting any sinking exercised during the next three years, our exposure estimate is reduced by 2 Steller sea lion exposures annually to sound and pressure waves that would result in behavioral changes or temporary threshold shift. Therefore, we would expect 4 Steller sea lions annually, to be exposed to underwater detonations at levels that result in behavioral harassment or temporary threshold shift.

Leatherback Sea Turtle

Several authors have reported leatherback sea turtles from waters off Washington and Oregon (Bowlby et al. 1994; Green et al. 1992). Most of the leatherback sea turtles these authors

reported were observed off Washington (74 percent) and about 62 percent of these sea turtles were observed in waters 200 to 2,000 meters in depth, with the remainder observed in waters less than 200 meters in depth. Leatherback sea turtles were observed from May through September, but the number of observations was highest in July. In our proposal to designate critical habitat for leatherback sea turtles, NMFS identified the nearshore area from the Umpqua River (Winchester Bay), Oregon, north to Cape Flattery, Washington, and offshore to the 2000 meter isobath as a principal foraging area for leatherback sea turtles.

This area overlaps with the offshore portions of the Northwest Training Range Complex. Therefore, we assume that leatherback sea turtles are likely to be exposed to military readiness activities on the Northwest Training Complex. Nevertheless, we do not have information on the density of leatherback sea turtles in the action area (or a surrogate for that area) that have allowed us to estimate the probability of leatherback sea turtles being exposed to the activities the U.S. Navy plans to conduct in the Northwest Training Range Complex from November 2012 through November 2015 other than to recognize that they are likely to be exposed to those activities.

However, their foraging distribution does not appear to bring them into Crescent Harbor Underwater Explosive Ordnance Disposal (EOD) Range, Hood Canal Underwater EOD Range, or the Indian Island Underwater EOD Range. As a result, leatherback sea turtles are not likely to be exposed to underwater detonations that would occur on these underwater EOD Ranges.

Endangered and Threatened Fish in the Northwest Training Range Complex

Our June 2010 Programmatic Biological Opinion concluded that endangered and threatened Georgia Basin rockfish (bocaccio, canary rockfish, and yelloweye rockfish) were not likely to be exposed to the sound fields or pressure waves associated with U.S. Navy training activities on the Northwest Training Range Complex and, therefore, the proposed training activities were not likely to adversely affect those species. The narrative we presented in that opinion focused on the distribution of adult rockfish which led several reviewers to ask if we would also discuss the potential effects of the proposed military readiness activities on larval and juvenile rockfish, which we had considered during the programmatic consultation, but did not discuss in the opinion. The following narratives represent that expanded discussion.

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 pressure waves or sound fields produced by the 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.

Larval rockfish occur over areas that extend several hundred miles offshore where they are passively dispersed by ocean currents and remain in larval form and as small juveniles for several months (Auth and Brodeur 2006; Moser and Boehlert 1991). They appear to concentrate over the continental shelf and slope, but have been captured more than 250 nautical miles offshore of the Oregon coast (Moser and Boehlert 1991). Larval rockfish have been reported to be uniformly distributed at depths of 13, 37, and 117 meters below surface, so they occur at depths that would bring them into sound fields produced by mid-frequency active sonar (Lenarz et al. 1991). Larval bocaccio had highest abundance at depths of 13 meters, but were also captured in the 117-meter samples. Larval canary rockfish were captured at all three depths, but their densities were highest at the 37- and 177-meter depths (Lenarz et al. 1991).

Because of the small size of the adult, breeding population of endangered and threatened rockfish, the large area over which those larvae are likely to disperse, and their low relative frequency (that is, their density as a percent of the density of the larvae of the more abundance species of rockfish), the density of larvae of endangered or threatened rockfish will be very small offshore. Of the three species, Georgia Basin bocaccio are likely to have the smallest densities because the size of the adult, breeding population in this species is very small and they have the lowest fecundities of the three species. Nevertheless, the density of Georgia Basin canary rockfish and Georgia Basin yelloweye rockfish are also very small relative to the densities of other, non-listed rockfish that have much larger adult population sizes and fecundities that overlap with those of yelloweye rockfish (which are the most fecund of the endangered or threatened rockfish). As a result, although larval rockfish are likely to be exposed to sound fields and pressure waves associated with active sonar training activities on the Northwest Training Range Complex, larval Georgia Basin bocaccio, canary rockfish, and yelloweye rockfish are not likely to be exposed to those sound fields or pressure waves.

Our June 2010 Programmatic Biological Opinion and the exposure analyses we conducted during our consultation on the proposed LOA concluded that southern green sturgeon, Pacific salmon and steelhead, and the southern population of eulachon were likely to be exposed to the sound field produced by mid-frequency active sonar and underwater detonations, although we

did not have the information we would have needed (density estimates for each species) to conduct quantitative exposure analyses. Nevertheless, we made the following assumptions:

1. Green sturgeon are likely to be exposed to training activities that occur in coastal areas of the Northwest Training Range Complex (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 Northwest Training Range Complex 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 Northwest Training Range Complex (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 Crescent Harbor, Port Townsend Bay, and Bangor in northern Hood Canal. Using a similar approach we applied in our 2008 biological opinion, such that we 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 Crescent Harbor; six adult Puget Sound Chinook salmon deaths during each underwater detonation at Hood Canal; and 27 dead adult Hood Canal summer-run Chinook salmon during each underwater detonation at SUBASE Bangor.

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, Port Townsend Bay, and Bangor in northern Hood Canal.

Because the U.S. Navy has chosen to exclude mid-frequency active sonar training in Puget Sound from the scope of their proposed action, we assume that none of these endangered and threatened fish species are likely to be exposed to mid-frequency active sonar in Puget Sound.

5.3 Response Analysis

The response analyses are designed to identify how endangered or threatened species (or designated critical habitat, when it is applicable) are likely to respond given their exposure to one or more of the stressors produced by different components of a proposed action. These analyses consider and weigh all of the evidence available, including the best scientific and commercial data available, to identify the probable responses of endangered and threatened species upon being exposed to stressors associated with proposed actions.

This section is organized by species or species group (in the case of fishes) that are likely to be exposed to stressors associated with the Navy's military readiness activities. These narratives do not repeat the extensive reviews of the available scientific and commercial literature that formed the foundation for the response analyses we presented in our June 2010 Programmatic Biological Opinion. Interested readers should refer to that document for those reviews. However, we summarize new information regarding potential responses to the stressors where applicable.

5.3.1 Responses to Disturbance from Vessel Traffic

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. 2006b; Bryant et al. 1984; Corkeron 1995; David 2002; Felix 2001; Goodwin and Cotton 2004; Hewitt 1985; Lusseau 2003; Lusseau 2006; Magalhaes et al. 2002; Nowacek et al. 2001; Richter et al. 2006; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005b; Watkins 1986; Williams and Ashe 2007; Williams et al. 2002b; 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 1991; Lusseau 2003; Nowacek et al. 2001; Stensland and Berggren 2007; 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 1985; Kruse 1991; 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 1991; 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. 2002b). 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 1991). 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 1991). 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 (1985) 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. 1995). 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. Additional information regarding each listed species is provided below. 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 Northwest Training Range Complex are likely to be exposed to visual and acoustic stimuli associated with vessel traffic and related activities. Because the proposed 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 during these small activities and any response to an exposure would be temporary.

5.3.2 Responses to Active Sonar and Underwater Detonations

The information that follows is presented as if endangered or threatened marine animals that occur on the Northwest Training Range Complexes would only be exposed to high- or mid-frequency active sonar or sound pressure waves associated with underwater detonations when, in fact, any individuals that occur in the area of a training event would be exposed to multiple potential stressors and would be responding to a wide array of cues from their environment including natural cues from other members of their social group, from predators, and other living

organisms. However, the information that is available generally focuses on the physical, physiological, and behavioral responses of marine mammals to one or two stressors or environmental cues rather than the suite of anthropogenic and natural stressors that most free-ranging animals must contend with in their daily existence. We present the information from studies that investigated the responses of animals to one or two stressors, but we remain aware that we might observe very different results if we presented those same animals with the suite of stressors and cues they would encounter in the wild.

Physical Damage: For the purposes of this assessment, an injury is physical trauma or damage that is a direct result of an acoustic exposure, regardless of the potential consequences of that injury to an animal (we distinguish between injuries that result from an acoustic exposure and injuries that result from an animal's behavioral reaction to an acoustic exposure, which are discussed later in this section of the Opinion). Based on the literature available, active sonar might injure marine animals through two mechanisms: acoustic resonance and noise-induced loss of hearing sensitivity (more commonly-called threshold shift).

Acoustic Resonance: Acoustic resonance results from hydraulic damage in tissues that are filled with gas or air that resonates when exposed to acoustic signals (Rommel et al. 2007). Based on studies of lesions in beaked whales that stranded in the Canary Islands and Bahamas associated with exposure to naval exercises that involved sonar, investigators have identified two physiological mechanisms that might explain some of those stranding events: tissue damage resulting from resonance effects (Cudahy and Ellison 2002; Ketten et al. 2004) and tissue damage resulting from gas and fat embolic syndrome (Fernández et al. 2005; Jepson et al. 2003). Fat and gas embolisms are believed to occur when tissues are supersaturated with dissolved nitrogen gas and diffusion facilitated by bubble-growth is stimulated within those tissues (the bubble growth results in embolisms analogous to the bends in human divers).

Cudahy and Ellison (2002) analyzed the potential for resonance from low frequency sonar signals to cause injury and concluded that the expected threshold for *in vivo* (in the living body) tissue damage for underwater sound is on the order of 180 to 190 dB. There is limited direct empirical evidence (beyond Schlundt et al. 2000) to support a conclusion that 180 dB is "safe" for marine mammals; however, evidence from marine mammal vocalizations suggests that 180 dB is not likely to physically injure marine mammals. For example, Frankel (1994) estimated the source level for singing humpback whales to be between 170 and 175 dB; McDonald et al. (2001) calculated the average source level for blue whale calls as 186 dB, Watkins et al. (1987) found source levels for fin whales up to 186 dB, and Møhl et al. (2000) recorded source levels for sperm whale clicks up to 223 dB_{rms}. Because whales are not likely to communicate at source levels that would damage the tissues of other members of their species, this evidence suggests

that these source levels are not likely to damage the tissues of the endangered and threatened species being considered in this consultation.

Crum and Mao (1994) hypothesized that received levels would have to exceed 190 dB in order for there to be the possibility of significant bubble growth due to super-saturation of gases in the blood. Jepson et al. (2003; 2005) and Fernández et al. (2004; 2005) concluded that *in vivo* bubble formation, which may be exacerbated by deep, long- duration, repetitive dives may explain why beaked whales appear to be particularly vulnerable to sonar exposures.

A recent paper by Kvadsheim et al. (2012) explored the risk of decompression sickness in several cetacean species. Their model estimates suggest that shallow (killer whales), intermediate (pilot whales) and deep diving whales (sperm whales, Cuvier's beaked whale, and Blainville's beaked whale) all live with high blood and tissue PN2 levels, but the deep divers seem to experience the most extreme values. The deep diving sperm whales which respond to sonar exposure by shallower but still deep diving were found to increase risk of decompression sickness, but not beyond the normal risk range of sperm whales. Further, they found no systematic changes during sonar exposure in the other species, for some animals PN2 level appeared to increase slightly, while for others it decreased. However, the variation increased with dive depth. Their results suggest that all species have natural high N2 levels, with deep diving generally resulting in higher end-dive PN2 as compared with shallow diving.

Sonar exposure caused some changes in dive behavior in both killer whales, pilot whales and beaked whales, but it did not lead to any increased risk of decompression sickness. However, in three of eight exposure sessions with sperm whales, the animal changed to shallower diving, and in all these cases this seemed to result in an increased risk of DCS, although risk was still within the normal risk range of this species. When a hypothetical removal of the normal dive response (bradycardia and peripheral vasoconstriction), was added to the behavioral response during model simulations, this led to an increased variance in the estimated end-dive N2 levels, but no consistent change of risk. Kvadsheim et al. could not rule out the possibility that a combination of behavioral and physiological responses to sonar have the potential to alter the blood and tissue end-dive N2 tension to levels which could cause decompression sickness and formation of in vivo bubbles, but their actually observed behavioral responses of cetaceans to sonar in their study, did not imply any significantly increased risk of decompression sickness.

Based on the information available, the endangered or threatened marine mammals and sea turtles that we are considering in this Opinion are not likely to experience acoustic resonance. All of the evidence available suggests that this phenomenon poses potential risks to smaller cetaceans like beaked whales rather than the larger cetaceans that have been listed as

endangered. Thus far, this phenomenon has not been reported for or associated with sea turtles, perhaps because they do not engage in dive patterns that are similar to those of beaked whales.

Noise-Induced Loss of Hearing Sensitivity: Noise-induced loss of hearing sensitivity or threshold shift refers to an ear's reduced sensitivity to sound following exposure to loud noises; when an ear's sensitivity to sound has been reduced, sounds must be louder for an animal to detect and recognize it. Noise-induced loss of hearing sensitivity is usually represented by the increase in intensity (in decibels) sounds must have to be detected. These losses in hearing sensitivity rarely affect the entire frequency range an ear might be capable of detecting, instead, they affect the frequency ranges that are roughly equivalent to or slightly higher than the frequency range of the noise itself. Nevertheless, most investigators who study TTS in marine mammals report the frequency range of the noise, which would change as the spectral qualities of a waveform change as it moves through water, rather than the frequency range of the animals they study. Without information on the frequencies of the sounds we consider in this Opinion at the point at which it is received by endangered and threatened marine mammals, we assume that the frequencies are roughly equivalent to the frequencies of the source.

Acoustic exposures can result in three main forms of noise-induced losses in hearing sensitivity: permanent threshold shift, temporary threshold shift, and compound threshold shift (Ward et al. 1998; Yost 2007). When permanent loss of hearing sensitivity, or PTS, occurs, there is physical damage to the sound receptors (hair cells) in the ear that can result in total or partial deafness, or an animal's hearing can be permanently impaired in specific frequency ranges, which can cause the animal to be less sensitive to sounds in that frequency range. Traditionally, investigations of temporary loss of hearing sensitivity, or TTS, have focused on sound receptors (hair cell damage) and have concluded that this form of threshold shift is temporary because hair cell damage does not accompany TTS and losses in hearing sensitivity are short-term and are followed by a period of recovery to pre-exposure hearing sensitivity that can last for minutes, days, or weeks. More recently, however, Kujawa and Liberman (2009) reported on noise-induced degeneration of the cochlear nerve that is a delayed result of acoustic exposures that produce TTS, that occurs in the absence of hair cell damage, and that is irreversible. They concluded that the reversibility of noise induced threshold shifts, or TTS, can disguise progressive neuropathology that would have long-term consequences on an animal's ability to process acoustic information. If this phenomenon occurs in a wide range of species, TTS may have more permanent effects on an animal's hearing sensitivity than earlier studies would lead us to recognize.

Although the published body of science literature contains numerous theoretical studies and discussion papers on hearing impairments that can occur with exposure to a strong sound, only a

few studies provide empirical information on noise-induced loss in hearing sensitivity in marine mammals. Most of the few studies available have reported the responses of captive animals exposed to sounds in controlled experiments. Schlundt et al. (2000), see also Finneran et al. (2003; 2001) provided a detailed summary of the behavioral responses of trained marine mammals during TTS tests conducted at the Navy's SPAWAR Systems Center with 1-second tones. Schlundt et al. (2000), reported on eight individual TTS experiments that were conducted in San Diego Bay. Fatiguing stimuli durations were 1 second. Because of the variable ambient noise in the bay, low-level broadband masking noise was used to keep hearing thresholds consistent despite fluctuations in the ambient noise.

