NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title:	Biological Opinion on U.S. Navy Training Activities on the Northwest Training Range and Research, Development, Test, and Evaluation Activities at the Naval Undersea Warfare Center Keyport Range Complex and Associated Letters of Authorization to Take Marine Mammals
Action Agency:	United States Navy Permits, Conservation, and Education Division, Office of Protected Resources, National Marine Fisheries Service
Consultation Conducted By:	Endangered Species Division, Office of Protected Resources, National Marine Fisheries Services

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

Agencies:	National Marine Fisheries Service, with the U.S. Navy as Action Agency and Applicant for a Federal Authorization
Activities Considered:	The U.S. Navy's proposed training activities on the Northwest Training Range from June 2010 to June 2015 Promulgation of regulations to authorize the U.S. Navy to "take" marine mammals incidental to training on the Northwest Training Range from June 2010 to June 2015 The U.S. Navy's proposed research, development, test, and evaluation activities at the Naval Undersea Warfare Center Keyport Range Complex from June 2010 to June 2015 Promulgation of regulations to authorize the U.S. Navy to "take" marine mammals incidental to research, development, test, and evaluation activities at the Naval Undersea Warfare Center Keyport Range Complex from June 2010 to June 2015
Consultation Conducted by:	Endangered Species Division of the Office of Protected Resources, National Marine Fisheries Service

Approved by: Helen Golde for J.H. Lecky

Date: JUN 15 2010

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 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 United States Navy, which proposes to (1) conduct training and research, development, test, and evaluation activities on the Northwest Training Range and (2) undertake research, development, test, and evaluation activities and conduct fleet activities at the Naval Undersea Warfare Center, Keyport Range Complex and NMFS' Office of Protected Resources –

Permits, Conservation, and Education Division, which proposes to promulgate regulations that would authorize the U.S. Navy to "take" marine mammals incidental to those training and research, development, test, and evaluation activities. The consulting agencies for these proposals are the U.S. Navy (for the military readiness activities they propose to conduct on the Keyport and Northwest Training Range Complexes) and NMFS' Office of Protected Resources - Endangered Species Division (for the Marine Mammal Protection Act authorizations).

These four activities have been combined into a single document for several reasons, First, the proposed Marine Mammal Protection Act authorizations to "take" marine mammals incidental to the military readiness activities the U.S. Navy proposes to conduct on the Keyport Range Complex and Northwest Training Range Complex, respectively, would have no independent ultility apart from the U.S. Navy's proposals. Consequently, the proposed MMPA authorizations are interdependent on the corresponding U.S. Navy proposals; as such, our effects analyses must consider the direct and indirect effects of the U.S. Navy's proposals as well as the direct and indirect effects of the MMPA authorizations on endangered and threatened species and critical habitat that has been designated for those species (50 CFR 402.02 and 402.14(g)). In addition, the military readiness activities the U.S. Navy proposes to conduct on the Keyport Range Complex and the Northwest Training Range Complex overlap in space and time; so these consultations have been batched to insure that this Opinion considers the potential individual and cumulative consequences of exposing endangered species, threatened species, and critical habitat that has been designated for those species to stressors associated with readiness activities on both range complexes.

This document represents NMFS' final programmatic biological opinion (Opinion) on the effects of these proposals by the U.S. Navy and the National Marine Fisheries Service's Permits, Conservation, and Education Division on endangered and threatened species and critical habitat that has been designated for those species..This Opinion has been prepared in accordance with section 7 of the ESA and considers and is based on information provided in the U.S. Navy's marine resources assessment for the Pacific Northwest Operating Area (U.S. Navy 2006), the U.S. Navy's request for letter of authorization for incidental harassment of marine mammals resulting from training activities within the Keyport Range Complex Extension (U.S. Navy 2008a), the Naval Sea System's Command, Naval Undersea Warfare Center Keyport Range Complex Extension Draft Environmental Impact Statement/ Overseas Environmental Impact Statement (U.S. Navy 2008b); request for letter of authorization for incidental harassment of marine mammals resulting from training activities within the Northwest Training Range Complex (U.S. Navy 2008c), the U.S. Navy's Draft Environmental Impact Statement/Overseas Environmental Impact Statement, Northwest Training Range Complex (U.S. Navy 2008d), the Naval Sea System's Command, Naval Undersea Warfare Center Keyport Range Complex Extension biological evaluation (U.S. Navy 2008e) the U.S. Navy's biological evaluation for the Northwest Training Range Complex (U.S. Navy 2009a), the U.S. Navy's amended biological evaluation for the Northwest Training Range Complex (U.S. Navy 2009b), amendments to the U.S. Navy's applications for the two Marine Mammal Protection Act authorizations considered in this Opinion, final and draft recovery plans for the endangered threatened species that are considered in this document, and publications that we identified, gathered, and examined from the public scientific literature, which are discussed in greater detail in the *Approach to the Assessment* section of this Opinion.

Procedural History for the Consultation on the Keyport Range Complex Extension

On 15 December 2008, the U.S. Navy submitted a biological evaluation and request for informal consultation on the Naval Sea System's Naval Undersea Warfare Center - Keyport Range Complex Extension to the National Marine Fisheries Service's (NMFS) Washington Habitat Office in Lacey, Washington. That request initiated a series of meetings and discussions between the U.S. Navy and personnel in NMFS' Washington Habitat Office.

On 10 April 2009, the U.S. Navy submitted a copy of its Draft Environmental Impact Statement and Overseas Environmental Impact Statement for the Keyport Extension to the National Marine Fisheries Service's Washington Habitat Office in Lacey, Washington.

On 7 July 2009, the National Marine Fisheries Service's Permits, Conservation and Education Division published proposed regulations to govern the unintentional taking of marine mammals incidental to activities conducted at the Naval Sea Systems Command, Naval Undersea Warfare Center, Keyport Range Complex for the period of June 2010 through June 2015. The Permits Division provided the National Marine Fisheries Services' Endangered Species Division with a copy of its draft final regulations for these activities on 7 October 2009.

On 4 February 2010, the National Marine Fisheries Service's Endangered Species Division provided the U.S. Navy and the Permits Division with copies of its draft biological opinion on the Keyport Range Complex extension and associated Marine Mammal Protection Act authorizations. On 26 March 2010, the Endangered Species Division received comments on its draft biological opinion from the Naval Sea System's Naval Undersea Warfare Center - Keyport Range Complex.

On 18 March 2010, the National Marine Fisheries Service published a final rule to list the southern population of Pacific eulachon as a threatened species. After discussions with the U.S. Navy, the Endangered Species Division agreed to incorporate eulachon into its consultation on the Keyport Range Complex extension and associated Marine Mammal Protection Act authorizations. After further discussions with the U.S. Navy, the Endangered Species Division also agreed to incorporate Georgia Basin bocaccio, Georgia Basin canary rockfish, and Georgia Basin yelloweye rockfish, which the National Marine Fisheries had proposed to list as threatened species into this consultation and treat them as if they had already been listed (that is, the triggers for consultation were "may affect" determinations, not the standard established in section 7(a)(4) of the Endangered Species Act of 1973, as amended, which would normally apply to species or critical habitat that have been proposed for listing or designation, respectively).

On 23 April 2010, , the National Marine Fisheries Service's Endangered Species Division provided the U.S. Navy and the Permits Division with copies of its second draft biological opinion on the Keyport Range Complex extension and associated Marine Mammal Protection Act authorizations.

Procedural History for the Consultation on the Northwest Training Range Complex

In 28 October 2008, the U.S. Navy submitted a request for a letter of authorization to "take" marine mammals incidental to training activities on the Northwest Training Range Complex to the National Marine Fisheries Service's Permits, Conservation and Education Division. In October 2008, the U.S. Navy also provided a final biological evaluation on the Northwest Training Range Complex. The U.S. Navy provided an updated biological evaluation on marine and terrestrial species in January 2009 and provided an amendment to that biological evaluation in October 2009.

In July 2009, the U.S. Navy submitted a copy of its Draft Environmental Impact Statement and Overseas Environmental Impact Statement for the Northwest Training Range Complex to the National Marine Fisheries Service's Office of Protected Resources.