Finneran et al. (2003; 2001) conducted TTS experiments using 1-second duration tones at 3 kHz. The test method was similar to that of Schlundt et al. (2000) except the tests were conducted in a pool with a very low ambient noise level (below 50 dB re 1 μPa2/Hz), and no masking noise was used. The signal was a sinusoidal amplitude modulated tone with a carrier frequency of 12 kHz, modulating frequency of 7 Hz, and SPL of approximately 100 dB re 1 μPa. Two separate experiments were conducted. In the first, fatiguing sound levels were increased from 160 to 201 dB SPL. In the second experiment, fatiguing sound levels between 180 and 200 dB re 1 μPa were randomly presented. Richardson et al.(1995) hypothesized that marine mammals within less than 100 meters of a sonar source might be exposed to mid-frequency active sonar transmissions at received levels greater than 205 dB re 1 Pa which might cause TTS. However, there is no empirical evidence that exposure to active sonar transmissions with this kind of intensity can cause PTS in any marine mammals; instead the probability of PTS has been inferred from studies of TTS (see Richardson et al. 1995). On the other hand, Kujawa and Liberman (2009) argued that traditional testing of threshold shifts, which have focused based on recovery of threshold sensitivities after exposure to noise, would miss acute loss of afferent nerve terminals and chronic degeneration of the cochlear nerve, which would have the effect of permanently reducing an animal's ability to perceive and process acoustic signals. Based on their studies of small mammals, Kujawa and Liberman (2009) reported that two hours of acoustic exposures produced moderate temporary threshold shifts but caused delayed losses of afferent nerve terminals and chronic degeneration of the cochlear nerve in test animals.

Despite the extensive amount of attention given to threshold shifts by researchers, environmental assessments conducted by the Navy and seismic survey operators, and its use in permits issued by NMFS Permits Division, it is not certain that threshold shifts are common. Several variables affect the amount of loss in hearing sensitivity: the level, duration, spectral content, and temporal pattern of exposure to an acoustic stimulus as well as differences in the sensitivity of individuals and species. All of these factors combine to determine whether an individual organism is likely to experience a loss in hearing sensitivity as a result of acoustic exposure (Ward et al. 1998; Yost

2007). In free-ranging marine mammals, an animal's behavioral responses to a single acoustic exposure or a series of acoustic exposure events would also determine whether the animal is likely to experience losses in hearing sensitivity as a result of acoustic exposure. Unlike humans whose occupations or living conditions expose them to sources of potentially-harmful noise, in most circumstances, free-ranging animals are not likely to remain in a sound field that contains potentially harmful levels of noise unless they have a compelling reason to do so (for example, if they must feed or reproduce in a specific location). Any behavioral responses that would take an animal out of a sound field or reduce the intensity of its exposure to the sound field would also reduce the animal's probability of experiencing noise-induced losses in hearing sensitivity.

More importantly, the data on captive animals and the limited information from free-ranging animals suggest that temporary noise-induced hearing losses do not have direct or indirect effect on the longevity or reproductive success of animals with this affliction. Like humans, free-ranging animals might experience short-term impairment in their ability to use their sense of hearing to detect environmental cues while their ears recover from the temporary loss of hearing sensitivity. Although we could not locate information regarding how animals that experience noise induced hearing loss alter their behavior or the consequences of any altered behavior on the lifetime reproductive success of those individuals, the limited information available would not lead us to expect temporary losses in hearing sensitivity to incrementally reduce the lifetime reproductive success of animals.

Behavioral Responses: Marine animals have not had the time and have not experienced the selective pressure necessary for them to have evolved a behavioral repertoire containing a set of potential responses to active sonar, other potential stressors associated with naval military readiness activities, or human disturbance generally. Instead, marine animals invoke behavioral responses that are already in their behavioral repertoire to decide how they will behaviorally respond to active sonar, other potential stressors associated with naval military readiness activities, or human disturbance generally. An extensive number of studies have established that these animals will invoke the same behavioral responses they would invoke when faced with predation and will make the same ecological considerations when they experience human disturbance that they make when they perceive they have some risk of predation (Beale and Monaghan 2004b; Frid 2003; Frid and Dill 2002; Gill and Sutherland 2001; Harrington and Veitch 1992; Lima 1998; Romero 2004). Specifically, when animals are faced with a predator or predatory stimulus, they consider the risks of predation, the costs of anti-predator behavior, and the benefits of continuing a pre-existing behavioral pattern when deciding which behavioral response is appropriate in a given circumstance (Bejder et al. 2009; Gill and Sutherland 2001; Houston et al. 1993; Lima 1998; Lima and Bednekoff 1999; Ydenberg and Dills 1986). Further,

animals appear to detect and adjust their responses to temporal variation in predation risks (Lima and Bednekoff 1999; Rodriguez-Prieto et al. 2009).

The level of risk an animal perceives results from a combination of factors that include the perceived distance between an animal and a potential predator, whether the potential predator is approaching the animal or moving tangential to the animal, the number of times the potential predator changes its vector (or evidence that the potential predator might begin an approach), the speed of any approach, the availability of refugia, and the health or somatic condition of the animal, for example, along with factors related to natural predation risk (Frid and Dill 2002; Papouchis et al. 2001). In response to a perceived threat, animals can experience physiological changes that prepare them for flight or fight responses or they can experience physiological changes with chronic exposure to stressors that have more serious consequences such as interruptions of essential behavioral or physiological events, alteration of an animal's time budget, or some combination of these responses (Frid and Dill 2002; Romero 2004; Sapolsky 2000; Walker et al. 2005).

The behavioral responses of animals to human disturbance have been documented to cause animals to abandon nesting and foraging sites (Sutherland and Crockford 1993), cause animals to increase their activity levels and suffer premature deaths or reduced reproductive success when their energy expenditures exceed their energy budgets (Daan et al. 1996; Feare 1976; Giese 1996; Müllner et al. 2004), or cause animals to experience higher predation rates when they adopt risk-prone foraging or migratory strategies (Frid and Dill 2002).

Based on the evidence available from empirical studies of animal responses to human disturbance, marine animals are likely to exhibit one of several behavioral responses upon being exposed to sonar transmissions: (1) they may engage in horizontal or vertical avoidance behavior to avoid exposure or continued exposure to a sound that is painful, noxious, or that they perceive as threatening; (2) they may engage in evasive behavior to escape exposure or continued exposure to a sound that is painful, noxious, or that they perceive as threatening, which we would assume would be accompanied by acute stress physiology; (3) they may remain continuously vigilant of the source of the acoustic stimulus, which would alter their time budget. That is, during the time they are vigilant, they are not engaged in other behavior; and (4) they may continue their pre-disturbance behavior and cope with the physiological consequences of continued exposure.

Marine animals might experience one of these behavioral responses, they might experience a sequence of several of these behaviors (for example, an animal might continue its pre-disturbance behavior for a period of time, then abandon an area after it experiences the

consequences of physiological stress) or one of these behaviors might accompany responses such as permanent or temporary loss in hearing sensitivity. The narratives that follow summarize the information available on these behavioral responses.

Behavioral Avoidance of Initial Exposures or Continued Exposure: As used in this Opinion, behavioral avoidance refers to animals that abandon an area in which active sonar is being used to avoid being exposed to the sonar (regardless of how long it takes them to return to the area after they have abandoned it), animals that avoid being exposed to the entire sound field produced by active sonar; and animals that avoid being exposed to particular received levels within a sound field produced by active sonar. Richardson et al. (1979) noted that avoidance reactions are the most obvious manifestations of disturbance in marine mammals. There are few empirical studies of avoidance responses of free-living cetaceans to mid-frequency sonar.

However, Kvadsheim et al. (2007) conducted a controlled exposure experiment in which killer whales (*Orcinus orca*) that had been fitted with D-tags were exposed to mid-frequency active sonar (Source A: was a 1.0 s upsweep 209 dB @ 1 - 2 kHz every 10 seconds for 10 minutes; Source B: was a 1.0 s upsweep 197 dB @ 6 - 7 kHz every 10 s for 10 min). When exposed to Source A, a tagged killer whale and the group it was traveling with did not appear to avoid the source. When exposed to Source B, the tagged whales along with other whales that had been carousel feeding, ceased feeding during the approach of the sonar and moved rapidly away from the source (the received level associated with this response was not reported). When exposed to Source B, Kvadsheim and his co-workers reported that a tagged killer whale seemed to try to avoid further exposure to the sound field by immediately swimming away (horizontally) from the source of the sound; by engaging in a series of erratic and frequently deep dives that seemed to take it below the sound field; or by swimming away while engaged in a series of erratic and frequently deep dives. Although the sample sizes in this study are too small to support statistical analysis, the behavioral responses of the orcas were consistent with the results of other studies. Maybaum (Maybaum 1993) conducted sound playback experiments to assess the effects of mid-frequency active sonar on humpback whales in Hawaiian waters. Specifically, she exposed focal pods to sounds of a 3.3-kHz sonar pulse, a sonar frequency sweep from 3.1 to 3.6 kHz, and a control (blank) tape while monitoring the behavior, movement, and underwater vocalizations. The two types of sonar signals differed in their effects on the humpback whales, although the whales exhibited avoidance behavior when exposed to both sounds. The whales responded to the pulse by increasing their distance from the sound source and responded to the frequency sweep by increasing their swimming speeds and track linearity.

Tyack et al. (Tyack et al. 2011) studied beaked whales in a naval underwater range where sonars were in regular use near Andros Island, Bahamas. An array of bottom-mounted hydrophones

detected beaked whales when they click anywhere within the range area. They used two complementary methods to investigate behavioral responses of beaked whales to sonar: an opportunistic approach that monitored whale responses to multi-day naval exercises involving tactical mid-frequency sonars, and an experimental approach using playbacks of simulated sonar and control sounds to whales tagged with a device that records sound, movement, and orientation. They found that in both exposure conditions beaked whales stopped echolocating during deep foraging dives and moved away. During actual sonar exercises, beaked whales were primarily detected near the periphery of the range, on average 16 km away from the sonar transmissions. Once the exercise stopped, beaked whales gradually filled in the center of the range over 2–3 days. A satellite tagged whale moved outside the range during an exercise, returning over 2–3 days post-exercise (Tyack et al. 2011). Their experimental approach used tags to measure acoustic exposure and behavioral reactions of beaked whales to one controlled exposure each of simulated military sonar, killer whale calls, and band-limited noise. The beaked whales reacted to these three sound playbacks at sound pressure levels below 142 dB re 1µPa by stopping echolocation followed by unusually long and slow ascents from their foraging dives.

McCarthy et al (2011) investigated changes in spatial and temporal distribution of vocal behavior of Blainville's beaked whales during multiship exercises with mid-frequency sonar. They found a decline in vocalization activity associated with foraging groups of Blainville's beaked whales during military exercises and postulated three possible explanations: (1) the animals moved off the range but continued to vocalize, (2) the animals did not vocalize during the military operations, or (3) the system failed to detect whale vocalizations in the midst of noise associated with military operations (i.e., masking occurred). The results of their analysis strongly suggest that the animals avoided ships using active sonar and moved off range during such exercises. Further, the data suggest animals return to the range after the cessation of sonar activity.

As stated above, Tyack et al. (2011) investigated the behavioral responses of beaked whales to multi-day naval exercises involving mid-frequency active sonar, playbacks of simulated sonar, and recorded killer whale calls with a device that records sound, movement, and orientation at the Atlantic Undersea Test and Evaluation Center (AUTEC), in the Tongue of the Ocean near Andros Island in the Bahamas. Tyack et al. (Tyack et al. 2011) found that beaked whales stopped echolocating during deep foraging dives and moved away from both simulated active sonar and killer whale sounds. During actual sonar exercises, beaked whales were primarily detected near the periphery of the range, on average 16 km away from the sonar transmissions. Once the exercise stopped, beaked whales gradually filled in the center of the range over 2–3 days. A satellite tagged whale moved outside the range during an exercise, returning over 2–3 days post-exercise. The beaked whales reacted to these three sound playbacks at sound pressure levels

below 142 dB re 1 µPa by stopping echolocation followed by unusually long and slow ascents from their foraging dives.

Tyack et al. (Tyack et al. 2011) stated that there was no evidence that beaked whales at AUTEC have stranded during periods when naval mid-frequency active sonar is being used, only that beaked whales move out of the area where sonar was being operated. Further, they noted that the avoidance responses reduce exposure to sonar which was a similar response to playback of killer whale sounds. In both, the active sonar and the killer whale sound scenarios, the beaked whales exhibited a similar prolonged avoidance response. The tagged whales responded to the sonar exercise and to the killer whale playback not with panicked flight, but with well oriented swimming toward the only deep water exit from the Tongue of the Ocean (Tyack et al. 2011).

Pirotta et al. (2012) used the AUTEC facility to investigate how vessel noise affects beaked whale behavior. They conducted an experiment involving the exposure of target whale groups to intense vessel-generated noise to test how these exposures influenced the foraging behavior of Blainville's beaked whales in the Tongue of the Ocean (Bahamas). They found that the duration of foraging bouts was not significantly affected by exposure to vessel noise. Although changes in the hydrophone over which the group was most frequently detected occurred as the animals moved around within a foraging bout, and their number was significantly less the closer the whales were to the sound source. Non-exposed groups also had significantly more changes in the primary hydrophone than exposed groups irrespective of distance. They suggest that broadband ship noise caused a significant change in beaked whale behavior up to at least 5.2 kilometers away from the vessel.

In the Caribbean, sperm whales avoided exposure to mid-frequency submarine sonar pulses, in the range 1000 Hz to 10,000 Hz (IWC 2005). Blue and fin whales have occasionally been reported in areas ensonified by airgun pulses; however, there have been no systematic analyses of their behavioral reactions to airguns. Sightings by observers on seismic vessels off the United Kingdom suggest that, at times of good sight-ability, the number of blue, fin, sei, and humpback whales seen when airguns are shooting are similar to the numbers seen when the airguns are not shooting (Stone 1997; Stone 1998; Stone 2000; Stone 2001; Stone 2003a). However, fin and sei whale sighting rates were higher when airguns were shooting, which may result from their tendency to remain at or near the surface at times of airgun operation (Stone 2003a). The analysis of the combined data from all years indicated that baleen whales stayed farther from airguns during periods of shooting (Stone 2003a) . Baleen whales also altered course more often during periods of shooting and more were headed away from the vessel at these times, indicating some level of localized avoidance of seismic activity (Stone 2003a).

Sperm whales responded to military sonar, apparently from a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent and becoming difficult to approach (Watkins 1985). Brownell (2004) reported the behavioral responses of western gray whales off the northeast coast of Sakhalin Island to sounds produced by seismic activities in that region. In 1997, the gray whales responded to seismic activities by changing their swimming speed and orientation, respiration rates, and distribution in waters around the seismic surveys. In 2001, seismic activities were conducted in a known feeding area of these whales and the whales left the feeding area and moved to areas farther south in the Sea of Okhotsk. They only returned to the feeding area several days after the seismic activities stopped. The potential fitness consequences of displacing these whales, especially mother-calf pairs and skinny whales, outside of their normal feeding area is not known; however, because gray whales, like other large whales, must gain enough energy during the summer foraging season to last them the entire year, sounds or other stimuli that cause them to abandon a foraging area for several days seems almost certain to disrupt their energetics and force them to make trade-offs like delaying their migration south, delaying reproduction, reducing growth, or migrating with reduced energy reserves.

Captive bottlenose dolphins and a beluga whale exhibited changes in behavior when exposed to 1 second pulsed sounds at frequencies similar to those emitted by the multi-beam sonar that is used by geophysical surveys (Ridgway and Carder 1997; Schlundt et al. 2000), and to shorter broadband pulsed signals (Finneran et al. 2000; Finneran et al. 2002a).

Behavioral changes typically involved 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. 2002b; Schlundt et al. 2000). Dolphins exposed to 1-sec intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa_{rms} and belugas did so at received levels of 180 to 196 dB and above. Received levels necessary to elicit such responses to shorter pulses were higher (Finneran et al. 2000; Finneran et al. 2002a). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran et al. 2002b). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway and Carder 1997; Schlundt et al. 2000). It is not clear whether or to what degree the responses of captive animals might be representative of the responses of marine animals in the wild. For example, wild cetaceans sometimes avoid sound sources well before they are exposed to received levels such as those used in these experiments. Further, the responses of marine animals in the wild may be more subtle than those described by Ridgway et al. (1997) and Schlundt et al. (2000).

Richardson et al. (1995) and Richardson and Wursig (1997) used controlled playback experiments to study the response of bowhead whales in Arctic Alaska. In their studies, bowhead whales tended to avoid drill ship noise at estimated received levels of 110 to 115 dB and seismic sources at estimated received levels of 110 to 132 dB. Richardson et al. (1995) concluded that some marine mammals would tolerate continuous sound at received levels above 120 dB re 1 Pa for a few hours. These authors concluded that most marine mammals would avoid exposures to received levels of continuous underwater noise greater than 140 dB when source frequencies were in the animal's most sensitive hearing range.

Several authors noted that migrating whales are likely to avoid stationary sound sources by deflecting their course slightly as they approached a source (LGL and Greenridge 1987 in Richardson et al. 1995). Malme et al. (1983; 1984) studied the behavioral responses of gray whales that were migrating along the California coast to various sound sources located in their migration corridor. The whales they studied showed statistically significant responses to four different underwater playbacks of continuous sound at received levels of approximately 120 dB. The sources of the playbacks were typical of a drillship, semi-submersible, drilling platform, and production platform.

Morton et al. (2002) exposed killer whales (*Orcinus orca*) to sounds produced by acoustic harassment devices (devices that were designed to harass harbor seals, source levels were 194 dB at 10 kHz re 1μ Pa at 1 meter). They concluded that observations of killer whales declined dramatically in the experimental area (Broughton Archipelago) during the time interval the harassment devices had been used (but not before or after the use). Other investigators have concluded that gray whales and humpback whales abandoned some of their coastal habitat in California and Hawai′i, respectively, because of underwater noise associated with extensive vessel traffic (Gard 1974; Reeves 1977; Salden 1988).

Nowacek et al. (Nowacek et al. 2004) conducted controlled exposure experiments on North Atlantic right whales using ship noise, social sounds of con-specifics, and an alerting stimulus (frequency modulated tonal signals between 500 Hz and 4.5 kHz). Animals were tagged with acoustic sensors (D-tags) that simultaneously measured movement in three dimensions. Whales reacted strongly to alert signals at received levels of 133-148 dB SPL, mildly to conspecific signals, and not at all to ship sounds or actual vessels. The alert stimulus caused whales to immediately cease foraging behavior and swim rapidly to the surface. Several studies have demonstrated that cetaceans will avoid human activities such as vessel traffic, introduced sounds in the marine environment, or both. Lusseau (Lusseau 2003) reported that bottlenose dolphins in Doubtful Sound, New Zealand, avoided approaching tour boats by increasing their mean diving interval. Male dolphins began to avoid tour boats before the boats were in visible range, while

female dolphins only began to avoid the boats when the boats became intrusive (he attributed the differential responses to differences in energetics: the larger body size of male dolphins would allow them to compensate for the energy costs of the avoidance behavior more than female dolphins). Bejder et al. (2006a) studied the effects of vessel traffic on bottlenose dolphins in Shark Bay, Australia, over three consecutive 4.5-year periods. They reported that the dolphins avoided the bay when two tour operators began to operate in the bay.

Marine mammals may avoid or abandon an area temporarily during periods of high traffic or noise, returning when the source of the disturbance declines below some threshold (Allen and Read. 2000; Lusseau 2004). Alternatively, they might abandon an area for as long as the disturbance persists. For example, Bryant et al. (1984 in Polefka 2004) reported that gray whales abandoned a calving lagoon in Baja California, Mexico following the initiation of dredging and increase in small vessel traffic. After the noise-producing activities stopped, the cow-calf pairs returned to the lagoon; the investigators did not report the consequences of that avoidance on the gray whales. Gard (1974) and Reeves (1977) reported that underwater noise associated with vessel traffic had caused gray whales to abandon some of their habitat in California for several years. Salden (1988) suggested that humpback whales avoid some nearshore waters in Hawaiʹi for the same reason.

As Bejder et al. (2009; 2006a) argued, animals that are faced with human disturbance must evaluate the costs and benefits of relocating to alternative locations; those decisions would be influenced by the availability of alternative locations, the distance to the alternative locations, the quality of the resources at the alternative locations, the conditions of the animals faced with the decision, and their ability to cope with or escape the disturbance (citing Beale and Monaghan 2004a; Beale and Monaghan 2004b; Frid and Dill 2002; Gill and Sutherland 2001; Lima and Dill. 1990). Specifically, animals delay their decision to flee from predators and predatory stimuli that they detect, or until they decide that the benefits of fleeing a location are greater than the costs of remaining at the location or, conversely, until the costs of remaining at a location are greater than the benefits of fleeing (Ydenberg and Dills 1986). Ydenberg and Dill (1986) and Blumstein (2003) presented an economic model that recognized that animals will almost always choose to flee a site over some short distance to a predator; at a greater distance, animals will make an economic decision that weighs the costs and benefits of fleeing or remaining; and at an even greater distance, animals will almost always choose not to flee.

Based on a review of observations of the behavioral responses of 122 minke whales, 2,259 fin whales, 833 right whales, and 603 humpback whales to various sources of human disturbance, Watkins (1986) reported that fin, humpback, minke, and North Atlantic right whales ignored sounds that occurred at relatively low received levels, that had the most energy at frequencies

below or above their hearing capacities, or that were from distant human activities, even when those sounds had considerable energies at frequencies well within the whale's range of hearing. Most of the negative reactions that had been observed occurred within 100 m of a sound source or when sudden increases in received sound levels were judged to be in excess of 12 dB, relative to previous ambient sounds From these observations, we would have to conclude that the distance between marine mammals and a source of sound, as well as the received level of the sound itself, will help determine whether individual animals are likely to respond to the sound and engage in avoidance behavior.

At the limits of the range of audibility, endangered and threatened marine mammals are likely to ignore cues that they might otherwise detect. At some distance that is closer to the source, endangered or threatened marine mammals may be able to detect a sound produced by military readiness activities, but they would not devote attentional resources to the sound (that is, they would filter it out as background noise or ignore it). For example, we would not expect endangered or threatened marine mammals that find themselves between 51 and 130 kilometers (between about 32 and 81 miles) from the source of a sonar ping to devote attentional resources to that stimulus, even though received levels might be as high as 140 dB (at 51 kilometers) because those individuals are more likely to be focusing their attention on stimuli and environmental cues that are considerably closer, even if they were aware of the signal. Those animals that are closer to the source and not engaged in activities that would compete for their attentional resources (for example, mating or foraging) might engage in low-level avoidance behavior (changing the direction of their movement to take them away from or tangential to the source of the disturbance) possibly accompanied by short-term vigilance behavior, but they are not likely to change their behavioral state (that is, animals that are foraging or migrating would continue to do so). For example, we would expect endangered or threatened marine mammals that find themselves between 25 and 51 kilometers (between about 15.5 and 32 miles) from a sonar transmission where received levels might range from 140 and 150 dB to engage in low-level avoidance behavior or short-term vigilance behavior, but they are not likely to change their behavioral state as a result of that exposure. At some distance that is closer still, these species are likely to engage in more active avoidance behavior followed by subsequent low-level avoidance behavior that does not bring them closer to the training activity. At the closest distances, we assume that endangered and threatened marine mammals would engage in vertical and horizontal avoidance behavior unless they have a compelling reason to remain in a location (for example, to feed). In some circumstances, this would involve abrupt vertical or horizontal movement accompanied by physiological stress responses.

The evidence available also suggests that marine mammals might experience more severe consequences if an acoustic cue associated with active sonar leads them to perceive they face an

imminent threat, but circumstances do not allow them to avoid or escape further exposure. At least six circumstances might prevent an animal from escaping further exposure to mid-frequency active sonar and could produce any of one the following outcomes: 1) when swimming away (an attempted escape) brings marine mammals into a shallow coastal feature that causes them to strand; 2) they cannot swim away because the exposure occurred in a coastal feature that leaves marine mammals no escape route (for example, a coastal embayment or fjord that surrounds them with land on three sides, with the sound field preventing an escape); 3) they cannot swim away because the marine mammals are exposed to multiple sound fields in a coastal or oceanographic feature that act in concert to prevent their escape; 4) they cannot dive below the sound field while swimming away because of shallow depths; 5) to remain below the sound field, they must engage in a series of very deep dives with interrupted attempts to swim to the surface (which might lead to pathologies similar to those of decompression sickness); 6) any combination of these phenomena.

Because many species of marine mammals make repetitive and prolonged dives to great depths, it has long been assumed that marine mammals have evolved physiological mechanisms to protect against the effects of rapid and repeated decompressions. Although several investigators have identified physiological adaptations that may protect marine mammals against nitrogen gas supersaturation (alveolar collapse and elective circulation) (Kooyman et al. 1972; Ridgway and Howard 1979). Ridgway and Howard (1979) reported that bottlenose dolphins (*Tursiops truncatus*) that were trained to dive repeatedly had muscle tissues that were substantially supersaturated with nitrogen gas. Houser et al. (2001) used these data to model the accumulation of nitrogen gas within the muscle tissue of other marine mammal species and concluded that cetaceans that dive deep and have slow ascent or descent speeds would have tissues that are more supersaturated with nitrogen gas than other marine mammals.

The evidence available suggests that whales are likely to engage in vertical or horizontal avoidance behavior in an attempt to avoid continued exposed to mid-frequency active sonar (or, at least, some components of the sound source), the ships associated with the active sonar, or both. However, the process of avoiding exposures can be costly to marine animals if (a) they are forced to abandon a site that is important to their life history (for example, if they are forced to abandon a feeding or calving area), (b) their flight response disrupts an important life history event (for example, reproduction), or (c) their diving pattern becomes sufficiently erratic, or if they strand or experience higher predation risk during the process of abandoning a site.

If whales respond to a Navy vessel that is transmitting active sonar in the same way that they might respond to a predator, their probability of flight responses should increase when they perceive that Navy vessels are approaching them directly, because a direct approach may convey

detection and intent to capture (Burger and Gochfeld 1981; Cooper 1997). The probability of flight responses should also increase as received levels of active sonar increase (and the ship is, therefore, closer) and as ship speeds increase (that is, as approach speeds increase). For example, the probability of flight responses in Dall's sheep *Ovis dalli dalli* (Frid 2003; Frid and Dill 2002), ringed seals *Phoca hispida* (Born et al. 1999), Pacific brant (*Branta bernicl nigricans*) and Canada geese (*B. Canadensis*) increased as a helicopter or fixed-wing aircraft approached groups of these animals more directly (Ward et al. 1999). Bald eagles (*Haliaeetus leucocephalus*) perched on trees alongside a river were also more likely to flee from a paddle raft when their perches were closer to the river or were closer to the ground (Steidl and Anthony 1996).

Vigilance: Attention is the cognitive process of selectively concentrating on one aspect of an animal's environment while ignoring other things (Posner 1994). Because animals (including humans) have limited cognitive resources, there is a limit to how much sensory information they can process at any time. The phenomenon called attentional capture occurs when a stimulus (usually a stimulus that an animal is not concentrating on or attending to) captures an animal's attention. This shift in attention can occur consciously or unconsciously (for example, when an animal hears sounds that it associates with the approach of a predator) and the shift in attention can be sudden (Dukas 2002). Once a stimulus has captured an animal's attention, the animal can respond by ignoring the stimulus, assuming a watch and wait posture, or treat the stimulus as a disturbance and respond accordingly, which includes scanning for the source of the stimulus or vigilance (Cowlishaw et al. 2004).

Vigilance is normally an adaptive behavior that helps animals determine the presence or absence of predators, assess their distance from conspecifics, or to attend cues from prey (Bednekoff and Lima 2002). Despite those benefits, however, vigilance has a cost of time: when animals focus their attention on specific environmental cues, they are not attending to other activities such a foraging. These costs have been documented best in foraging animals, where vigilance has been shown to substantially reduce feeding rates (Beauchamp and Livoreil 1997; Fritz et al. 2002; Saino 1994).

Animals will spend more time being vigilant, which translates to less time foraging or resting, when disturbance stimuli approach them more directly, remain at closer distances, have a greater group size (for example, multiple surface vessels), or when they co-occur with times that an animal perceives increased risk (for example, when they are giving birth or accompanied by a calf). Most of the published literature, however, suggests that direct approaches will increase the amount of time animals will dedicate to being vigilant. For example, bighorn sheep and Dall's sheep dedicated more time being vigilant, and less time resting or foraging, when aircraft made direct approaches over them (Frid 2003; Stockwell et al. 1991).

Several authors have established that long-term and intense disturbance stimuli can cause population declines by reducing the body condition of individuals that have been disturbed, followed by reduced reproductive success, reduced survival, or both (Daan et al. 1996; Madsen 1985). For example, Madsen (1985) reported that pink-footed geese (*Anser brachyrhynchus*) in undisturbed habitat gained body mass and had about a 46 percent reproductive success compared with geese in disturbed habitat (being consistently scared off the fields on which they were foraging) which did not gain mass and has a 17 percent reproductive success. Similar reductions in reproductive success have been reported for mule deer (*Odocoileus hemionus*) disturbed by all-terrain vehicles (Yarmoloy et al. 1988), caribou disturbed by seismic exploration blasts (Bradshaw et al. 1998), caribou disturbed by low-elevation military jet-fights (Luick et al. 1996), and caribou disturbed by low-elevation jet flights (Harrington and Veitch 1992). Similarly, a study of elk (*Cervus elaphus*) that were disturbed experimentally by pedestrians concluded that the ratio of young to mothers was inversely related to disturbance rate (Phillips and Alldredge 2000).

The primary mechanism by which increased vigilance and disturbance appear to affect the fitness of individual animals is by disrupting an animal's time budget and, as a result, reducing the time they might spend foraging and resting (which increases an animal's activity rate and energy demand). For example, a study of grizzly bears (*Ursus horribilis*) reported that bears disturbed by hikers reduced their energy intake by an average of 12 kcal/min (50.2 x 103kJ/min), and spent energy fleeing or acting aggressively toward hikers (White et al. 1999).

Continued Pre-Disturbance Behavior, Habituation, or No Response: Under some circumstances, some individual animals that would be exposed to active sonar transmissions and other sounds associated with military readiness activities will continue the behavioral activities they were engaged in before they were exposed (Richardson et al. 1995). For example, Watkins (1986) reviewed data on the behavioral reactions of fin, humpback, right and minke whales that were exposed to continuous, broadband low-frequency shipping and industrial noise in Cape Cod Bay. He concluded that underwater sound was the primary cause of behavioral reactions in these species of whales and that the whales responded behaviorally to acoustic stimuli within their respective hearing ranges. Watkins also noted that whales showed the strongest behavioral reactions to sounds in the 15 Hz to 28 kHz range, although negative reactions (avoidance, interruptions in vocalizations, etc.) were generally associated with sounds that were either unexpected, too loud, suddenly louder or different, or perceived as being associated with a potential threat (such as an approaching ship on a collision course). In particular, whales seemed to react negatively when they were within 100 m of the source or when received levels increased suddenly in excess of 12 dB relative to ambient sounds. At other times, the whales ignored the source of the signal and all four species habituated to these sounds. Nevertheless, Watkins

concluded that whales ignored most sounds in the background of ambient noise, including the sounds from distant human activities even though these sounds may have had considerable energies at frequencies well within the whale's range of hearing. Further, he noted that fin whales were initially the most sensitive of the four species of whales, followed by humpback whales; right whales were the least likely to be disturbed and generally did not react to low-amplitude engine noise. By the end of his period of study, Watkins (1986) concluded that fin and humpback whales had generally habituated to the continuous, broad-band, noise of Cape Cod Bay while right whales did not appear to change their response.