On 13 July 2009, the National Marine Fisheries Service's Permits, Conservation and Education Division published proposed regulations to govern the unintentional taking of marine mammals incidental to activities conducted in the Northwest Training Range Complex, off the coasts of Washington, Oregon, and northern California, for the period of June 2010 through June 2015. The Permits Division provided the National Marine Fisheries Services' Endangered Species Division with a copy of its draft final regulations for these activities on 3 December 2009.

On 4 February 2010, the National Marine Fisheries Service's Endangered Species Division provided the U.S. Navy and the Permits Division with copies of its draft biological opinion on the Northwest Training Range Complex and associated Marine Mammal Protection Act authorizations. On 25 March 2010, the Endangered Species Division received comments on its draft biological opinion from the Northwest Training Range Complex.

On 18 March 2010, the National Marine Fisheries Service published a final rule to list the southern population of Pacific eulachon as a threatened species. After discussions with the U.S. Navy, the Endangered Species Division agreed to incorporate eulachon into its consultation on the Northwest Training Range Complex and associated Marine Mammal Protection Act authorizations. After further discussions with the U.S. Navy, the Endangered Species Division also agreed to incorporate Georgia Basin bocaccio, Georgia Basin canary rockfish, and Georgia Basin yelloweye rockfish, which the National Marine Fisheries had proposed to list as threatened species into this consultation and treat them as if they had already been listed (that is, the triggers for consultation were "may affect" determinations, not the standard established in section 7(a)(4) of the Endangered Species Act of 1973, as amended, which would normally apply to species or critical habitat that have been proposed for listing or designation, respectively).

On 23 April 2010, , the National Marine Fisheries Service's Endangered Species Division provided the U.S. Navy and the Permits Division with copies of its second draft biological opinion on the Keyport Range Complex extension and associated Marine Mammal Protection Act authorizations and the Northwest Training Range Complex and associated Marine Mammal Protection Act authorizations.

BIOLOGICAL OPINION

1.0 Description of the Proposed Action

This biological opinion addresses 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) to allow the U.S. Navy to "take" marine mammals 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.

The purpose of the activities the U.S. Navy proposes to conduct on the Keyport Range Complex and Northwest Training Range Complex is to meet the requirements of the U.S. Navy's Fleet Response Training Plan, allow NUWC Keyport to continue fulfilling its mission of providing test and evaluation services and expertise to support the Navy's evolving manned and unmanned undersea vehicle program; and allow Navy personnel to remain proficient in anti-submarine warfare and mine warfare skills. The purpose of the Permits Division's regulations is to allow the U.S. Navy to "take" marine mammals incidental to in-water Research, Development, Test and Evaluation activities at the U.S. Naval Undersea Warfare Center, Keyport Range Complex; and incidental to readiness activities on the Northwest Training Range Complex.

The following narratives summarize the information the U.S. Navy provided on the various readiness activities it plans to conduct each year over the five-year duration of the proposed regulations. Each narrative only describes those elements of the U.S. Navy's preferred alternatives that might be relevant to our assessment of the potential direct or indirect effects of those activities on endangered or threatened species or critical habitat that has been designated for those species. More detailed descriptions of each activity are available in the U.S. Navy's Draft Environmental Impact Statement/Overseas Environmental Impact Statement, Northwest Training Range Complex (U.S. Navy 2008d), the Naval Sea System's Command's Draft Environmental Impact Statement/Overseas Environmental Impact Statement on the Naval Undersea Warfare Center Keyport Range Complex Extension (U.S. Navy 2008), the U.S. Navy's biological evaluation and amended biological evaluation for the Northwest Training Range Complex (2009a, 2009b), the U.S. Navy's biological evaluation and amended biological evaluation for the Keyport Range Complex extension (2008e), and applications for the proposed MMPA permits and amendments to those applications.

1.1 Keyport Range Complex

The Keyport Range Site is located in Kitsap County and includes portions of Liberty Bay and Port Orchard Reach (also known as the Port Orchard Narrows). The Dabob Bay Range Complex is located in Hood Canal and Dabob Bay, in Jefferson and Kitsap counties. The Quinault Underwater Tracking Range is located in the Pacific Ocean off the coast of Jefferson County. The Permits Division proposes to promulgate regulations governing the "take" of marine mammals (50 CFR Part 218.170) to allow NMFS to issue annual letters of authorization that would allow the U.S. Navy to "take" marine mammals for a five-year period beginning in June 2010 and ending in June 2015 incidental to these training activities.

Activities conducted at the various range sites may be related operationally in that certain tests are run interdependently and are used in tandem (e.g., one test may be at the Dabob Bay Range Complex Site and another run simultaneously at the Keyport Range Site). However, each test is conducted solely at a single range site location, and each site is independently monitored for safety and operational purposes. While one suite of tests may be conducted over various portions of the range complex, each specific activity is planned and executed independently.

Proposed Extensions of the Keyport Range Complex

The U.S. Navy proposes the following extensions of the Naval Undersea Warfare Center (NUWC) Keyport Range Complex

1. At the Keyport Range Site, the U.S. Navy proposes to extend the range boundaries to the north, east, and south, increasing the size of the range from 1.5 nm^2 to 3.2 nm^2 (5.2 km2 to 11.0 km2) and increase the average annual days of use would increase from 55 to 60 days.
2. At the Dabob Bay Range Complex, the U.S. Navy proposes to extend the southern boundary approximately 10 nm (19 km), and the northern boundary to 1 nm (2 km) south of the Hood Canal Bridge, increasing the size of the range from 32.7 nm2 to 45.7 nm^2 (112.1 km^2 to 156.7 km^2). The U.S. Navy does not propose to increase the average annual number of days they engage in activities at Dabob Bay.
3. At the Quinault Underwater Tracking Range, lies within the Northwest Training Range Complex and underlies a portion of Warning Area 237A, the U.S. Navy proposes to extend the range boundaries to coincide with the overlying special use airspace of W-237A and locate a 7.8 nm^2 (26.6 km^2) surf zone at Pacific Beach. The average annual use for offshore activities would increase from 14 days to 16 days and activities in the selected surf zone would occur an average of 30 days per year (see Figures 1 and 2 for maps of these locations).

Activities Conducted at the Keyport Range Complex

The activities the U.S. Navy typically conducts at NUWC Keyport support undersea warfare research, development, test and evaluation (RDT&E) program, but they also support general equipment test and military personnel training needs, including fleet activities, which do not include the use of surface ship and submarine hull-mounted sonars.

Historically, the number of days each range site has been used have averaged about 60 days for the Keyport Range Site, 130 days for the Dabob Bay Site, and 20 days for the Quinault Underwater Tracking Range Site. Currently, the U.S. Navy uses the Keyport Range Site for an average annual of 55 days, the Dabob Bay Site for an annual average of 200 days, and the Quinault Underwater Tracking Range Site for an annual average of 14 days. At the Quinault Underwater Tracking Range, the U.S. Navy proposes to increase the average annual use from 14 days to 16 days.

Test Vehicle Propulsion

Test vehicles propulsion refers to the type of fuel or energy used to power test vehicles operating at a range site. Test vehicles used at the nuwc Keyport Range Complex sites feature two types of propulsion systems: thermal and electric/chemical.

Thermal propulsion systems, powered by Otto Fuel II, rocket fuel, diesel fuel, and/or jet fuels, are open cycle systems whereby combustion byproducts are exhausted to the water column. There are also closed cycle thermal systems that have no emissions into the environment other than heat. Several torpedoes and Unmanned Undersea Vehicles use thermal engines for high speed and short duration.

Table 1. Activities the U.S. Navy proposes to conduct in the Keyport Range Complex each year over the next five years

Range Activity	Platform or System Used	Number of Activities Proposed Per Year by Area *		
		Keyport Range Site	DBRC Site	QUTR Site
Test Vehicle Propulsion	Thermal propulsion systems	5	130	30
	Electric/Chemical propulsion systems	55	140	30
Other Testing Systems and Activities	Submarine testing	0	45	15
	Inert mine detection, classification and localization	5	20	10
	Non-Navy testing	5	5	5
	Acoustic & non-acoustic sensors (magnetic array, oxygen)	20	10	5
	Countermeasure test	5	50	5
	Impact testing	0	10	5
	Static in-water testing	10	10	6
	Unmanned undersea vehicle test	45	120	40
	Unmanned Aerial System (UAS) test	0	2	2
Fleet Activities** (excluding RDT&E)	Surface Ship activities	1	10	10
	Aircraft activities	0	10	10
	Submarine activities	0	30	30
	Diver activities	45	5	15
Deployment Systems (RDT&E)	Range support vessels:			
	Surface launch craft	35	180	30
	Special purpose barges	25	75	0
	Fleet vessels***	15	20	20
	Aircraft (rotary and fixed wing)	0	10	20
	Shore and pier	45	30	30

* There may be several activities in 1 da. These numbers provide an estimate of types of range activities over the year.