Aicken et al. (2005) monitored the behavioral responses of marine mammals to a new low-frequency active sonar system that was being developed for use by the British Navy. During those trials, fin whales, sperm whales, Sowerby's beaked whales, long-finned pilot whales (*Globicephala melas*), Atlantic white-sided dolphins, and common bottlenose dolphins were observed and their vocalizations were recorded. These monitoring studies detected no evidence of behavioral responses that the investigators could attribute to exposure to the low-frequency active sonar during these trials (some of the responses the investigators observed may have been to the vessels used for the monitoring).

There are several reasons why such animals might continue their pre-exposure activity:

1. Risk Allocation. When animals are faced with a predator or predatory stimulus, they consider the risks of predation, the costs of anti-predator behavior, and the benefits of continuing a pre-existing behavioral pattern when deciding which behavioral response is appropriate in a given circumstance (Bejder et al. 2009; Gill and Sutherland 2001; Houston et al. 1993; Lima 1998; Lima and Bednekoff 1999; Ydenberg and Dills 1986). Further, animals appear to detect and adjust their responses to temporal variation in predation risks (Lima and Bednekoff 1999; Rodriguez-Prieto et al. 2009). As a result, for animals that decide that the ecological cost of changing their behavior exceeds the benefits of continuing their behavior, we would expect them to continue their pre-existing behavior. For example, baleen whales, which only feed during part of the year and must satisfy their annual energetic needs during the foraging season, are more likely to continue foraging in the face of disturbance. Similarly, a cow accompanied by her calf is less likely to flee or abandon an area at the cost of her calf's survival.

This does not mean, however, that there are no costs involved with continuing pre-disturbance behavior in the face of predation or disturbance. We assume that individual animals that are exposed to sounds associated with military readiness activities will apply the economic model we discussed earlier (Ydenberg and Dills 1986). By extension, we assume that animals that choose to continue their pre-disturbance behavior would have to cope with the costs of doing so,

which will usually involve physiological stress responses and the energetic costs of stress physiology (Frid and Dill 2002).

2. Habituation. When free-ranging animals do not appear to respond when presented with a stimulus, they are commonly said to have become habituated to the stimulus (Bejder and Lusseau. 2008; Rodriguez-Prieto et al. 2009). Habituation has been given several definitions, but we apply the definition developed by Thompson and Spencer (1966) and Groves and Thompson (1970), which are considered classic treatments of the subject, as modified by Rankin et al. (2009): an incremental reduction in an animal's behavioral response to a stimulus that results from repeated stimulation to that stimulus and that does not involve sensory adaptation, sensory fatigue, or motor fatigue. The value of this definition, when compared with other definitions (for example Bejder et al. 2009 citing Thorpe 1963), is that it would lead us to establish that an animal did not experience reduced sensory sensitivity to a stimulus (which would be accompanied by threshold shifts, for example) before we would conclude that the animal had become habituated to the stimulus. Habituation has been traditionally distinguished from sensory adaptation or motor fatigue using dishabituation (presentation of a different stimulus that results in an increase of the decremented response to the original stimulus), by demonstrating stimulus specificity (the response still occurs to other stimuli), or by demonstrating frequency dependent spontaneous recovery (more rapid recovery following stimulation delivered at a high-frequency than following stimulation delivered at a low frequency). Animals are more likely to habituate (and habituate more rapidly) to a stimulus, the less intense the stimulus ((Rankin et al. 2009). Conversely, numerous studies suggest that animals are less likely to habituate (that is, exhibit no significant decline in their responses) as the intensity of the stimulus increases (Rankin et al. 2009).

Further, after animals have become habituated to a stimulus, their responses to that stimulus recover (a process that is called spontaneous recovery) over time, although habituation becomes more rapid and pronounced after a series of habituation-recovery events (a process that is called potentiation of habituation).

3. Decreased Sensitivity. The individuals that might be exposed may have lowered sensitivity to the stimulus. This might occur because the animals are naïve to the potential risks associated with military readiness activities (which would be more common among juveniles than adults) or they have limited sensory sensitivity by physiological constitution or constitutional endowment.

The results reported by Watkins (1986) and Aicken et al. (2005) could be explained either by concluding that the marine mammals had habituated to the sounds or they could be explained by concluding that the animals had made a decision to continue their pre-disturbance behavior

despite the potential risks represented by the sounds (that is, the animals tolerated the disturbance). The results reported by Watkins (1986) are better explained using risk allocation than habituation because he associated the strongest, negative reactions (avoidance, interruptions in vocalizations, etc.) with sounds that were either unexpected, too loud, suddenly louder or different, were perceived as being associated with a potential threat (such as an approaching ship on a collision course), or were from distant human activities despite having considerable energy at frequencies well within the whale's range of hearing (whales would be less likely to respond to cues they would associate with a predator if their distance from the predator preserved their ability to escape a potential attack).

Because it would be difficult to distinguish between animals that continue their pre-disturbance behavior when exposed to active sonar because of a risk-decision and animals that habituate to disturbance (that is, they may have experienced low-level stress responses initially, but those responses abated over time), we do not assume that endangered or threatened marine mammals that do not appear to respond to active sonar or other sounds associated with military readiness activities have become habituated to those sounds. Without more evidence of actual habituation, such an assumption would lead us to fail to protect these species when protection was warranted.

Impaired Communication: Communication is an important component of the daily activity of animals and ultimately contributes to their survival and reproductive success. Animals communicate to find food (Elowson et al. 1991; Marler et al. 1986), acquiring mates (Krakauer et al. 2009; Ryan 1985), assessing other members of their species (Owings et al. 2002; Parker 1974), evading predators (Greig-Smith 1980), and defending resources (Zuberbuhler et al. 1997). Human activities that impair an animal's ability to communicate effectively might have significant effects on the animals experiencing the impairment. Communication usually involves individual animals that are producing a vocalization or visual or chemical display for other individuals. Masking, which we discuss separately (below), affects animals that are trying to receive acoustic cues in their environment, including cues vocalizations from other members of the animals' species or social group. However, anthropogenic noise presents separate challenges for animals that are vocalizing. This subsection addresses the probable responses of individual animals whose attempts to vocalize or communicate are affected by active sonar. When they vocalize, animals are aware of environmental conditions that affect the active space of their vocalizations, which is the maximum area within which their vocalizations can be detected before it drops to the level of ambient noise (Brumm 2004; Lohr et al. 2003). Animals are also aware of environmental conditions that affect whether listeners can discriminate and recognize their vocalizations from other sounds, which are more important than detecting a vocalization (Brumm 2004; Patricelli and Blickley 2006).

Most animals that vocalize have evolved with an ability to make vocal adjustments to their vocalizations to increase the signal-to-noise ratio, active space, and recognizability of their vocalizations in the face of temporary changes in background noise (Brumm 2004; Patricelli and Blickley 2006). Vocalizing animals will make one or more of the following adjustments to preserve the active space and recognizability of their vocalizations:

1. *Adjust the amplitude of vocalizations*. Animals responding in this way increase the amplitude or pitch of their calls and songs by placing more energy into the entire vocalization or, more commonly, shifting the energy into specific portions of the call or song.

This response is called the Lombard reflex or Lombard effect and represents a short-term adaptation to vocalizations in which a signaler increases the amplitude of its vocalizations in response to an increase in the amplitude of background noise (Lombard 1911). This phenomenon has been studied extensively in humans, who raise the amplitude of their voices while talking or singing in the face of high, background levels of sound (Lombard 1911).

Other species experience the same phenomenon when they vocalize in the presence of high levels of background sound. Brumm (2004) studied the songs of territorial male nightingales (*Luscinia megarhynchos*) in the city of Berlin, Germany, to determine whether and to what degree background noise (from automobile traffic) produced a Lombard effect in these birds. Based on his studies, the birds increased the volume of their songs in response to traffic noise by 14 dB (their songs were more than 5 times louder than birds vocalizing in quiet sites). Cynx et al. (1998) reported similar results based on their study of zebra finches (*Taeniopygia guttata*) exposed to white noise.

Although this type of response also has not been studied extensively in marine animals, Holt et al. (2007) reported that endangered southern resident killer whales (*Orcinus orca*) 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.

2. *Adjust the frequency structure of vocalizations*. Animals responding in this way adjust the frequency structure of their calls and songs by increasing the minimum frequency of their vocalizations while maximum frequencies remain the same. This reduces the frequency range of their vocalizations and reduces the amount of overlap between their vocalizations and background noise.

Slabbekorn and Ripmeister (2008), Slabbekorn and den Boer-Visser (2006), and Slabbekorn and Peet (2003a) studied patterns of song variation among individual great tits (*Parus major*) in an urban population in Leiden, The Netherlands, and among 20 different urban and forest

populations across Europe and the United Kingdom. Adult males of this species that occupied territories with more background noise (primarily traffic noise) sang with higher minimum frequencies than males occupying non-urban or quieter sites. Peak or maximum frequencies of these songs did not shift in the face of high background noise.

3. *Adjust temporal structure of vocalizations*. Animals responding this way adjust the temporal structure of their vocalizations by changing the timing of modulations, notes, and syllables within vocalizations or increasing the duration of their calls or songs.

Cody and Brown (1969) studied the songs of adult male Bewick wrens and wrentits that occupied overlapping territories and whose songs had similar physical characteristics (similar song lengths, frequency structure, and amplitude). They reported that wrentits adjusted the timing of their songs so they occurred when the songs of the Bewick wrens subsided.

Ficken et al. (1974) studied vocalizations of ten red-eyed vireos (*Vireo olivaceus*) and least flycatchers (*Empidonax minimus*) at Lake Itasca, Minnesota (a total of 2283 songs). They reported that flycatchers avoided acoustic interference from red-eyed vireos by inserting their shorter songs between the longer songs of the vireos. Although there is some mutual avoidance of acoustic interference, the flycatcher tends more strongly to insert its short songs in between the longer songs of the vireo rather than vice versa. Indeed, most of the overlap occurred when the flycatcher began singing just after the vireo had begun, suggesting that the flycatcher had not heard the vireo begin singing.

A few studies have demonstrated that marine mammals make the same kind of vocal adjustments in the face of high levels of background noise. Miller et al. (2000) recorded the vocal behavior of singing humpback whales continuously for several hours using a towed, calibrated hydrophone array. They recorded at least two songs in which the whales were exposed to low-frequency active sonar transmissions (42 second signals at 6 minute intervals; sonar was broadcast so that none of the singing whales were exposed at received levels greater than 150 dB re 1μPa).

They followed sixteen singing humpback whales during 18 playbacks. In nine follows, whales sang continuously throughout the playback; in four follows, the whale stopped singing when he joined other whales (a normal social interaction); and in five follows, the singer stopped singing, presumably in response to the playback. Of the six whales whose songs they analyzed in detail, songs were 29 percent longer, on average, during the playbacks. Song duration returned to normal after exposure, suggesting that the whale's response to the playback was temporary.

Foote et al. (2004) compared recordings of endangered 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). They suggested that the amount of boat noise may have reached a threshold above which the killer whales needed to increase the duration of their vocalization to avoid masking by the boat noise.

4. *Adjust the temporal delivery of vocalizations*. Animals responding in this way change when they vocalize or change the rate at which they repeat calls or songs. For example, tawny owls (*Strix aluco*) reduce the rate at which they call during rainy conditions (Lengagne and Slater 2002). Brenowitz (1982) concluded that red-winged blackbirds (*Agelaius phoeniceus*) had the largest active space, or broadcast area, for their calls at dawn because of relatively low turbulence and background noise when compared with other times of the day. Brown and Handford (2003) concluded that swamp and white-throated sparrows (*Melospiza georgiana* and *Zonotrichia albicollis*, respectively) tended to sing at dawn, as opposed to other times of the day, because they encountered the fewest impediments to acoustic transmissions during that time of the day.

Many animals will combine several of these strategies to compensate for high levels of background noise. For example, Brumm et al. (2004) reported that common marmosets (*Callithrix jacchus*) increased the median amplitude of the twitter calls as well as the duration of the calls in response to increased background noise. King penguins (*Aptenodytes patagonicus*) increase the number of syllables in a call series and the rate at which they repeat their calls to compensate for high background noise from other penguins in a colony or high winds (Lengagne et al. 1999).

California ground squirrels (*Spermophilus beecheyi*) shifted the frequencies of their alarm calls in the face of high ambient noise from highway traffic (Rabin et al. 2003). However, they only shifted the frequency of the second and third harmonic of these alarm calls, without changing the amount of energy in the first harmonic. By emphasizing the higher harmonics, the ground squirrels placed the peak energy of their alarm calls above the frequency range of the masking noise from the highway. Wood and Yezerinac (2006) reported that song sparrows (*Melospiza melodus*) increased the frequency of the lowest notes in their songs and reduced the amplitude of the low frequency range of their songs. Fernandez-Juricic et al. (2005) reported that house finches (*Carpodacus mexicanus*) adopted the same strategy to compensate for background noise.

Although this form of vocal adjustment has not been studied extensively in marine animals, Dahlheim (1987) studied the effects of man-made noise, including ship, outboard engine and oil-drilling sounds, on gray whale calling and surface behaviors in the San Ignacio Lagoon, Baja, California. She reported statistically significant increases in the calling rates of gray whales and

changes in calling structure (as well as swimming direction and surface behaviors) after exposure to increased noise levels during playback experiments. Although whale responses varied with the type and presentation of the noise source, she reported that gray whales generally increased their calling rates, the level of calls received, the number of frequency-modulated calls, the number of pulses produced per pulsed-call series and call repetition rate as noise levels increased.

Park and Tyack (2007) reported that surface active groups of North Atlantic right whales would adopt this strategy as the level of ambient noise increased. As ambient noise levels increased from low to high, the minimum frequency of right whale scream calls increased from 381.4 Hz (± 16.50), at low levels of ambient noise, to 390.3 Hz (± 15.14) at medium noise levels, to 422.4 Hz (± 15.55) at high noise levels. Surface active groups of North Atlantic right whales would also increase the duration and the inter-call interval of their vocalizations as the level of ambient noise increased. As noise levels increased from low to high, the duration of right whale scream calls would increase from 1.18 seconds (± 0.08) at low levels of ambient noise to 1.22 seconds (± 0.08) at high noise levels (durations decreased to 1.11 seconds ± 0.07 at medium noise levels). The inter-call intervals of these vocalizations would increase from 17.9 seconds (± 5.06) at low levels of ambient noise, to 18.5 seconds (± 4.55) at medium noise levels, to 28.1 seconds (± 4.63) at high noise levels.

Fitness Consequences of Vocal Adjustments. Although the fitness consequences of these vocal adjustments remain unknown, like most other trade-offs animals must make, some of these strategies probably come at a cost (Patricelli and Blickley 2006). For example, vocalizing more loudly in noisy environments may have energetic costs that decrease the net benefits of vocal adjustment and alter the bird's energy budget (Brumm 2004; Wood and Yezerinac 2006). Lambrechts (1996) argued that shifting songs and calls to higher frequencies was also likely to incur energetic costs.

In addition, Patricelli et al. (2006) argued that females of many species use the songs and calls of males to determine whether a male is an appropriate potential mate (that is, they must recognize the singer as a member of their species); if males must adjust the frequency or temporal features of their vocalizations to avoid masking by noise, they may no longer be recognized by conspecific females ((Brumm 2004; Slabbekoorn and Peet 2003b; Wood and Yezerinac 2006). Although this line of reasoning was developed for bird species, the same line of reasoning should apply to marine mammals, particularly for species like fin and sei whales whose song structures appear to be very similar. However, if an animal fails to make vocal adjustments in the presence of masking noise, that failure might cause the animal to experience reduced reproductive success or longevity because it fails to communicate effectively with other members of its species or social group, including potential mates.

Masking. Marine mammals use acoustic signals for a variety of purposes, which differ among species, but include communication between individuals, navigation, foraging, reproduction, and learning about their environment (Erbe and Farmer 2000; Tyack and Clark 2000). Masking, or auditory interference, generally occurs when sounds in an animal's environment are louder than and of a similar frequency to, acoustic signals on which the animal is trying to focus.

Masking can occur (1) when competing sounds reduce or eliminate the salience of the acoustic signal or cue on which the animal is trying to focus or (2) when the spectral characteristics of competing sounds reduce or eliminate the coherence of acoustic signals on which the animal is trying to focus. In the former, the masking noise might prevent a focal signal from being salient to an animal; in the latter, the masking noise might prevent a focal signal from being coherent to an animal. Masking, therefore, is a phenomenon that affects animals that are trying to receive acoustic information about their environment, including sounds from other members of their species, predators, prey, and sounds that allow them to orient in their environment. Masking these acoustic signals can disturb the behavior of individual animals, groups of animals, or entire populations.

Richardson et al. (1995) argued that the maximum radius of influence of an industrial noise (including broadband low frequency sound transmission) on a marine mammal is the distance from the source to the point at which the noise can barely be heard. This range is determined by either the hearing sensitivity of the animal or the background noise level present. Industrial masking is most likely to affect some species' ability to detect communication calls and natural sounds (i.e., vocalizations from other members of its species, surf noise, prey noise, etc.; Richardson et al. 1995).

Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses produced 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). Furthermore, because of their apparent role as important predators of mesopelagic squid and fish, changes in their abundance could affect the distribution and abundance of other marine species.

The echolocation calls of toothed whales are subject to masking by high frequency sound. Human data indicate low frequency sound can mask high frequency sounds (i.e., upward masking). Studies on captive odontocetes by Au et al. (Au 1993; Au et al. 1985; Au et al. 1974)

indicate that some species may use various processes to reduce masking effects (e.g., adjustments in echolocation call intensity or frequency as a function of background noise conditions). There is also evidence that the directional hearing abilities of odontocetes are useful in reducing masking at the high frequencies these cetaceans use to echolocate, but not at the low-to-moderate frequencies they use to communication (Zaitseva et al. 1980).

Allostasis: Classic stress responses begin when an animal's central nervous system perceives a potential threat to its homeostasis. That perception triggers stress responses regardless of whether a stimulus actually threatens the animal; the mere perception of a threat is sufficient to trigger a stress response (Moberg 2000; Sapolsky 2006; Selye 1950). Once an animal's central nervous system perceives a threat, it mounts a biological response or defense that consists of a combination of the four general biological defense responses: behavioral responses, autonomic nervous system responses, neuroendocrine responses, or immune responses.

In the case of many stressors, an animal's first and most economical (in terms of biotic costs) response is behavioral avoidance of the potential stressor or avoidance of continued exposure to a stressor. An animal's second line of defense to stressors involves the autonomic nervous system and the classical fight or flight response which includes the cardiovascular system, the gastrointestinal system, the exocrine glands, and the adrenal medulla to produce changes in heart rate, blood pressure, and gastrointestinal activity that humans commonly associate with stress. These responses have a relatively short duration and may or may not have significant long term effect on an animal's welfare.

An animal's third line of defense to stressors involves its neuroendocrine or sympathetic nervous systems; the system that has received the most study has been the hypothalmus-pituitary-adrenal system (also known as the HPA axis in mammals or the hypothalamus-pituitary-interrenal axis in fish and some reptiles). Unlike stress responses associated with the autonomic nervous system, virtually all neuroendocrine functions that are affected by stress – including immune competence, reproduction, metabolism, and behavior – are regulated by pituitary hormones. Stress-induced changes in the secretion of pituitary hormones have been implicated in failed reproduction (Moberg 2000) and altered metabolism (Elsasser et al. 2000), reduced immune competence (Blecha 2000) and behavioral disturbance. Increases in the circulation of glucocorticosteroids (cortisol, corticosterone, and aldosterone in marine mammals) have been equated with stress for many years (Romano et al. 2004).

The primary distinction between stress (which is adaptive and does not normally place an animal at risk) and distress is the biotic cost of the response. During a stress response, an animal uses glycogen stores that can be quickly replenished once the stress is alleviated. In such

circumstances, the cost of the stress response would not pose a risk to the animal's welfare. However, when an animal does not have sufficient energy reserves to satisfy the energetic costs of a stress response, energy resources must be diverted from other biotic functions which impair those functions that experience the diversion. For example, when mounting a stress response diverts energy away from growth in young animals, those animals may experience stunted growth. When mounting a stress response diverts energy from a fetus, an animal's reproductive success and its fitness will suffer. In these cases, the animals will have entered a pre-pathological or pathological state which is called distress (sensu Seyle 1950) or allostatic loading (McEwen and Wingfield 2003). This pathological state will last until the animal replenishes its biotic reserves sufficient to restore normal function.

Relationships between these physiological mechanisms, animal behavior, and the costs of stress responses have also been documented fairly well through controlled experiment; because this physiology exists in every vertebrate that has been studied, it is not surprising that stress responses and their costs have been documented in both laboratory and free-living animals (for examples see, (Holberton et al. 1996; Hood et al. 1998; Jessop et al. 2003; Lankford et al. 2005). Although no information has been collected on the physiological responses of marine mammals upon exposure to anthropogenic sounds, studies of other marine animals and terrestrial animals would lead us to expect some marine mammals to experience physiological stress responses and, perhaps, physiological responses that would be classified as distress upon exposure to mid-frequency and low-frequency sounds. For example, Jansen (1998) reported on the relationship between acoustic exposures and physiological responses that are indicative of stress responses in humans (for example, elevated respiration and increased heart rates). Jones and Broadbent (1998) reported on reductions in human performance when faced with acute, repetitive exposures to acoustic disturbance. Trimper et al. (1998) reported on the physiological stress responses of osprey to low-level aircraft noise while Krausman et al. (2004) reported on the auditory and physiology stress responses of endangered Sonoran pronghorn to military overflights. Smith et al. (2004) identified noise-induced physiological stress responses in hearing-specialist fish that accompanied short- (TTS) and long-term (PTS) hearing losses. Welch and Welch (1970) reported physiological and behavioral stress responses that accompanied damage to the inner ears of fish and several mammals.

Hearing is one of the primary senses cetaceans use to gather information about their environment and to communicate with other members of their species. Although empirical information on the relationship between sensory impairment (TTS, PTS, and acoustic masking) on cetaceans remains limited, it seems reasonable to assume that reducing an animal's ability to gather information about its environment and to communicate with other members of its species would be stressful for animals that use hearing as their primary sensory mechanism. Therefore, we

assume that acoustic exposures sufficient to trigger onset PTS or TTS would be accompanied by physiological stress responses because terrestrial animals exhibit those responses under similar conditions (NRC 2003). More importantly, marine mammals might experience stress responses at received levels lower than those necessary to trigger onset TTS. Based on empirical studies of the time required to recover from stress responses (Moberg 2000), we also assume that stress responses are likely to persist beyond the time interval required for animals to recover from TTS and might result in pathological and pre-pathological states that would be as significant as behavioral responses to TTS.

Stranding Events: In what follows, we address the evidence bearing on assertions that low-frequency active sonars cause marine mammals to strand. Some authors first published articles that initially identified low frequency active sonar as the cause of marine mammal stranding events in the Canary Islands and the Mediterranean Sea, and then later published articles that identified mid-frequency active sonar as the cause of those stranding events after the Bahamas stranding report became available (NMFS and Navy 2001). We disagree with these causal claims: that beaked whale stranding events had a causal association with low frequency active sonar, mid-frequency active sonar, a combination of the two, or neither of the two. The earlier claims for example, (Frantzis 1998) asserting low-frequency active sonar as causal are not compatible with the revised claims of a causal relationship between the stranding events and mid-frequency active sonar.

D’Amico et al. (2009) reviewed the relationship between the use of Naval sonars to mass strandings and concluded that of 126 reported mass strandings, only two reported details on the use, timing, and location of sonar in relation to the strandings. Ten other mass strandings coincided in space and time with naval exercises that may have included mid-frequency active sonar with an additional 27 mass stranding events occurring near a naval base or ship but with no direct evidence of sonar use (D'Amico et al. 2009). The remaining 87 mass strandings investigated had no evidence for a link with any naval activity. Six of these 87 cases have evidence for a cause unrelated to active sonar (D'Amico et al. 2009).

Nonetheless, there remains a high level of controversy over the use of mid-frequency active sonar even though there have been only a small number of instances in which marine mammal stranding events have been associated with mid-frequency sonar and despite the fact that none of these stranding events involved endangered or threatened species. For these analyses, we defined a stranded marine mammal as any dead marine mammal on a beach or floating nearshore; any live cetacean on a beach or in water so shallow that it is unable to free itself and resume normal activity; or any live pinniped which is unable or unwilling to leave the shore because of injury or poor health (Gulland et al. 2001; Wilkinson 1991).

Marine mammals are known to strand for a variety of reasons, although the cause or causes of most stranding are unknown (Best 1982; Eaton 1979; Geraci et al. 1976; Odell et al. 1980). Klinowska (1985; 1986) correlated marine mammal stranding events and geomagnetism and geomagnetic disturbance. Numerous other studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might predispose them to strand when exposed to another phenomenon. For example, several studies of stranded marine mammals suggest a linkage between unusual mortality events and body burdens of toxic chemicals in the stranded animals (Kajiwara et al. 2002; Kuehl and Haebler 1995). These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Creel 2005; Fair and Becker 2000; Moberg 2000; Relyea 2009; Romero 2004; Sih et al. 2004).

Those studies suggest that, in many animal species, disease, reproductive state, age, experience, stress loading, energy reserves, and genetics combine with other stressors like body burdens of toxic chemicals to create fitness consequences in individual animals that would not occur without these risk factors. The contribution of these potential risk factors to stranding events (or causal relationships between these risk factors and stranding events) is still unknown, but the extensive number of published reports in the literature suggests that an experimental investigation into a causal relationship is warranted. Over the past three decades, several mass stranding events — stranding events 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 introduce sound into the marine environment.

Although only one of these events involved threatened or endangered species, we analyzed the information available on stranding events to determine if listed cetaceans are likely to strand following an exposure to mid-frequency active sonar. To conduct these analyses, we searched for and collected any reports of mass stranding events of marine mammals and identified any causal agents that were associated with those stranding events.

Global Stranding Patterns: Several sources have published lists of mass stranding events of cetaceans during attempts to identify relationships between those stranding events and military sonar (Hildebrand 2004; IWC 2005; Taylor et al. 2004). For example, based on a review of stranding records between 1960 and 1995, the International Whaling Commission (IWC 2005) identified ten mass stranding events of Cuvier's beaked whales that had been reported and one mass stranding of four Baird's beaked whale (*Berardius bairdii*). The IWC concluded that, out of eight stranding events reported from the mid-1980s to the summer of 2003, seven had been

associated with the use of mid-frequency sonar, one of those seven had been associated with the use of low-frequency sonar, and the remaining stranding event had been associated with the use of seismic airguns.

Taxonomic Patterns Most of the stranding events reviewed by the International Whaling Commission involved beaked whales. A mass stranding of Cuvier's beaked whales (*Ziphius cavirostris*) in the eastern Mediterranean Sea occurred in 1996 (Frantzis 1998) and mass stranding events involving Gervais' beaked whales (*Mesoplodon europaeus*), de Blainville's dense-beaked whales (*M. densirostris*), and Cuvier's beaked whales occurred off the coast of the Canary Islands in the late 1980s (Simmonds and Lopez-Jurado 1991). Other stranding events of beaked whales have also occurred in the Bahamas and Canary Islands (which included Gervais' beaked whales, de Blainville's dense-beaked whales, *M. densirostris*, and Cuvier's beaked whales)(Simmonds and Lopez-Jurado 1991). The stranding events that occurred in the Canary Islands and Kyparissiakos Gulf in the late 1990s and the Bahamas in 2000 have been the most intensively-studied mass stranding events and have been associated with naval maneuvers that were using sonar. These investigations did not evaluate information associated with the stranding of Cuvier's beaked whales, *Ziphius cavirostris*, around Japan (IWC 2005).

Between 1960 and 2006, 48 (68 percent) of strandings involved beaked whales, 3 (4 percent) involved dolphins, and 14 (20 percent) involved whale species. Cuvier's beaked whales were involved in the greatest number of these events (48 or 68 percent), followed by sperm whales (7 or 10 percent), and Blainville and Gervais' beaked whales (4 each or 6 percent). Naval activities that might have involved active sonar are reported to have coincided with 9 (13 percent) or 10 (14 percent) of those stranding events.

Between the mid-1980s and 2003 (the period reported by the International Whaling Commission) (IWC 2005), we identified reports of 44 mass cetacean stranding events of which at least 7 have been correlated with naval exercises that were using mid-frequency sonar.

Stranding events involving baleen whales (blue, bowhead, Bryde's, fin, gray, humpback, minke, right, and sei whales) and stranding events involving sperm whales have very different patterns than those of beaked whales and other smaller cetaceans. First, mass stranding events of baleen whales are very rare. Fourteen humpback whales stranded on the beaches of Cape Cod, Massachusetts between November 1987 and January 1988 (Geraci 1989); however, that stranding event has been accepted as being caused by neurotoxins in the food of the whales. In 1993, three humpback whales stranded on the east coast of Sao Vincente Island in the Cape Verde Archipelago, but they were in an advanced state of decay when they stranded so their cause of death remains unknown (Reiner et al. 1996). Finally, two minke whales (*Balaenoptera*

acutirostra) stranded during the mass stranding event in the Bahamas in 2000 (see further discussion of this stranding event below). This is noteworthy because it is the only mass stranding of baleen whales that has coincided with the Navy's use of mid-frequency active sonar and because there are so few mass stranding events involving baleen whales.

Sperm whales, however, commonly strand and commonly strand in groups. Our earliest record of a mass stranding of sperm whales is for six sperm whales that stranded in Belgium in 1403 or 1404 (De Smet 1997). Since then, we have identified 85 mass stranding events involving sperm whales that have been reported. Of those 85 mass stranding events, 29 represent stranding events that occurred before 1958; 25 of those 29 (about 34 percent) stranding events occurred before 1945 (which would pre-date the use of this mid-frequency active sonar). Ten of these stranding events involved sperm whales and long-finned pilot whales (*Globicephala melas*). These mass stranding events have been reported in Australia, Europe, North America, Oceania, and South America.

Our exposure analyses concluded that blue whales, fin whales, humpback whales, sei whales, southern resident killer whales, sperm whales, Steller sea lions, leatherback turtles, and several species of fishes were likely to be exposed to active acoustic sources on the Northwest Training Range Complex.

Blue Whale

Blue whales are not likely to respond to high-frequency sound sources associated with the proposed training activities because of their hearing sensitivities. Preliminary results from the behavioral response study on the Southern California Range Complex suggest that blue whales not only hear mid-frequency active sonar transmissions, in some cases they respond to those transmissions (Southall et al. 2011). Southall et al. (2011) reported that blue whales appeared to ignore sonar transmissions at received levels lower than about 150 dB and ignored received levels greater than these when they were engaged in some feeding behavior. In other instances, blue whales engaged in short, avoidance movements when they were engaged in other kinds of feeding behavior (Southall et al. 2011).

Melcón et al. (2012) tested whether mid-frequency active sonar and other anthropogenic noises in the mid-frequency band affected the production of d-calls in blue whales in the Southern California Bight (the same area that Southall et al. conducted their study). Despite being classified as "low-frequency hearing specialists," Melcón et al. (2012) reported that blue whales heard, responded to and changed their behavior in response to sounds in the mid-frequency range. 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.