** Fleet activities in the NAVSEA NUWC Keyport Range Complex do not include the use of surface ship and submarine hull-mounted active sonars.

*** As previously noted, Fleet vessels can include very small craft such as SEAL Delivery Vehicles.

The U.S. Navy currently conducts activities involving thermal propulsion of test vehicles for an average of 130 days per year within the Dabob Bay Site and 20 days per year within the Quinault Underwater Tracking Range Site (currently, no activities involving thermal propulsion occur at the Keyport Range Site). Activities using thermal propulsion systems may be scheduled for anywhere from 10 minutes to 24 hours.

Electric propulsion systems are powered by motors using different types of batteries. Battery types include lithium thionyl, lithium ion, lead acid, silver zinc, and nickel hydride. For these closed cycle systems only heat energy is transferred into the environment. Electric propulsion is generally used for mobile targets, unmanned undersea vehicles, and other systems that run for relatively long periods. Chemical propulsion systems are usually based on a lithium boiler that is a closed cycle system. Chemical propulsion system are

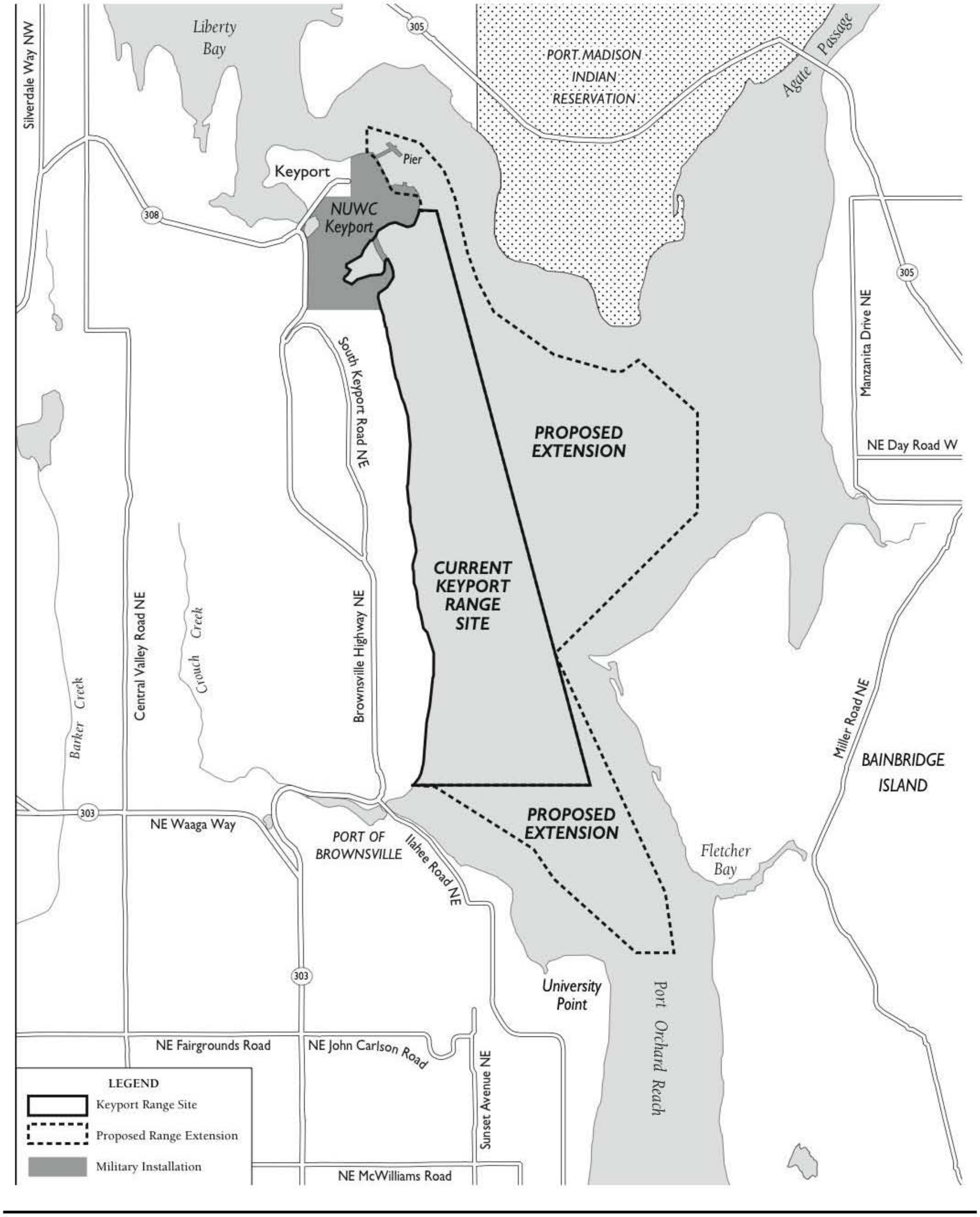

Figure 1. The proposed extension of the Keyport Range Complex site (adapted from Figure 2-4a of the U.S. Navy's Draft Environmental Impact Statement/Overseas Environmental Impact Statement on the Keyport Range Complex Extension (U.S. Navy 2008b)

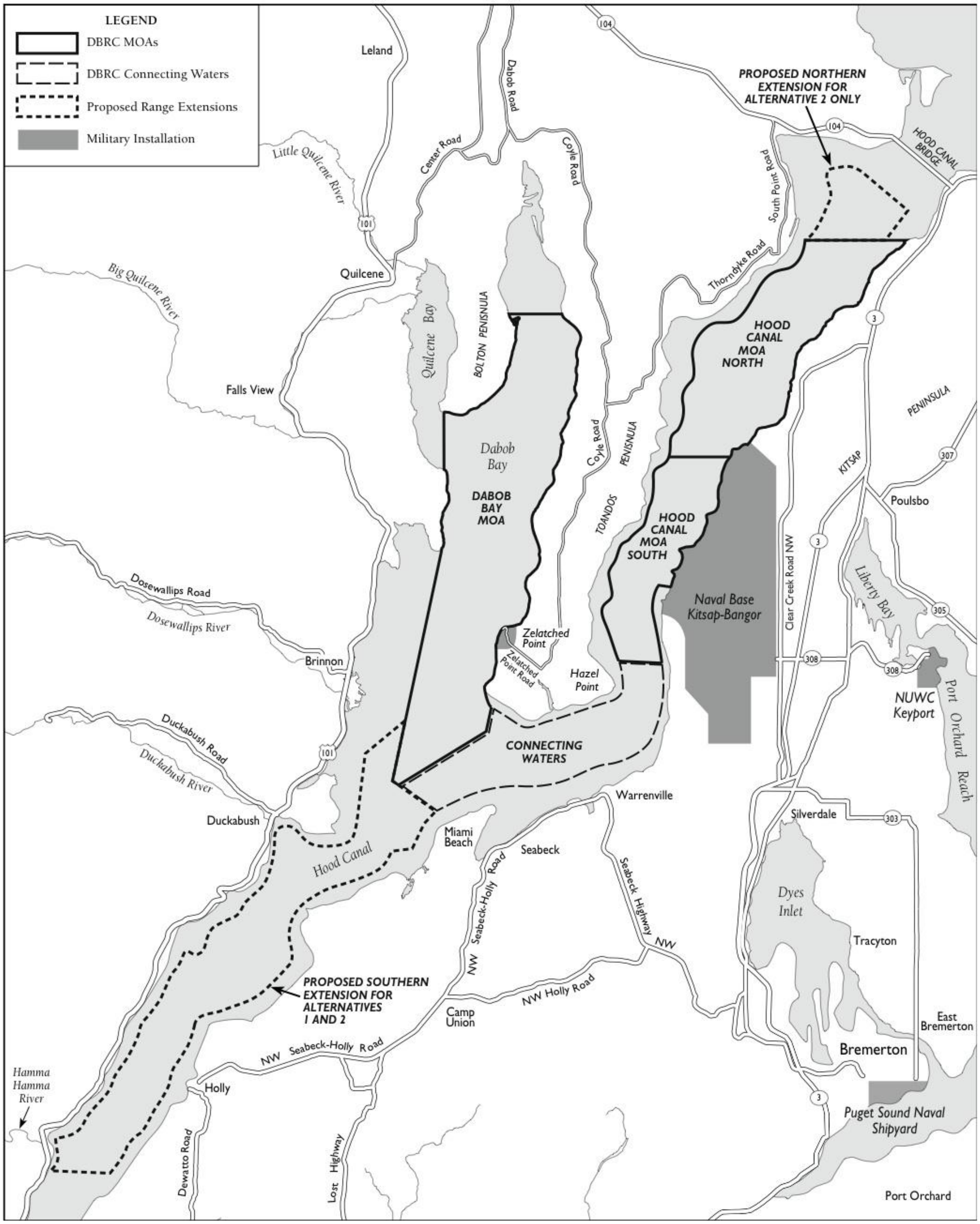

Figure 2. The proposed extension of the Dabob Bay Range Complex sites (adapted from Figure 2-5a of the U.S. Navy's Draft Environmental Impact Statement/Overseas Environmental Impact Statement on the Keyport Range Complex Extension (U.S. Navy 2008b)

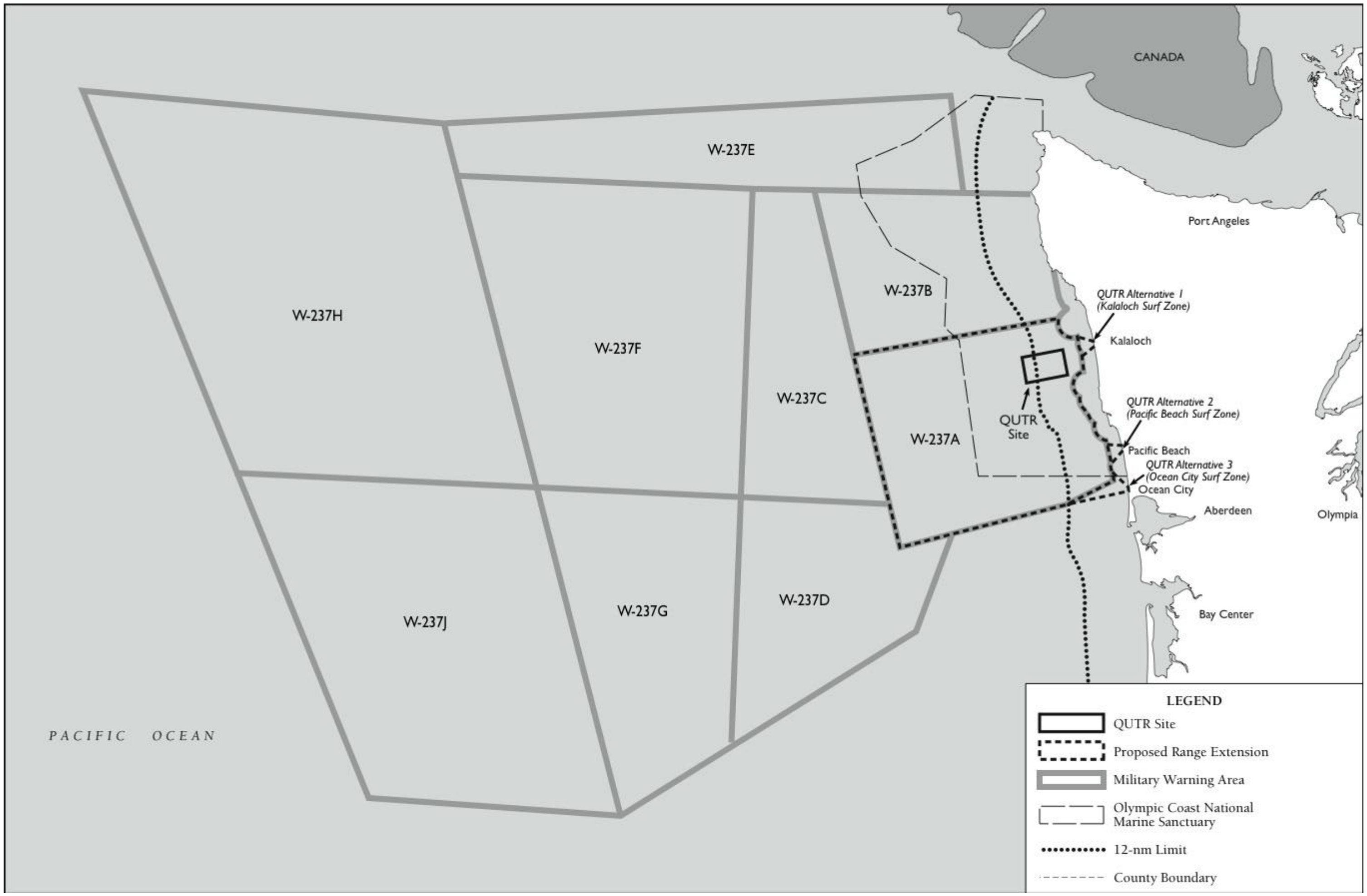

Figure 3. The proposed extension of the Quinault Underwater Tracking Range site (adapted from Figure 2-6a of the U.S. Navy's Draft Environmental Impact Statement/Overseas Environmental Impact Statement on the Keyport Range Complex Extension (U.S. Navy 2008b)

generally used for high speed and short duration torpedoes and unmanned undersea vehicles.

The U.S. Navy currently conducts activities involving electric or chemical propulsion of test vehicles for an average of 45 days per year at the Keyport Range Site, 140 days per year within the Dabob Bay Site, and 10 days per year within the Quinault Underwater Tracking Range Site. Test vehicles utilizing electric/chemical propulsion systems are typically scheduled for 4 hours of use during each activity.

SUBMARINE TESTING. Submarine RDT&E testing includes any Fleet or civilian submarine used in support of testing. The vessel may be small enough to be launched from another submarine or surface craft or it may be as large as an Ohio class submarine. Currently, the U.S. Navy schedules activities of this type for an average of 45 days per year within the Dabob Bay Site and 10 days per year within the Quinault Underwater Tracking Range Site (no activities involving submarine testing occur at the Keyport Range Site). The typical duration of submarine testing activity is up to 8 hours.

INERT MINE DETECTION, CLASSIFICATION, AND LOCALIZATION. This type of activity supports RDT&E of inert mine systems and provides training to Navy personnel on how to deploy, detect, and defend against mine systems. For example, unmanned undersea vehicle mine sensors may be tested to ensure they can detect, classify, and localize inert mines amongst rocky outcrops or inert shapes. These sensors may also be associated with a vessel, or placed before a single inert mine or inert mine field is put in place. The inert mines themselves may be tested to ensure they deploy as required and Fleet operators may be trained in mine field placement.

The U.S. Navy currently conducts activities involving inert mine detection, classification, or localization for an average of 5 days per year at the Keyport Range Site, 20 days per year within the Dabob Bay Site, and 5 days per year within the Quinault Underwater Tracking Range Site. Activities of this type may be anywhere from 4 hours to multiple days in duration.

NON-NAVY TESTING. These activities may involve a wide variety of non-Navy applications including from private enterprise and universities. Usually the non-Navy customer is doing RDT&E in support of Office of Naval Research or to prepare an item for a Navy or Department of Defense application. RDT&E of non-Navy equipment/software/processes are applied to Department of Defense and usually Navy mission. An example of this would be the test of the American Native Technologies glider. The company hopes to provide this system to the

Navy to measure environmental characterization sound velocity profiles measuring salinity and temperature with respect to depth. Non-Navy testing can also involve development of software for use aboard an aircraft carrier or in a Fleet helicopter for managing data from one platform to another. The test would be of the software package on the helicopter for example.

The U.S. Navy currently conducts activities involving non-Navy testing for an average of 5 days per year at each of the 3 range sites. Activities involving non-Navy testing may be scheduled for anywhere from 10 minutes to multiple days.