Although Southall et al. (2011) reported that blue whales appeared to ignore sonar transmissions at received levels lower than about 150 dB and ignored received levels greater than these when they were engaged in some feeding behavior, the results produced by Melcón et al. (2012) challenge those conclusions because blue whales produce d-calls while foraging. The blue whales studied by Melcón et al. (2012) responded behaviorally to mid-frequency active sonar at received levels below 120 dB SPL (re: 1 µPa). The proportion of d-calls that occurred in the presence of mid-frequency active sonar at received levels of 85, 95, 105, and 115 dB (re: 1 µPa) was 0.3235 (95% CI 0.2283 to 0.4361). The proportion of d-calls that occurred in the presence of non-anthropogenic noise at the same received levels was 0.5089 (95% CI 0.4446 to 0.5730). The risk ratio of these proportions is 0.6357 (0.3235/0.5089), suggested that the proportion d-calls in the presence of mid-frequency active sonar was 36.43 percent lower at these received levels.

Based on this information, we would not expect the 143 blue whales that find themselves between 51 and 130 kilometers from the source of a mid-frequency active sonar ping to devote attentional resources to that stimulus, even though received levels might be as high as 140 dB (at 51 kilometers). Similarly, we would not expect the 71 blue whales that find themselves between 10 and 51 kilometers (between about 6.2 and 32 miles) from a sonar transmission to change their behavioral state, despite being exposed to received levels ranging from 140 and 160 dB; these whales might engage in low-level avoidance behavior or short-term vigilance behavior. The 15 blue whales that might occur between 0.56 and 10 kilometers of a sonar ping might change their behavioral state if they are migrating, but they are not likely to change their behavioral state if they are actively foraging at the surface. However, as we discussed previously, we do not assume that these blue whales would respond only to the active sonar. Rather all of the environmental cues produced by a vessel moving through the ocean's surface while transmitting active sonar may result in short-term behavioral changes.

The one instance in which blue whales might be exposed to underwater detonations experience temporary threshold shifts as a result of their exposure to shock waves or sound fields associated with those detonations would experience short term threshold shift.

Fin Whale

Fin whales are not likely to respond to high-frequency sound sources associated with the proposed 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.

Based on this information, we would not expect the 495 fin whales that find themselves between 51 and 130 kilometers from the source of a mid-frequency active sonar ping to devote attentional resources to that stimulus, even though received levels might be as high as 140 dB (at 51 kilometers). Although fin whales appear to be able to hear mid-frequency (1 kHz–10 kHz) sounds, sounds in this frequency range lie at the periphery of their hearing range and they are less likely to devote attentional resources to stimuli in this frequency range. Similarly, we would not expect the 245 fin whales that find themselves between 10 and 51 kilometers from a sonar transmission to change their behavioral state, despite being exposed to received levels ranging from 140 and 160 dB; these whales might engage in low-level avoidance behavior or short-term vigilance behavior. The 50 fin whales that might occur between 0.56 and 10 kilometers of a sonar ping are likely to change their behavioral state, although such a change is less likely if they are actively foraging. We do not assume that these fin whales would respond only to the active sonar, rather all of the environmental cues produced by a vessel moving through the ocean's surface while transmitting active sonar may result in short-term behavioral changes.

We would expect 7 instances in which fin whales would be exposed to underwater detonations and experience temporary threshold shifts as a result of their exposure to shock waves or sound fields associated with those detonations each year. This exposure could result in temporary threshold shift that may result in short-term behavioral changes.

Humpback Whale

Humpback whales are not likely to respond to high-frequency sound sources associated with the proposed 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. 1995; 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. 1995; Thompson et al. 1986). Sounds often associated with possible aggressive behavior by males (Silber 1986; Tyack 1983) 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 proposes to conduct 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. 1996). 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. 1996). The explosions may also have increased the number of humpback whales entangled in fishing nets (Todd et al. 1996). 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.

Based on this information, in the 260 instances each year in which humpback whales find themselves between 51 and 130 kilometers from the source of a mid-frequency active sonar ping, we still would not expect those whales to devote attentional resources to that stimulus, even though received levels might be as high as 140 dB (at 51 kilometers). Similarly, we would not expect the 129 instances in which humpback whales find themselves between 10 and 51 kilometers from a sonar transmission to cause the whales to change their behavioral state, despite being exposed to received levels ranging from 140 and 160 dB; these whales might engage in low-level avoidance behavior or short-term vigilance behavior. The 26 instances in which humpback whales might occur between 0.56 and 10 kilometers of a sonar ping are likely to cause those whales to experience acoustic masking, impairment of acoustic communication, behavioral disturbance, and physiological stress responses as a result of that exposure.

Because we would not expect any instances in which humpback whales would be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in behavioral harassment, temporary threshold shifts, or 50 percent tympanic membrane rupture or slight lung injury, we would not expect humpback whales to respond to that stressor.

Sei Whale

Like blue and fin whales, sei whales are not likely to respond to high-frequency sound sources associated with the proposed 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.

Based on this information, we would not expect the 71 instances in which sei whales would find themselves between 51 and 130 kilometers from the source of a mid-frequency active sonar ping

to cause the sei whales devote attentional resources to that stimulus, even though received levels might be as high as 140 dB (at 51 kilometers). We make the same assumption with sei whales that we made with blue and fin whales: they are probably able to hear mid-frequency (1 kHz–10 kHz) sounds, but sounds in this frequency range lie at the periphery of their hearing range and they are less likely to devote attentional resources to stimuli in this frequency range. Similarly, we would not expect the 35 instances in which sei whales might find themselves between 10 and 51 kilometers (between about 6.2 and 32 miles) from a sonar transmission to cause these whales to change their behavioral state, despite being exposed to received levels ranging from 140 and 150 dB; instead, these whales might engage in low-level avoidance behavior or short-term vigilance behavior. The 7 exposures in which sei whales might occur between 0.56 and 10 kilometers of a sonar ping, might cause these whales to change their behavioral state if they are migrating, but they are not likely to change their behavioral state if they are actively foraging.

Because we would not expect any instances in which sei whales would be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in behavioral harassment, temporary threshold shifts, or 50 percent tympanic membrane rupture or slight lung injury, we would not expect sei whales to respond to that stressor.

Sperm Whale

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 proposes to conduct 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. 1994), 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. 2000), and to shorter broadband pulsed signals (Finneran et al. 2000; Finneran et al. 2002b). 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. 2002b; Schlundt et al. 2000). 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. 2000; Finneran et al. 2002b). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran et al. 2002b). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway and Carder 1997; Schlundt et al. 2000). 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. (2000).

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. (1995) 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. 1994).

A recent 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.

Based on this information, we would not expect the 1,043 instances in which sperm whales would find themselves between 51 and 130 kilometers from the source of a mid-frequency active sonar ping to cause the sperm whales devote attentional resources to that stimulus, even though received levels might be as high as 140 dB (at 51 kilometers). Similarly, we would not expect the 516 instances in which sperm whales might find themselves between 10 and 51 kilometers (between about 6.2 and 32 miles) from a sonar transmission to cause these whales to change their behavioral state, despite being exposed to received levels ranging from 140 and 150 dB; instead, these whales might engage in low-level avoidance behavior or short-term vigilance behavior. The 105 exposures in which sperm whales might occur between 0.56 and 10 kilometers of a

sonar ping might cause these whales to change their behavioral state if they are migrating, but they are not likely to change their behavioral state if they are actively foraging.

On an annual basis, we expect 6 instances in which sperm whales might be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in behavioral harassment or experience temporary threshold shift. No instance in which a sperm whale might be exposed to received levels of 205 dB or 13 psi-ms associated with underwater detonations and experience 50 percent tympanic membrane rupture or slight lung injury.

Southern Resident Killer Whale

The U.S. Navy estimated that 13 killer whales (NMFS Permits Division estimated 14 killer whales) might be exposed to active sonar associated with the training activities it proposes to conduct on the Northwest Training Range Complex and exhibit behavioral responses that would qualify as "take," in the form of behavioral harassment, as a result of that exposure. This estimate did not separate southern resident killer whales from other killer whale distinct population segments that reside in the action area. Further, this estimate did not account for the mitigation activities, such as lookouts and watchstanders. Killer whales travel in groups (average group size is 6.5 animals), have conspicuous coloring, and pronounced dorsal fins that together increase the likelihood that they would be detected by Navy lookouts.

The southern resident killer whale population consists of three pods, designated J, K, and L pods, that reside for part of the year in the inland waterways of Washington State and British Columbia (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound), principally during the late spring, summer, and fall (Ford et al. 2000; Krahn et al. 2002). Pods have visited coastal sites off Washington and Vancouver Island (Ford et al. 2000), and are known to travel as far south as central California and as far north as the Queen Charlotte Islands. Winter and early spring movements and distribution are largely unknown for the population. Although there is considerable overlap in the geographic ranges of Southern and Northern Residents, pods from the two populations have not been observed to intermix (Ford et al. 2000).

Given that killer whales are likely to be visible to watchstanders and that individuals from the southern resident killer whale populations are more likely to be found in Puget Sound rather than off shore areas, we assume that only about 10 percent of the Navy's estimate of killer whales exposed to active sonar would be from the southern resident killer whale DPS. Because the U.S. Navy has chosen to exclude mid-frequency active sonar training in Puget Sound from the scope of their proposed action, we assume that any southern resident killer whales that might be exposed to mid-frequency active sonar would not be exposed in Puget Sound. Therefore, we

assume that all of these exposures would occur off the coast of Washington, Oregon, or northern California.

Unlike the baleen whales we have considered in this Opinion, killer whales hearing and vocalizations substantially overlap with the frequencies of the mid-frequency active sonar the U.S. Navy proposes to employ on the Northwest Training Range Complex. Because of the incident involving the U.S.S. SHOUP In May 2003, we know that killer whales experience distress when exposed to mid-frequency active sonar (AN/SQS-53) at received levels of about 169.3 dB (Fromm 2004); we do not know if those whales suffered stress pathology or other physical or physiological sequelae as a result of that exposure, but they probably experienced allostatic loading and social disruption as a result of that exposure. Because the U.S. Navy has chosen to exclude mid-frequency active sonar training in Puget Sound from the scope of their proposed action and because we assume the Haro Strait incident occurred because of the acoustic environment of Puget Sound, we do not expect the incident to be repeated as a result of the training the U.S. Navy proposes to conduct on the Northwest Training Range Complex.

We expect southern resident killer whales that find themselves within the sound field produced during an active sonar ping to adjust the amplitude of their vocalizations (Holt et al. 2009). Southern resident killer whales are also likely to adjust the temporal structure of their vocalizations by changing the timing of modulations, notes, and syllables within vocalizations or increasing the duration of their calls or songs. For example, Foote et al. (2004) compared recordings of endangered 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. Although we are not certain whether the same conclusion would apply to active sonar pings, 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). They 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.

Evidence that would be more applicable to southern resident killer whales exposed to mid-frequency active sonar in an open, marine ecosystem is still equivocal. Kvadsheim et al. (2007) exposed killer whales that had been fitted with D-tags to two sources of mid-frequency active sonar (Source A: was a 1.0 s upsweep 209 dB at 1 - 2 kHz every 10 seconds for 10 minutes; Source B: was a 1.0 s upsweep 197 dB at 6 - 7 kHz every 10 s for 10 min). When exposed to Source A, a tagged killer whale and the group it was traveling with did not appear to avoid the source. When exposed to Source B, the tagged whales along with other whales that had been carousel feeding, ceased feeding during the approach of the sonar and moved rapidly away from the source (the received level associated with this response and the distance between the whales

and the source were not reported). When exposed to Source B, Kvadsheim and his co-workers reported that a tagged killer whale seemed to try to avoid further exposure to the sound field by immediately swimming away (horizontally) from the source of the sound; by engaging in a series of erratic and frequently deep dives that seemed to take it below the sound field; or by swimming away while engaged in a series of erratic and frequently deep dives. Although the sample sizes in this study are too small to support statistical analysis, the behavioral responses of the orcas were consistent with the results of other studies.

Based on the evidence available, we would expect southern resident killer whales that are exposed to mid-frequency active sonar on the open-water portions of the Northwest Training Range Complex to engage in horizontal movements that would allow them to avoid continued exposure. At the same time, we would expect southern resident killer whales to experience impaired communication because they vocalize at frequencies that overlap with those of the high- and mid-frequency active sonar systems the U.S. Navy plans to employ during training on the Northwest Training Range Complex. To preserve the saliency of their vocalizations and the coherence of their social interactions, southern resident killer whales might have to make one or more of the vocal adjustments discussed earlier in this narrative. Because any reductions in the active space of whale vocalizations that result from active sonar transmissions associated with the proposed missions would be temporary and episodic, any vocal adjustments southern resident killer whales would have to make would also be temporary.

The evidence available suggests that southern resident killer whales are likely to be aware of and pay attention to the mid-frequency active sonar transmissions associated with the training activities the U.S. Navy plans to conduct on the Northwest Training Range Complex. In most circumstances, southern resident killer whales are likely to try to avoid being exposed to those sounds or are likely to avoid the specific areas in which those sounds occur. Those southern resident killer whales that do not avoid the sound field created by mid-frequency sonar might interrupt communications, echolocation, or foraging behavior. In either case, southern resident killer whales that avoid these sound fields, stop communicating, echolocating or foraging might experience significant disruptions of normal behavior patterns that would otherwise be essential to their individual fitness. However, because of the relatively short duration of the acoustic transmissions associated with the active sonar training the U.S. Navy plans to conduct on the Northwest Training Range Complex, we do not, however, expect these disruptions to result in the death or injury of any individual southern resident killer whale.

Individual southern resident killer whales are also likely to respond to the ship traffic associated with the training activities that might approximate their responses to whale-watch vessels. As discussed in the earlier in this Opinion, those responses are likely to depend on the distance of a

whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver. The closer southern resident killer whales are to these maneuvers and the greater the number of times they are exposed, the greater their likelihood of being exposed and responding to that exposure. Particular whales might not respond to the vessels, while in other circumstances, southern resident killer whales might change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Amaral and Carlson 2005; Au and Green 2000; 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). Some of these whales might experience physiological stress responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, we would not expect those stress responses to result in stress pathologies because of the relatively short duration of the active sonar training the U.S. Navy plans to conduct on the Northwest Training Range Complex. Specifically, we do not expect any stress responses to continue long-enough to have fitness consequences for individual southern resident killer whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and the additional demands of any stress responses. Therefore, we would not expect southern resident killer whales to experience reductions in their annual or lifetime reproductive success as a result of their response to being exposed to active sonar during the training the U.S. Navy plans to conduct on the Northwest Training Range Complex.

Because we would not expect any instances in which southern resident killer whales would be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in behavioral harassment, temporary threshold shifts, or 50 percent tympanic membrane rupture or slight lung injury, we would not expect southern resident killer whales to respond to that exposure.

Steller Seal Lion- Eastern Population

As with every other species we consider in this Opinion, the critical question is how Steller sea lions are likely to respond upon being exposed to mid-frequency active sonar on the Northwest Training Range Complex. Sea lions appear to vocalize as part of their social behavior and are able to hear well in and out of water; however, there are few studies of the response of pinnipeds that are exposed to sounds in water. Frost et al. (1988) reported that ringed seal densities around islands on which drilling was occurring declined over the period of observation; they concluded that the acoustic exposure was at least a contributing factor in that reduced density. Richardson et al. (1991; 1990), however, reported that ringed and bearded seals appeared to tolerate playbacks of underwater drilling sounds.

Norberg (2000) measured the responses of California sea lions to acoustic harassment devices (10-kHz fundamental frequency; 195 dB re: 1 μPa-m source level; short train of 2.5-ms signals repeated every 17 s) that were deployed in Puget Sound to reduce the effect of these predators on "wild" salmon in aquaculture facilities. He concluded that exposing California sea lions to this harassment device did not reduce the rate at which the sea lions fed on the steelhead.

Jacobs and Terhune (2002) observed the behavioral responses of harbor seal exposed to acoustic harassment devices with source levels of 172 dB re:1 μPa-m deployed around aquaculture sites. The seals in their study generally did not respond to sounds from the harassment devices and in two trials, seals approached to within 43 and 44 m of active harassment devices and did not appear to exhibit any measurable behavioral responses to the exposure.