ACOUSTIC AND NONACOUSTIC SENSORS. Acoustic sensors are any hydrophones on any kind of platform or mounted to crafts or towed at bottom or mid-depth. An example of the application of an acoustic sensor is the bottom moored array at the Dabob Bay Site, which is an array of hydrophones moored to the bottom and suspended in the water column to enable identification of noise from passing torpedoes. The level of noise may change if there is a nick in a propeller or if a mechanism in the vehicle is malfunctioning.

These problems can be found by listening with passive acoustics before they become apparent with the vehicle in the shop. An example of a nonacoustic sensor is an oxygen sensor that detects the level of dissolved oxygen in the water with respect to depth. Sensors for Conductivity and Temperature with respect to depth are used frequently to improve tracking with updated sound velocity profiles from raw data. Magnetic sensors are non-acoustic sensors that can be placed on the bottom to detect passing vessels. A sensor may also be put on a unmanned undersea vehicle as a payload.

The U.S. Navy currently conducts acoustic and nonacoustic sensor tests for an average of 20 days per year at the Keyport Range Site, 10 days per year within the Dabob Bay Site, and 5 days per year within the Quinault Underwater Tracking Range Site. Activities involving these systems may be anywhere from 10 minutes to multiple days in duration.

COUNTERMEASURE TEST. Countermeasures, which may take many different forms and represent a range of tactics, attempt to disrupt an attack intended for a target. Underwater, a countermeasure may emit sound that is louder than the target or in a different location that is similar to the target, causing the attacker to detour away from the target. A countermeasure could also be something that looks like a threat or mimics the magnetic characteristics of a target, so that the actual threat or target remains undetected. By design, countermeasures emit active acoustic energy of varying frequencies into the water.

The U.S. Navy currently conducts activities involving countermeasures for an average of 5 days per year at the Keyport Range Site, 50 days per year within the Dabob Bay Site, and 5 days per year within the Quinault Underwater Tracking Range Site. Activities involving these systems may last anywhere from 8 to 36 hours.

IMPACT TESTING. This type of test evaluates the durability of test vehicles by causing an impact between them or between the test vehicle and some other object. Such tests evaluate the functioning of approach and guidance and control capabilities of test vehicles. Currently, the U.S. Navy schedules activities of this type for an average of 10 days per year within the Dabob Bay Site and 5 days per year within the Quinault Underwater Tracking Range Site (no impact testing activities occur at the Keyport Range Site). Individual tests of this type typically last about 8 hours.

STATIC IN-WATER TESTING. Static tests are performed by holding the system under test in place, either hanging over the side of a vessel, mounted on the sea floor, or suspended within the water column. Static in-water testing includes any kind of test in which the system under test doesn’t actually move through the water.

The U.S. Navy currently conducts static testing activities for an average of 10 days per year at the Keyport Range Site, 10 days per year within the Dabob Bay Site, and 5 days per year within the Quinault Underwater Tracking Range Site. Individual tests of this type may be conducted for as little as 10 minutes to as much as 8 hours.

UNMANNED UNDERSEA VEHICLE TESTING. unmanned undersea vehicles are any unmanned underwater vehicle that swims, floats, or crawls along the sea floor. They include torpedoes and they may carry a payload (e.g., an active acoustic system or a passive acoustic or nonacoustic sensor) that is being tested.

The U.S. Navy currently conducts activities involving unmanned undersea vehicles for an average of 45 days per year at the Keyport Range Site, 120 days per year within the Dabob Bay Site, and 20 days per year within the Quinault Underwater Tracking Range Site. unmanned undersea vehicle tests may be anywhere from 10 minutes to multiple days in duration.

Fleet Activities (Not Including RDT&E Activities)

Fleet activities that occur within the Keyport Range Complex include the use of ships, aircraft, submarines, or Navy divers. Such activities provide sailors the opportunity to train with actual Naval assets in a controlled range environment. None of the fleet activities conducted in the NUWC Keyport Range Complex involve the use of hull-mounted active sonars.

Fleet activities involving surface ships occur an average of once per year at the Keyport Range Site, and approximately 10 times per year at the Dabob Bay and Quinault Underwater Tracking Range Sites. Each occurrence of these activities typically lasts about 8 hours. Surface ships are outfitted with navigation tracking systems so that their location on the instrumented range can be very accurately determined. Surface ships and the range use active acoustics to support navigation (tracking, depth sensors, etc.), detection, classification and localization. Surface ships may launch a lightweight torpedo and active and passive underwater targets while at a range site. There may also be a target simulator with passive acoustics to simulate a target engine noise at depth.

Aircraft activities and submarine activities do not occur at the Keyport Range Site at all, and occur an average of 10 days (aircraft) and 30 days (submarines) per year at the Dabob Bay and Quinault Underwater Tracking Range Sites. Training activities involving aircraft typically last from 2 to 4 hours each, while submarine activities often last as much as 8 hours. Aircraft may drop or launch active and passive sonobuoys for detection, location and classification of underwater targets. There may be a target simulator with passive acoustics to simulate a target engine noise at depth. Additionally the aircrew may drop a torpedo and the torpedo acoustics may be activated as part of the training activity. Similarly, submarines are also outfitted with navigation tracking systems so that their location on the instrumented range can be accurately determined.

Submarines and the range both also use active acoustics to support navigation (tracking, depth sensors etc.), detection, classification and localization. A submarine may launch a lightweight torpedo and active and passive underwater targets, and there may be a target simulator with passive acoustics to simulate a target engine noise at depth.

Fleet training for divers includes the Navy SEAL cold water training and other diver training related to Navy divers supporting range operations. Passive acoustic systems may be used in diver training and, unless on the tracking range, the diver activities are not likely to use acoustics for tracking, but they may have navigation. Diver activities occur an average of 45 days per year at the Keyport Range Site, 5 days per year at the Dabob Bay Site, and 10 days per year at the Quinault Underwater Tracking Range Site. Each training session involving divers may last from 8 to 36 hours.

RANGE SUPPORT SURFACE LAUNCH CRAFT. A variety of small craft are used to deploy, tow, launch, and retrieve test vehicles, systems and platforms in support of testing activities. Such vessels may use standard commercial acoustic navigation (tracking, depth sensors, etc.) systems. No tactical hull-mounted active sonars are used. The U.S. Navy employs these craft for an average of 35 days per year at the Keyport Range Site, 180 days at the Dabob Bay Site, and 30 days at the Quinault Underwater Tracking Range Site. Typical activities involving such craft may be from 8 hours to 1 week in duration.

RANGE SUPPORT SPECIAL PURPOSE BARGES. These are platforms for deploying and monitoring recovery vehicles and operations. They may have self-propulsion or they may be towed into place and moved around by tug boats. They perform many of the same functions as the surface launch craft.

The U.S. Navy currently conducts range support barges for an average of 25 days per year at the Keyport Range Site and 75 days per year at the Dabob Bay Site, but are not used at the Quinault Underwater Tracking Range Site. Activities involving these barges may be anywhere from 8 hours to 2 weeks in duration.

Other RDT&E deployment systems include Fleet vessels, rotary and fixed-wing aircraft, and shore/pier facilities. Fleet vessels may include any craft in the Fleet, including small surface and underwater craft used by Navy SEALS and divers. These vessels provide direct support to Fleet training at the range sites, and also take advantage of the Fleet platforms in the area for testing RDT&E systems using the platform and the sailors to ensure the equipment works and the sailors know how to use it before they are deployed.

Fleet vessels may provide berthing and personnel support for test managers, scientists, and others. These vessels may also deploy RDT&E systems from an existing system like a towed array and provide locations for launch and retrieval. Fleet vessel use typically ranges from 8 hours to 1 week in duration. Aircraft used in support of RDT&E deployment may include P-3s, float planes, helicopters, and other aircraft both civilian and military. Fixed wing and rotary aircraft are used for surveillance of the range for marine mammals, transporting personnel, and launching of sonobuoys, torpedoes, and sensors. Use of aircraft for such purposes typically ranges from 10 minutes to 2 hours. The pier and shore areas function as stand alone platforms that support range operations, berthing and loading of ships, launch and retrieval of test vehicles, and other uses. Use of such resources is typically 8 hours at any one time.

NUWC Keyport civilian and military customers conduct tests based on objectives that are appropriate for the development level of their particular system. Some systems are one-of-a-kind undergoing initial

Targets come in many forms, including mobile, moored, and over-the-side, which can be expendable or recoverable. A mobile target can be either towed or free-swimming, providing acoustic and maneuvering capability. Mobile targets can be tested on range or used as a test component, depending on the test plan. Some moored targets can be moved up and down in the water column from the sea floor. Some targets used on the range complex are temporary; they are not permanently moored to the ocean floor and can be removed when no longer necessary for test activities. Over-the-side targets can be placed or suspended in the water column from a surface vessel.

Autonomous and Non-Autonomous Vehicles

The autonomous vehicles the U.S. Navy typically deploys at the Keyport Range Complex include unmanned undersea, surface, and aerial self-guided vehicles. Unlike weapon/torpedo launch and retrieval, which is relatively standardized, autonomous vehicles launch and retrieval methods are highly variable because of the differences in autonomous vehicles technology involved and of the variety of tasks the U.S. Navy uses these vehicle to accomplish. For increased efficiency, many autonomous vehicles have multiple test objectives or payloads (such as cameras and side-scan or multibeam sonars) onboard so that numerous tests can be run during a single test activity.

Non-autonomous or remotely controlled vehicles are also used and tested. These may be tethered like remote-operated vehicles or remotely controlled vehicles that have radio links. They may be aerial, surface, or underwater (including bottom) vehicles. Some vehicles may be used to transport personnel (whether inside or outside the vehicle). They may have both manual and autonomous control capabilities. For example, they may be driven to a location and parked, driven to a destination and sent ‘home,’ or they may autonomously navigate their way to a rendezvous spot and be piloted ‘home.’

Retrieval and Recovery Capabilities

System retrieval and recovery occurs after the completion of a test. *Retrieval* is the collection of the test vehicle from the surface of the water by surface vessel or helicopter. *Recovery* is the collection of the test vehicle when it is lying on the bottom or has become buried in bottom sediments and requires some digging for collection. Approximately 95 percent of the underwater test vehicles contain buoyancy systems that allow the vehicles to float to the surface for retrieval upon test completion. Approximately 5 percent of test vehicles sink to the bottom and are typically recovered by either an remotely-operated vehicle or a Submerged Object Recovery Device.

NUWC Keyport personnel regularly apply their expertise in vehicle retrieval and recovery as they collect all major test equipment used anywhere within the NUWC Keyport Range Complex. This includes systems under test for post analysis and test equipment requiring maintenance or upgrade. This capability allows unique systems in early development to be tested and expensive equipment to be returned. Keyport personnel and equipment have also been called upon when private companies are unable either to locate or recover downed aircraft.

Acoustic Systems Routinely Used

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. NUWC Keyport uses a number of passive acoustic measurement systems including a bottom moored array and various surface deployed arrays. The instrumented portions of the range sites have tracking arrays mounted on the sea floor to detect sound amd the permanent tracking arrays provide 3-D tracking capability at the Dabob Bay and Quinault Underwater Tracking Range sites. Most test vehicles are instrumented with active acoustic sources to track real-time speed, location and recovery or retrieval at the end of activities.

Table 2. Primary Acoustic Sources Routinely Used within the NAVSEA NUWC Keyport Range Complex

Active Acoustic Source	Frequency (kHz)	Maximum Source Level (dB re 1 µPa @ 1 m)
Sonars		
General range tracking (at Keyport Range Site)	10 – 100	195
General range tracking (at DBRC and QUTR Sites)	10 - 100	203
unmanned undersea vehicle tracking	10 – 100	195
Torpedoes/Test vehicles	10 - 100	233
Range targets and special tests (at Keyport Range Site)	5 – 100	195
Range targets and special tests (at DBRC and QUTR Sites)	5 – 100	238
Special sonars (e.g., unmanned undersea vehicle payload)	100 – 2,500	235
Fleet aircraft—active sonobuoys and helo-dipping sonars	2 – 20	225
Side-scan	100 – 700	235
Other Acoustic Sources		
Acoustic modems	10 – 300	210
Target simulator	0.1 - 10	170
Aid to navigation (range equipment)	70 - 80	210
Sub-bottom profiler	2 - 7	210
	35 - 45	220
Engine noise (surface vessels, submarines, torpedoes, unmanned undersea vehicles)	0.05 – 10	170

GENERAL RANGE TRACKING on the instrumented ranges and portable range sites have active output in narrow frequency bands. Operating frequencies are 10 to 100 kHz. At the Keyport Range Site, the sound pressure level (SPL) of the source (source level) is a maximum of 195 decibels reference 1 micro Pascal at 1 meter (dB re 1 µPa @ 1 m). At the Dabob Bay and Quinault Underwater Tracking Range sites, the source level for general range tracking is a maximum of 203 dB re 1 µPa @ 1 m.

UNMANNED UNDERSEA VEHICLE TRACKING SYSTEMS operate at frequencies of 10 to 100 kHz with maximum source levels of 195 dB re 1 µPa @ 1 m at all range sites.

TORPEDO OR TEST VEHICLE SONARS are used for several purposes including detection, classification, and location and vary in frequency from 10 to 100 kHz. The maximum source level of a torpedo or test vehicle sonar is 233 dB re 1 µPa @ 1 m.

RANGE TARGETS AND SPECIAL TEST SYSTEMS are within the 5 to 100 kHz frequency range at the Keyport Range Site with a maximum source level of 195 dB re 1 µPa @ 1 m. At the Dabob Bay and Quinault Underwater Tracking Range sites, the maximum source level is 238 dB re 1 µPa @ 1 m.

SPECIAL SONARS can be carried as a payload on a unmanned undersea vehicle, suspended from a range craft, or set on or above the sea floor. These can vary widely from 100 kHz to a very high frequency of 2,500 kHz. The maximum source level of these acoustic sources is 235 dB re 1 µPa @ 1 m.

SONOBUOYS AND HELICOPTER DIPPING SONARS are deployed from Fleet aircraft and operate at frequencies of 2 to 20 kHz with maximum source levels of 225 dB re 1 µPa @ 1 m. Dipping sonars are active or passive devices that are lowered on cable by helicopters or surface vessels to detect or maintain contact with underwater targets.

SIDE-SCAN SONAR is used for mapping, detection, classification, and localization of items on the sea floor such as cabling, shipwrecks, and mine shapes. It is high frequency typically 100 to 700 kHz using multiple frequencies at one time with a very directional focus. The maximum source level is 235 dB re 1 µPa @ 1 m. Side-scan and multibeam sonar systems are towed or mounted on a test vehicle or ship.

1.2 Northwest Training Range Complex

As part of the U.S. Navy's preferred alternative (Alternative 2 in their Preliminary Final EIS.OEIS; U.S. Navy 2009c), the U.S. Navy proposes to continue the training it currently conducts, with increases in the frequency and intensity of some training activities, and the U.S. Navy proposes to implement range enhancements that include development of a portable undersea tracking range, new electronic combat threat simulators and targets, development of a underwater training minefield, and development of air and surface target services (see Table 3). The Permits Division proposes to promulgate regulations governing the "take" of marine mammals (50 CFR Part 216) to allow NMFS to issue annual letters of authorization that would allow the U.S. Navy to "take" marine mammals for a five-year period beginning in June 2010 and ending in June 2015 incidental to these training activities.

1.2.1 Anti-Air Warfare Training

This training encompasses events and exercises that train ship and aircraft crews to employ the Navy's various weapons systems against simulated threat aircraft or targets. It includes air combat maneuvers, surface- to-air and air-to-air missile exercises, and surface-to-air gunnery exercises..

AIR COMBAT MANEUVERS. Air Combat Maneuvers include basic flight maneuvers in which aircraft engage in offensive and defensive maneuvering against each other. These maneuvers typically involve two aircraft; however, based upon the training requirement, air combat maneuvers may involve over a dozen aircraft. For the purposes of this document, aircraft activities will be described by the term 'sortie.' A sortie is defined as a single operation by one aircraft, which uses a range or operating area. A single aircraft sortie is one complete flight (i.e., one takeoff and one final landing).

Air Combat Maneuvers activities within the Northwest Training Range Complex are primarily conducted by EA-6B Prowlers (and EA-18G Growlers in the future) within military operating areas and warning areas. However, as proposed by the U.S. Navy, Air Combat Maneuvers include other aircraft activities that include instrument training, in-flight refueling, basic familiarization training, and formation flying. In addition, Air Force or Air National Guard F-15s and Marine Corps FA-18s would continue to conduct Air

Combat Maneuvers in these areas, although on a much less frequent basis (about 5 percent of the total events).