Costa et al. (2003) placed acoustic data loggers placed on translocated elephant seals and exposed them to an active Acoustic Thermometry of the Ocean Climate (ATOC) source off northern California (source was located at a depth of 939 meters with the following source characteristics: 75-Hz signal with 37.5- Hz bandwidth; 195 dB re: 1 μPa-m max. source level, ramped up from 165 dB re: 1 μPa-m over 20 min). Seven control seals were instrumented similarly and released when the ATOC source was not active. Received exposure levels of the ATOC source for experimental subjects averaged 128 dB re: 1 μPa (range 118 to 137 dB) in the 60- to 90-Hz band. None of the animals in the study terminated dives or radically altered behavior when they were exposed to the ATOC source, but nine individuals exhibited changes in their dive patterns that were statistically significant.

Koschinski et al. (2003) studied the behavioral responses of harbor seals exposed to playbacks of simulated wind turbine noise while underwater (maximum energy between 30 and 800 Hz; spectral density source levels of 128 dB re: 1 μPa/Hz at 80 and 160 Hz). Moulton et al. (2005; 2003) studied ringed seals before and during the construction and operation of an oil production facility and reported that the ringed seals did not avoid the area around the various industrial sources. Studies of the effects of low frequency sounds on elephant seals (*Mirounga spp*.), which are considered more sensitive to low frequency sounds than other pinnipeds (Croll et al. 1999b; Kastak and Schusterman 1996; LeBoeuf and Peterson 1969), suggest that elephant seals did not experience even short-term changes in behavior given their exposure to low frequency sounds.

Nevertheless, we would expect 114 of the 445 instances in which Steller sea lions would be exposed to active sonar between 0.56 and 10 kilometers of the source of a sonar ping to result in behavioral responses that would qualify as "take" as a result of that exposure.

We would expect 4 instances annually in which Steller sea lions might be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in

behavioral harassment or experience temporary threshold shifts as a result. We would not expect any instances in which Steller sea lions might be exposed to received levels of 205 dB or 13 psi-ms associated with underwater detonations and experience 50 percent tympanic membrane rupture or slight lung injury as a result of that exposure.

Leatherback Sea Turtle

The information on the hearing capabilities of sea turtles is also limited, but the information available suggests that the auditory capabilities of sea turtles are centered in the low-frequency range (<1 kHz) (Bartol et al. 1999; Lenhardt 1994; Lenhardt et al. 1983; Ridgway et al. 1969). Ridgway et al. (1969) studied the auditory evoked potentials of three green sea turtles (in air and through mechanical stimulation of the ear) and concluded that their maximum sensitivity occurred from 300 to 400 Hz with rapid declines for tones at lower and higher frequencies. They reported an upper limit for cochlear potentials without injury of 2000 Hz and a practical limit of about 1000 Hz. This is similar to estimates for loggerhead sea turtles, which had most sensitive hearing between 250 and 1000 Hz, with rapid decline above 1000 Hz (Bartol et al. 1999). These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

No audiometric data are available for leatherback sea turtles, but we assume that they have hearing ranges similar to those of other sea turtles (or at least, their hearing is likely to be closer to that of other sea turtles than to the hearing sensitivities of marine mammals). Based on this information sea turtles exposed to received levels of active mid-frequency sonar are not likely to hear mid-frequency sounds (sounds between 1 kHz and 10 kHz); therefore, they are not likely to respond physiologically or behaviorally to those received levels.

A recent study on the effects of airguns on sea turtle behavior also suggests that sea turtles are most likely to respond to low-frequency sounds. McCauley et al. (2000) reported that green and loggerhead sea turtles will avoid air-gun arrays at 2 km and at 1 km with received levels of 166 dB re 1 Pa and 175 dB re 1 Pa, respectively. The sea turtles responded consistently: above a level of approximately 166 dB re 1 Parms the turtles noticeably increased their swimming activity compared to non-airgun operation periods. Above 175 dB re 1 Pa mean squared pressure their behavior became more erratic possibly indicating the turtles were in an agitated state.

Threatened and Endangered Fish

Threatened and endangered salmonids and listed eulachon may be exposed to active sonar sound fields. Popper (2003) and Hastings and Popper (2005) presented evidence that establishes that most fish only detect sounds within the 1-3 kHz range, which would make them sensitive to the lower end of the frequency range of mid-frequency active sonar. The U.S. Navy's Biological Evaluation for the Northwest Training Range Complex (Navy 2009a; Navy 2009b) provided a thorough review of the information available on the probable responses of endangered and threatened fish to active sonar. We have extracted most of the narratives that follow from that review, although we have made a few corrections and clarifications and supplemented the analyses with a few additional studies.

Gearin et al. (2000) and Culik et al. (2001) studied the effects of exposing fish to sounds produced by acoustic deterrent devices, which produce sounds in the mid frequency range. Adult sockeye salmon exhibited an initial startle response to the placement of inactive acoustic alarms but resumed their normal swimming pattern within 10 to 15 seconds. After 30 seconds, the fish approached the inactive alarm to within 30 cm (1 foot). When the experiment was conducted with an alarm active, the fish exhibited the same initial startle response from the insertion of the alarm into the tank; but were swimming within 30 cm of the active alarm within 30 seconds. After five minutes, the fish did not show any reaction or behavior change except for the initial startle response.

Jørgensen et al. (2005) exposed fish larvae and juveniles representing three different species to sounds that were designed to simulate mid-frequency sonar transmissions (1 to 6.5 kHz) to study the effects of the exposure on the survival, development, and behavior of the larvae and juveniles (the study used larvae and juveniles of Atlantic herring, Atlantic cod, saithe (*Pollachius virens*), and spotted wolfish (*Anarhichas minor*). Their experiments have often been reported to have concluded that the sonar exposures produced mortalities of 20 to 30 percent, but those reports appear to have been in error. Jørgensen and his co-workers conducted a total of 42 trials for six different experiments with each trial consisting of a control group and an experimental group with the experimental group exposed to active sonar at a specific received level over a specific time interval. They reported the size of the fish, source frequency (in kHz), received level (Sound Pressure Level in dB rms), number of pulses the fish were exposed to, total energy (SEL in Pascals squared per second), and outcome of the trial: number of animals alive versus number of animals dead.

Fish died in 11 of the 42 trials they conducted with Atlantic herring, but some of the fish that died were from the control group that was not exposed to active sonar. In the two trials that

resulted in 20 to 30 percent mortalities, the fish died in both control and experimental groups, so it would be incorrect to conclude that the mortalities were caused by exposure to active sonar.

More importantly, Jørgensen and his co-workers did not report the frequency, received level, duration, or total energy associated with the four trials that resulted in the 20 to 30 percent mortality (they only report that the fish died 10 or 11 days after the trial), so these data do not support a conclusion that the deaths were caused by exposure to active sonar. Because Jørgensen and his co-workers did not report the frequency, received level, duration, or total energy associated with the four trials that resulted in the 20 to 30 percent mortality, those trials could not establish a causal relationship between sonar exposures and the death of the fish so the trials should have been censored from subsequent study.

An examination of the data from all of the trials (censored to eliminate the four trials without exposure data), still showed that mortalities associated with the experimental group were substantially greater than those of the control group (27 out of 1189 or 0.0227 percent versus 7 out of 881 or 0.0079 percent), which is a fraction of the 20 to 30 percent mortality that has been reported based on that study. Further, correlation coefficients between the percent of dead animals in the experimental group and (1) sound pressure level (r-squared = 0.0658), (2) total energy received (r-squared = 0.1721), (3) source frequency (r-squared = 0.0052), and (4) number of pulses (r-squared = 0.0145) were too small to establish any coherent relationship between any of these variables, which limits the applicability of the study results.

Hastings et al. (1996) studied the effects of low frequency underwater sound on fish hearing. More recently, Popper et al. (2007; 2009; 2005) investigated the potential effects of exposing several fish species to the U.S. Navy's SURTASS low frequency active sonar, focusing on hearing and on non-auditory tissues. Their study exposed the fish to low frequency active sonar pulses for time intervals that would be substantially longer than what would occur in nature, but the fish did not die or suffer tissue damage at the gross or histological level. Some fish experienced temporary losses in their hearing sensitivity but they recovered within several days of exposure.

Sivle et al. (2012) investigated the impact of naval sonar on Atlantic herring during summer feeding. They found that adult Atlantic herring did not show any behavioral response to 1–7 kHz naval sonar signals at received SPL up to 176 dB re 1 µPa and SEL up to 181 dB re 1 μPa_{rms} during summer feeding migration. This is in agreement with results from studies on overwintering Atlantic herring (Doksaeter et al. 2009) and captive Atlantic herring (Doksaeter et al. 2012).

Based on the evidence available, if they were exposed to transmissions associated with mid-frequency active sonar training activities on the Northwest Training Range Complex, 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 Northwest Training Range Complex 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 Northwest Training Range Complex, 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.

As we did 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 on the Northwest Training Range. 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 Northwest Training Range Complex evaluated the Navy’s proposal to conduct no more than four such detonations each year, with the single detonation it planned to conduct at Indian Island moved to Hood Canal, and a reduced net explosive weight of the detonations used in the training event from 2.5 pounds to 1.5 pounds. In that assessment, we used a similar approach we applied in our 2008 biological opinion, such that we 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 Crescent Harbor; six adult Puget Sound Chinook salmon deaths during each underwater detonation at Hood Canal; and 27 dead adult Hood Canal summer-run Chinook salmon during each underwater detonation at SUBASE Bangor.

The U.S. Navy proposes to change to Explosive Ordnance Disposal underwater detonation training events for the remainder of the proposed action (2012 to 2015) to add the option of dividing the authorized explosive change into several smaller charges. As currently described, two underwater demolition events are proposed annually at each of the two training sites; Crescent Harbor and Hood Canal. 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. 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.

It is difficult to determine the number of each salmon or steelhead species that might be exposed to the proposed 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 year the four surface detonations would result in the death or injury of one adult and one juvenile Puget Sound Chinook salmon at Crescent Harbor; six adult Puget Sound Chinook salmon deaths during each underwater detonation at Hood Canal; and 27 dead adult Hood Canal summer-run Chinook salmon during each underwater detonation at SUBASE Bangor.

5.4 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 biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

During this consultation, NMFS searched for information on future State, tribal, local, or private actions that were reasonably certain to occur in the action area. Most of the action area includes federal military reserves or is outside of territorial waters of the United States of America, which would preclude the possibility of future state, tribal, or local action that would not require some form of federal funding or authorization. NMFS conducted electronic searches of business journals, trade journals, and newspapers using *First Search*, Google, and other electronic search engines. Those searches produced no evidence of future private action in the action area that would not require federal authorization or funding and is reasonably certain to occur. As a result, NMFS is not aware of any actions of this kind that are likely to occur in the action area during the foreseeable future.

5.5 Potential for Accumulative Impacts

Although we did not explicitly discuss the potential accumulative impacts of the annual "take" estimates in our 2010 Programmatic Biological Opinion, we explicitly considered those potential cumulative impacts as part of our consultation (as demonstrated in the consultation record) and now explain our assessment in more detail. 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.

In the sense of 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 accumulate[3]. 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); and injuries and tissue damage; 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, 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 senses of we 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

[3] These example phenomena are not a concern in this biological opinion.

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 five-year duration of the MMPA regulations.

Thus, while the number of individuals "taken" gets larger over time when, 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 15 instances of exposing blue whales to mid-frequency active sonar in a single year, or 75 instances (50 instances based on actual take estimates for November 2010- November 2012) of exposing them to active sonar over five years, would result in effects that would be greater than what we would expect from a single exposure event. To the contrary, we did 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.

With respect to threatened and endangered marine mammals, our conclusion that the aggregate number of exposures over the five-year duration of the MMPA regulations or the three-year duration of the proposed LOA is unlikely to result in accumulated adverse impacts is consistent with the negligible impact determination contained in the MMPA rulemaking. See 75 FR 69317-18; 74 FR 33828, 33884-92. Furthermore, as discussed above, the level of take that has occurred thus far under the five-year MMPA regulations (and thus the estimated aggregate level of take) is substantially lower than originally anticipated in both the 2010 Programmatic Biological Opinion and the MMPA regulations. Thus, while the number of individuals "taken" gets larger over time when, 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 15 instances of exposing blue whales to mid-frequency active sonar in a single year, or 75 instances (50 instances based on actual take estimates for November 2010 - November 2012) of exposing them to active sonar over five years, would result in effects that would be greater than what we would expect from a single exposure event. To the contrary, we did 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.

With respect to threatened and endangered marine mammals, our conclusion that the aggregate number of exposures over the five-year duration of the MMPA regulations or the three-year duration of the proposed LOA is unlikely to result in accumulated adverse impacts that are likely to jeopardize the continued existence of any of the affected species is also supported by the negligible impact determination contained in the MMPA rulemaking. See 75 FR 69317-18; 74 FR 33828, 33884-92. Our initial conclusion is further supported by the fact that the level of take that has occurred thus far under the five-year MMPA regulations (and thus the estimated aggregate level of take) is substantially lower than originally anticipated in both the 2010 Programmatic Biological Opinion and the MMPA regulations.

6 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 proposed 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 2000; Brandon 1978; Mills and Beatty 1979; Stearns 1977; Stearns 1992). 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 proposed 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 that endangered or threatened individuals that are likely to be exposed to the military readiness activities the U.S. Navy proposes to conduct at the Northwest Training Range Complex are not likely to experience reductions in the fitness.

6.1 Blue Whale

Blue whales that are exposed to the training activities in the Northwest Training Range Complex might not respond to the acoustic cues generated by Navy vessels, while in other circumstances, they are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. Some blue whales may be less likely to engage in these responses on the Northwest Training Range Complex because they occur on the Northwest Training Range Complex to feed; while they forage, they are less likely to devote attentional resources to the periodic activities the U.S. Navy will conduct on the range complex. The blue whales that are likely to be exposed on the Northwest Training Range Complex would have had prior experience with similar stressors resulting from their exposure on the Southern California Range Complex earlier in the year; that experience will make some blue whales more likely to avoid activities associated with the training while others would be less likely to engage in avoidance behavior. Some blue whales might experience physiological stress (but not distress) responses if they attempt to avoid one ship and encounter a second ship as they engage in avoidance behavior. However, these responses are not likely to reduce the fitness of the blue whales that occur in the Northwest Training Range Complex.

During the first two LOA periods, the Navy estimated that there were two instances where blue 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 two blue whales made short-term behavioral adjustments that did not appreciably reduce the blue whales’ likelihood of surviving and recovering in the wild. Combined with the estimated take that could occur over the next three years from exposure to active sonar, vessel movements associated with the sonar training exercises, and detonations we expect that there would be approximately 50 instances, over five years, where blue whales would make similar short-term behavioral adjustments.

Based on the evidence available, we conclude that training exercises and other activities the U.S. Navy has conducted from 2010 to 2012 and plans to conduct in the Northwest Training Range Complex from November 2012 through November 2015, 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). As a result, the activities the U.S. Navy plans to conduct in the

Northwest Range Complex through November 2015 are not likely to appreciably reduce the blue whales' likelihood of surviving and recovering in the wild.

6.2 Fin Whale

Fin whales that are exposed to the training activities in the Northwest Training Range Complex might not respond to the acoustic cues generated by Navy vessels, while in other circumstances, they are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. Some fin whales may be less likely to engage in these responses on the Northwest Training Range Complex because they occur on the Northwest Training Range Complex to feed; while they forage, they are less likely to devote attentional resources to the periodic activities the U.S. Navy will conduct on the range complex. The fin whales that are likely to be exposed on the Northwest Training Range Complex would have had prior experience with similar stressors resulting from their exposure on the Southern California Range Complex earlier in the year; that experience will make some fin whales more likely to avoid activities associated with the training while others would be less likely to engage in avoidance behavior. Some fin whales might experience physiological stress (but not distress) responses if they attempt to avoid one ship and encounter a second ship as they engage in avoidance behavior. However, these responses are not likely to reduce the fitness of the fin whales that occur in the Northwest Training Range Complex.