Typically, Air Combat Maneuvers events last between 1.0 to 1.5 hours and do not occur below 5,000 ft. No ordnance would be released during events. The U.S. Navy plans to conduct about 2,000 of these events each year in the Northwest Training Range Complex, which is an increase from the 1,353 events that are conducted each year under current training schedules.

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. Additionally, weapons may be fired against or a LUU-2B/B illumination paraflares or Tactical Air Launched Decoys dropped by supporting aircraft. Typically, about half of the missiles fired have live warheads and half have telemetry packages. The fired missiles and targets are not recovered, with the exception of the BQM drones, which have parachutes and will float to the surface where they are recovered by boat.

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. Each year, the U.S. Navy plans to conduct about 24 of these training events, involving 30 missiles, in the Northwest Training Range Complex; none of these events occur with current training schedules.

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 threat. A typical scenario involves a guided missile destroyer with 5-inch guns or a fast frigate with 76 mm Main Battery Guns that is faced with a “threat” posed by an aircraft or anti-ship missile that is simulated by an aircraft towing a target toward the ship below 10,000 ft, at a speed between 250 and 500 kts. Main battery guns on the surface ships would be manned and 5-inch or 76 mm rounds fired at the target to destroy it before it reaches the ship. Ships involved in these exercises maneuver as necessary but would typically operate at 10 to 12 kts or less during the exercise.

Another typical scenario involves a guided missile destroyer or guided mssile fast frigate is similar, except the ships involved engage the simulated threat aircraft or missile with with 20 mm Close-in-Weapon System, which can expend between 900 to 1400 rounds per mount per firing run for a total of up to five runs during the typical two hour exercise. The actual number of rounds expended during one of these exercises depends on the ship class, the model of the with 20 mm Close-in-Weapon System that is installed on the ship, and the available ammunition allowance. Preventive maintenance requires test firing of the with 20 mm Close-in-Weapon System before one of these exercises, which typically last for 30 minutes and can expend about 250 rounds of 20 mm each year.

These exercises last about two hours which normally includes several non-firing tracking runs followed by one or more firing runs. The target must maintain an altitude above 500 ft for safety reasons and is not destroyed during the exercise. Each year, the U.S. Navy plans to conduct about 160 of these training events, in the Northwest Training Range Complex, which is an increase from the 72 training events that occur under current training schedules.

SURFACE-TO-AIR MISSILE EXERCISE. In surface-to-air missile exercises, surface ships engage threat missiles and aircraft with surface-to-air missiles with the goal of disabling or destroying the threat. One live or telemetered-inert-missile is expended against a target towed by an aircraft after two or three tracking runs. The exercise lasts about two hours. A BQM-74 target drone, sometimes augmented with a Target Drone Unit, is used as an alternate target for this exercise. The BQM target is a subscale, subsonic, remote controlled ground or air launched target. A parachute deploys at the end of target flight to enable recovery at sea. The launched surface-to-air missiles can be a Rolling Airframe Missile if installed on an aircraft carrier; otherwise the U.S. Navy uses the NATO Sea Sparrow Missile.

All of these exercise occur in the Offshore Area of the Northwest Training Range Complex. Each year, the U.S. Navy plans to conduct about 4 of these training events, in the Northwest Training Range Complex; none of these events occur under current training schedules..

1.2.2 Anti-Submarine Warfare

In the Northwest Training Range Complex, anti-submarine warfare training events primarily consist of tracking exercises, which the U.S. Navy uses to train aircraft, ship, and submarine crews in the tactics, techniques, and procedures for searching, detecting, localizating, and tracking submarines with the goal of determining firing solutions that could be used to launch torpedoes and destroy the submarine. A typical unit-level exercise involves one anti-submarine warfare unit (an aircraft, ship, or submarine) against one target, usually a MK-30 Mobile anti-submarine warfare target, a MK-39 Expendable Mobile Anti-submarine warfare Training Target, or a live submarine. These target may be non-evading while operating on a specified track track or it might engage in full evasive maneuvers. Units that participate in these exercises use active and passive sensors, including hull-mounted sonar, towed arrays, variable depth sonar, and sonobuoys for tracking. If the exercise continues to involve firing a practice torpedo it is termed a Torpedo Exercise, which usually starts as a tracking exercise to develop a firing solution.

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 sono-buoys, 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 patterns vary in size and coverage area based on anticipated threat and water conditions. Typically, maritime patrol aircraft will use passive sonobuoys first to avoid alerting the target submarine. They then use active sonobuoys as necessary either to locate extremely quiet submarines, or to further localize and track submarines previously detected by passive sonobuoys.

Table 3. Activities the U.S. Navy proposes to conduct in the Northwest Training Range each year over the next five 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 2011 and 2015), SSQ-77 VLAD	12 events	
	P-8 MMA			
Anti-submarine Warfare Tracking Exercise – Surface Ship	Guided missile destroyer	SQS-53 mid-frequency active sonar	26 events 43 sonar hours	
	Guided missile frigate	SQS-56 mid-frequency active sonar	39 events 65 sonar hours	
Anti-submarine Warfare Tracking Exercise – Submarine	Ballistic missile submarine	BQQ-5 sonar (passive only)	100 events	
	Cruise missile submarine	BQQ-5 sonar (passive only)		
ANTI-SURFACE WARFARE				
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	

Table 3. Activities the U.S. Navy proposes to conduct in the Northwest Training Range each year over the next five years (adapted from Table 2-9, U.S. Navy 2008d)

Range Operation	Platform	System or Ordnance	Proposed Action	Location
	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	2 events	Offshore Area
	P-3	MK-82, AGM-65 Maverick		
	FA-18	MK-82, MK-83, MK-84, SLAM-ER		
	EA-6B	AGM-88C HARM missile		
	EA-18G	AGM-88C HARM missile		
	SH-60	AGM-114 HELLFIRE missile		
	Guided missile destroyer	5-inch/54 ordnance		
	Guided missile frigate	76 mm ordnance		
	Fast-attack submarine (Nuclear propulsion)	MK-48 ADCAP torpedo		
ELECTRONIC COMBAT				
Electronic Combat Exercises	EA-6B/EA-18G	None	4,580 events	Offshore Area
	P-3		28 events	
	EP-3		390 events	
	Multi-Purpose Aircraft Carrier (Nuclear Propulsion)		50 events	
	Guided missile destroyer		50 events	
	Guided missile frigate		100 events	
	Fast combat support ship		25 events	
	Cruise missile submarine		25 events	

Table 3. Activities the U.S. Navy proposes to conduct in the Northwest Training Range each year over the next five years (adapted from Table 2-9, U.S. Navy 2008d)

Range Operation	Platform	System or Ordnance	Proposed Action	Location	
	Ballistic missile submarine		25 events		
MINE WARFARE					Cruise missile subr
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	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	