During the first two LOA periods, the Navy reported that there were eight instances in which fin 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 fin whales made short-term behavioral adjustments that did not appreciably reduce their likelihood of surviving and recovering in the wild. Combined with the estimated take that could occur over the next three years from exposure to active sonar, vessel movements associated with the sonar training exercises, and detonations we expect that there would be approximately 179 instances, over five years, where fin whales would make short-term behavioral adjustments.

Based on the evidence available, we conclude that training exercises and other activities the U.S. Navy has conducted from 2010 to 2012 and plans to conduct in the Northwest Training Range Complex from November 2012 through November 2015, 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). As a result, the activities the U.S. Navy plans to conduct in the

Northwest Range Complex through November 2015 are not likely to appreciably reduce the fin whales' likelihood of surviving and recovering in the wild.

6.3 Humpback Whale

Like blue and fin whales, humpback whales that are exposed to the training activities in the Northwest Training Range Complex might not respond to the acoustic cues generated by Navy vessels, while in other circumstances, they are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Amaral and Carlson 2005; Au and Green 2000; 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). Some humpback whales may be less likely to engage in these responses on the Northwest Training Range Complex because they occur on the Northwest Training Range Complex to feed; while they forage, they are less likely to devote attentional resources to the periodic activities the U.S. Navy will conduct on the range complex. The humpback whales that are likely to be exposed on the Northwest Training Range Complex would have had prior experience with similar stressors resulting from their exposure on the Southern California Range Complex earlier in the year; that experience will make some humpback whales more likely to avoid activities associated with the training while others would be less likely to engage in avoidance behavior. Some humpback whales might experience physiological stress (but not distress) responses if they attempt to avoid one ship and encounter a second ship as they engage in avoidance behavior. However, these responses are not likely to reduce the fitness of the humpback whales that occur in the Northwest Training Range Complex.

During the first two LOA periods, the Navy reported that there were two instances in which humpback 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 humpback whales made short-term behavioral adjustments that did not appreciably reduce their likelihood of surviving and recovering in the wild. Combined with the estimated take that could occur over the next three years from exposure to active sonar and vessel movements associated with the sonar training exercises we expect there would be approximately 47 instances, over five years, where humpback whales would make short-term behavioral adjustments.

Based on the evidence available, we conclude that training exercises and other activities the U.S. Navy has conducted from 2010 to 2012 and plans to conduct in the Northwest Training Range Complex from November 2012 through November 2015, 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 of the populations those

individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities the U.S. Navy plans to conduct in the Northwest Range Complex through November 2015 are not likely to appreciably reduce the humpback whales' likelihood of surviving and recovering in the wild.

6.4 Sei Whale

During the first two LOA periods, the Navy reported that there were no instances in which sei whales were "taken." Combined with the estimated take that could occur over the next three years as a result of exposure to active sonar and vessel movements associated with the sonar training, we expect that there would be approximately 3 instances, over five years, where sei whales would make short-term behavioral adjustments.

Based on the evidence available, we conclude that training exercises and other activities the U.S. Navy has conducted from 2010 to 2012 and plans to conduct in the Northwest Training Range Complex from November 2012 through November 2015, 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 of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities the U.S. Navy plans to conduct in the Northwest Range Complex through November 2015 are not likely to appreciably reduce the humpback whales' likelihood of surviving and recovering in the wild.

6.5 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. Combined with the estimated take that could occur over the next three years from exposure to active sonar and vessel movements associated with the sonar training exercises we expect would be approximately eight instances, over five years, where Southern Resident killer whales would make short-term behavioral adjustments.

Based on the evidence available, we conclude that training exercises and other activities the U.S. Navy has conducted from 2010 to 2012 and plans to conduct in the Northwest Training Range Complex from November 2012 through November 2015, 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 of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities the U.S. Navy plans to conduct in the Northwest Range Complex through November 2015 are not likely to appreciably reduce the Southern Resident killer whales' likelihood of surviving and recovering in the wild.

6.6 Sperm Whale

During the first two LOA periods, the Navy reported that there were 19 instances in which sperm 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 sperm whales made short-term behavioral adjustments that did not appreciably reduce their likelihood of surviving and recovering in the wild Combined with the estimated take that could occur over the next three years from exposure to active sonar, vessel movements associated with the sonar training exercises, and detonations we expect there would be approximately 352 instances, over five years, where sperm whales would make short-term behavioral adjustments.

We do not expect the instances in which sperm whales might change their behavioral state to result in reductions in the fitness of the individuals that would exhibit these responses because the duration of the effect is not likely to last long enough to alter the health, physiology, bioenergetics, migratory patterns, or social ecology of whales that are as large as sperm whales. Similarly, we do not expect the instances in which sperm whales might experience temporary threshold shift to reduce the fitness of the whales affected because the whales are likely to regain full hearing sensitivity within days of the threshold shift (we do not know the magnitude of the shift — whether it would consist of fractions of a decibel, six dB, or more — but we assume, for the purposes of our assessment, that the shift would be at least 6 dB and would affect the whale's hearing sensitivity in the low- and mid-frequency ranges).

In the previous biological opinions on the Navy's activities in the Northwest Training Range Complex we estimated that one sperm whale (per year) might experience 50 percent tympanic membrane rupture or slight lung injury. Thirty percent of several species of terrestrial mammals that experienced that kind of rupture of their tympanic membrane experienced long-term or permanent loss of hearing (Ketten 1995), so we assumed the sperm whale has a 30 percent chance of experiencing long-term or permanent hearing loss. Slight lung injury is likely to cause the sperm whale to experience severe discomfort, shortness of breath, and physiological distress and it may interfere with the whale's ability to feed while symptoms persist, which may take weeks depending on the severity of the injury (Walsh and Gearhart 2001). Although we did not expect this sperm whale to die from its injuries, we assume that the whale will experience

clinically significant reductions in its longevity or reproductive success. Over the next three years, under the proposed activities in this Opinion we do not expect any sperm whales to be exposed to shock waves or sound levels that would result in any injuries.

Based on the evidence available, we conclude that training exercises and other activities the U.S. Navy has conducted from 2010 to 2012 and plans to conduct in the Northwest Training Range Complex from November 2012 through November 2015, are not likely to reduce the sperm whales' likelihood of surviving and recovering in the wild by reducing its numbers, reproduction, or distribution.

6.7 Eastern Population of Steller Sea Lion

During the first two LOA periods, the Navy reported that there were 19 instances in which Steller sea lions 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 Steller sea lions made short-term behavioral adjustments that did not appreciably reduce their likelihood of surviving and recovering in the wild. Combined with the estimated take that could occur over the next three years from exposure to active sonar, vessel movements associated with the sonar training exercises, and detonations we expect there would be approximately 373 instances, over five years, where Steller sea lions would make short-term behavioral adjustments.

Based on the evidence available, we conclude that training exercises and other activities the U.S. Navy has conducted from 2010 to 2012 and plans to conduct in the Northwest Training Range Complex from November 2012 through November 2015, are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual Steller sea lions in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual Steller sea lions would not be likely to reduce the viability of the populations those individual Steller sea lions represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities the U.S. Navy plans to conduct in the Northwest Range Complex through November 2015 are not likely to appreciably reduce the Steller sea lions' likelihood of surviving and recovering in the wild.

6.8 Leatherback Sea Turtles

Because the sonar that would be used during the proposed exercises transmits at frequencies above hearing thresholds for sea turtles, leatherback sea turtles that are exposed to those transmissions are not likely to respond to that exposure. As a result, mid-frequency active sonar associated with the proposed exercises is not likely to adversely affect leatherback sea turtles.

Because we would not expect any instances in which leatherback sea turtles would be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in behavioral harassment, temporary threshold shifts, or 50 percent tympanic membrane rupture or slight lung injury, we would not expect leatherback sea turtles to respond to that stressor.

6.9 Threatened and Endangered Fishes

During the first two LOA periods, the Navy reported that there were no instances of "take" of any ESA-listed fishes. Combined with the estimated take that could occur over the next three years as a result of underwater detonations we expect that there would be approximately 75 Puget Sound Chinook salmon and 324 Hood Canal summer-run Chinook salmon and as a result of active sonar an unquantifiable number of larval Georgia Basin bocaccio, Georgia Basin canary rockfish, and Georgia Basin yelloweye rockfish, over five years, that would be "taken."

The number of larvae or juveniles that are likely to be 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). As a result, the activities the U.S. Navy plans to conduct in the Northwest Range Complex through November 2015 would not appreciably reduce the likelihood of Georgia Basin bocaccio, Georgia Basin canary rockfish, Georgia Basin yelloweye rockfish, Pacific salmon, steelhead, green sturgeon, or southern eulachon surviving and recovering in the wild.

7 CONCLUSION

After reviewing the current status of blue whales, fin whales, humpback whales, sei whales, Southern resident killer whales, sperm whales, Steller sea lion (eastern population), leatherback sea turtles, Georgia Basin bocaccio, Georgia Basin canary rockfish, Georgia Basin yelloweye rockfish, southern green sturgeon, 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, the environmental baseline for the action area, the effects of the military readiness activities the U.S. Navy plans to conduct on the Northwest Training Range Complex and the cumulative effects, it is NMFS' biological opinion that the military readiness activities the U.S. Navy proposes to conduct on the Northwest

Training Range Complex from November 2012 through November 2015 under the MMPA regulations and the proposed LOA are not likely to jeopardize the continued existence of these threatened and endangered species under NMFS jurisdiction. We also reaffirm our prior conclusion in the 2010 Programmatic Biological Opinion, taking into account the updated information described above, that the level of take expected to occur during the five-year duration of the MMPA regulations for the Northwest Training Range Complex, whether considered on an annual basis or in the aggregate, is not likely to jeopardize the continued existence of any threatened and endangered species under NMFS jurisdiction.

The Opinion also concluded that military readiness activities the U.S. Navy plans to conduct on the Northwest Training Range Complex are not likely to adversely affect critical habitat that has been designated for endangered or threatened species in the action area. Therefore they are not likely to result in the destruction or adverse modification of that habitat.

8 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 (ITS).

8.1 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 proposed 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 Biological Opinion concluded that individual blue whales, fin whales, humpback whales, sei whales, sperm whales, Southern Resident killer whales, Steller sea lions, 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 8 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 significant disruptions of the normal behavioral patterns of the animals that have been exposed. No whales are likely to die or be wounded as a result of their exposure to the training activities the U.S. Navy plans to conduct on the Northwest Training Range Complex. Therefore, for the purposes of this Biological Opinion and Incidental Take Statement, we assume that the training activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex is likely to result in incidental "take" shown in Table 8.

Table 8 also shows the estimated take that occurred during the first two years (November 2010-November 2012) covered by the MMPA regulations and prior LOAs and the total estimated take levels that will occur during the five-year period of the regulations. 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 8. The number of threatened or endangered species that are likely to be "taken" in the form of harassment or harm as a result of their exposure to U.S. Navy military readiness activities conducted on the Northwest Training Range Complex between November 2010 and November 2015[1].

Species	2010-2011		2011-2012		ITS Total 2010-2012	Actual Take 2010-2012	Annual Estimate 2013-2015			Take Estimate 2013-2015	5-year Take Estimate 2010-2015
	ITS	Actual	ITS	Actual			Sonar	Detonations	Total		
Blue Whale	17	0	17	2	34	**2**	15	1	16	48	**50**
Fin Whale	62	0	70	8	132	**8**	50	7	57	171	**179**
Humpback Whale[2]	26	0	15	2	41	**2**	15	0	15	45	**47**
Sei Whale[2]	7	0	1	0	8	**0**	1	0	1	3	**3**
Southern Resident Killer Whale	2	0	14[3]	2	16	**2**	2	0	2	6	**8**
Sperm Whale	128	1	128	18	256	**19**	105	6	111	333	**352**
Steller Sea Lion	117	2	120	17	237	**19**	114	4	118	354	**373**
Puget Sound Chinook Salmon	14	0	25	0	39	**0**	0	25	25	75	**75**
Hood Canal Summer-run Chinook Salmon	27	0	108	0	135	**0**	0	108	108	324	**324**

[1] *Different approaches to round values less than 1.0, result in slightly different "take" estimates.*
[2] *The number of animals that may be "taken" is limited by the applicable MMPA rule (50 CFR § 218.110; 76 FR 20257).*
[3] *The 2011 Opinion mirrored the "take" of killer whales that was authorized by the 2011 LOA, which did not distinguish between the "take" of southern resident killer whales and the "take" of all other killer whales.*

"Take" of these species will have been exceeded if these estimates are exceeded or if the monitoring program associated with the training activities detects any individuals of these species that have been harmed, injured, or killed as result of exposure to active sonar transmissions or underwater detonations.

As a result of the underwater detonations the U.S. Navy proposes to conduct, we expect one adult and one juvenile Puget Sound Chinook salmon to die or be injured during each surface detonation of 2.5-pound ordnance at Crescent Harbor; six adult Puget Sound Chinook salmon to die during each of the two underwater detonations of 2.5-pound ordnance at Hood Canal; and 27 adult Hood Canal summer-run Chinook salmon during each underwater detonation of 2.5-pound ordnance at SUBASE Bangor. The Navy may conduct up to four explosive exercises annually at each detonation site.

"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.

8.2 Effect of the Take

In the accompanying Opinion and in our June 15, 2010 Programmatic Biological Opinion, which is incorporated by reference, NMFS determined that the above level of take, considered either on an annual basis or in the aggregate over the entire five-year course of the applicable MMPA regulations, 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.

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. 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 senses of we 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 listed in Table 8 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 five-year duration of the MMPA regulations.

8.3 Reasonable and Prudent Measures

The National Marine Fisheries Service believes the following reasonable and prudent measures are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

> The U.S. Navy shall employ the mitigation measures included as part of its proposed action and the mitigation measures required by the Permits Division's 2012 LOA for the Northwest Training Range Complex.
>
> NMFS Permits and Conservation Division shall ensure that the U.S. Navy adheres to the mitigation and measures required by the 2012 LOA.

8.4 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 the preceding Biological Opinion and

contained in the LOA issued under section 101(a)(5)(A) of the Marine Mammal Protection Act.

2. Northwest Training Range Complex 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 exercises that use active sonar or explosives for which annual reports are required (Annual Northwest Training Range Complex Exercise Reports and Northwest Training Range Complex Monitoring Plan Reports). This report will be submitted at the end of the fourth year of the rule (March 2013), covering activities that have occurred through October 1, 2012.

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 Northwest Training Range Complex, and the Gulf of Alaska.

    (i) The Navy shall respond to NMFS comments and requests for additional information or clarification on the Northwest Training Range Complex Comprehensive Report, the Comprehensive National Anti-Submarine Warfare report, the Annual Northwest Training Range Complex Exercise Report, or the Annual Northwest Training Range Complex 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 3 months of receipt. 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.

4. The U.S. Navy shall deliver a report of data collected during the first six month of the Letter of Authorization not later than 90 days before the expiration of the LOA followed by an annual report delivered not later than 45 days after the expiration of the Letter of Authorization. These reports must include numbers and locations of all threatened and endangered species sightings, and all information required by Letter of Authorization, including the results, if any, of coordination with coastal marine mammal stranding networks. In addition to requirements of the Letter of Authorization for marine mammals, the annual report must address all affected threatened and endangered species addressed in this Opinion. The annual 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.

5. 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.

6. NMFS Permits and Conservation Division shall provide NMFS 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.

9 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 proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The following conservation recommendations would provide information for future consultations involving the issuance of marine mammal permits that may affect endangered 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 Endangered Species Act Interagency Cooperation Division informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Permits Division of the Office of Protected Resources should notify the Endangered Species Act

Interagency Cooperation Division of any conservation recommendations they implement in their final action.

10 REINITIATION NOTICE

This concludes formal consultation on military readiness activities the U.S. Navy plans to conduct on the Northwest Training Range Complex from November 2012 through November 2015 and the National Marine Fisheries Service's 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.

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