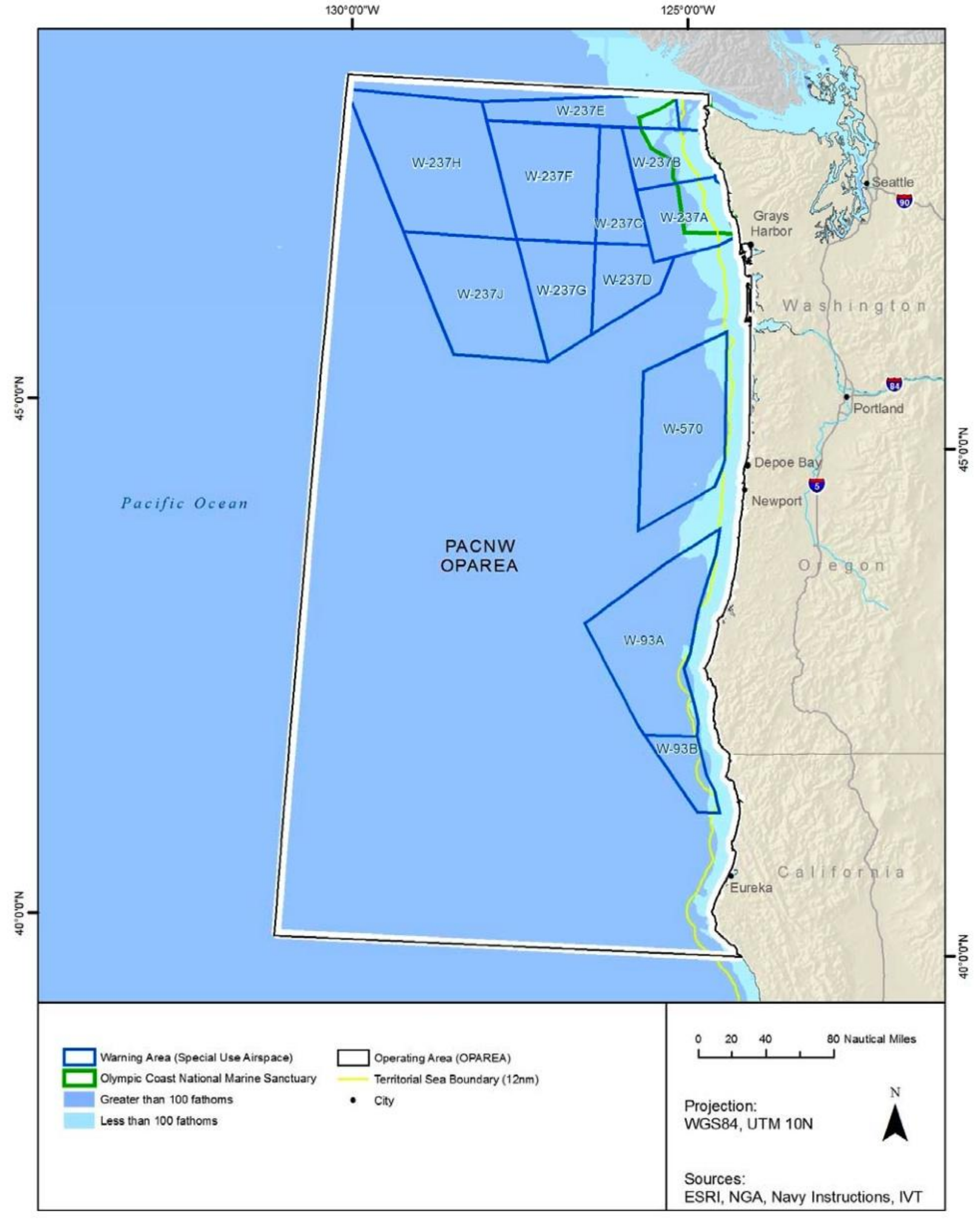

Figure 4. The offshore areas of the Northwest Training Range Complex (adapted from Figure 2-1 of the U.S. Navy's Draft Environmental Impact Statement/Overseas Environmental Impact Statement on the Northwest Training Range Complex (U.S. Navy 2008d)

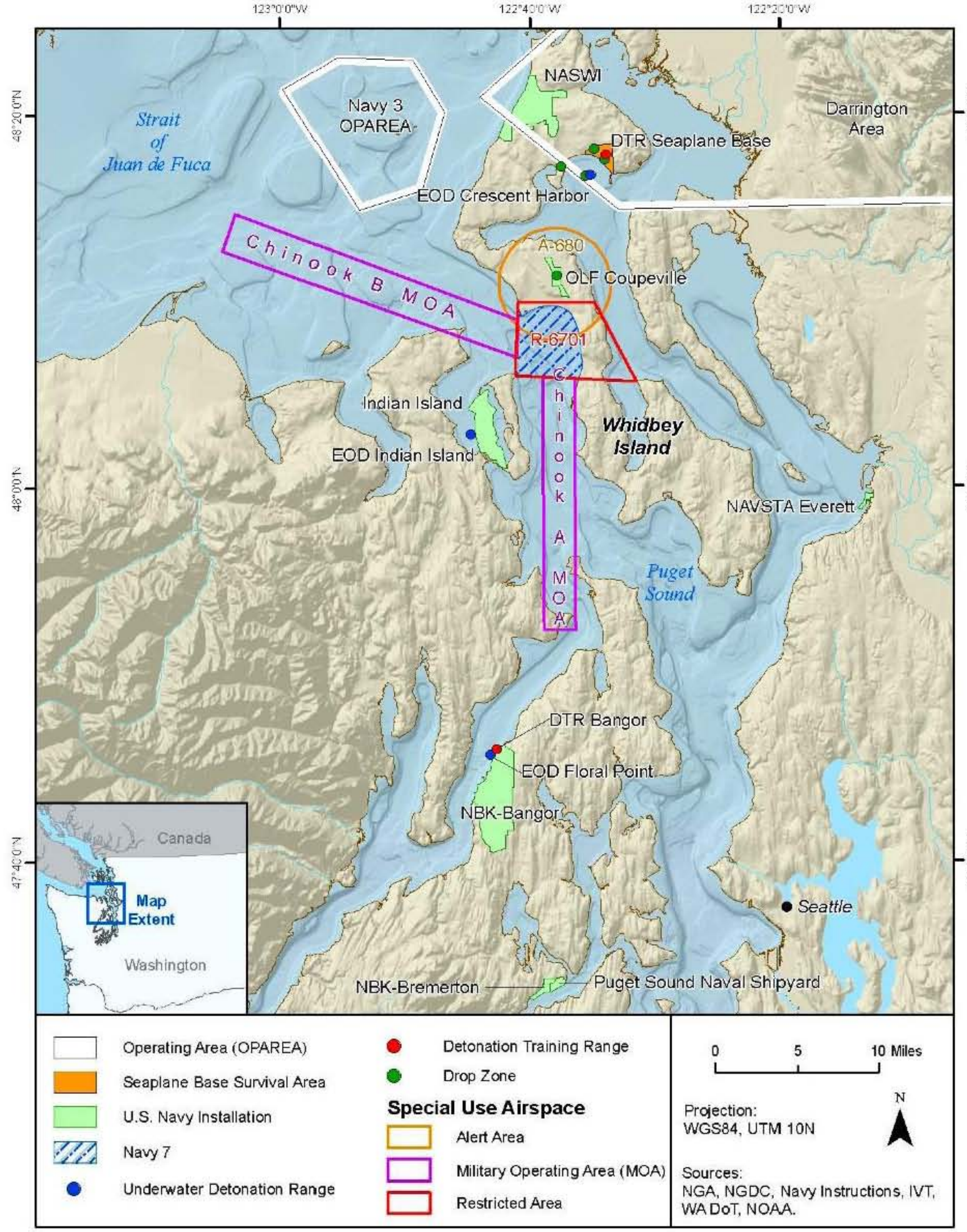

Figure 5. The Puget Sound training areas of the Northwest Training Range Complex (adapted from Figure ES-2 of the U.S. Navy's Draft Environmental Impact Statement/Overseas Environmental Impact Statement on the Northwest Training Range Complex (U.S. Navy 2008d)

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, which is a slight increase over the 200 events the U.S. Navy conducts with current schedules. All of these events would occur in the Offshore Area of the Northwest Training Range Complex.

ANTI-SUBMARINE WARFARE TRACKING EXERCISE, EXTENDED ECHO RANGING (EER): These training events are at-sea flying events, typically conducted 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 reflected from the surface of a submarine. The AN/SSQ-110 Sonobuoy Series is an expendable and commandable sono-buoy: 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.

These sonobuoys are designed to provide underwater acoustic data necessary for naval aircrews to quickly and accurately detect submerged submarines. After visual searching an area for marine mammals, sonobuoy pairs are dropped from fixed-wing aircraft into the ocean in a predetermined pattern with a few buoys covering a large area.

Between 2011 and 2015, the U.S. Navy proposes to phase out the existing EER/IEER system and replace them with the Advanced Extended Echo Ranging (AEER) system, which is operationally similar to the EER/IEER system. The AEER system uses the same sonobuoy as an acoustic receiver and the U.S. Navy would used it for a large area anti-submarine warfare search capability in both shallow and deep water. However, instead of using an explosive as an impulsive source for the active acoustic wave, the AEER system uses a battery powered (electronic) source. The AEER system is scheduled to enter the fleet in 2011 and the U.S. Navy’s NEPA documents assumed that the AEER system would begin to replace the existing systems at 25 percent per year beginning in 2011, would reach 50 percent replacement levels by 2012, 75 percent replacement levels by 2013, and would completely replace the EER/IEER systems in 2014 (those systems would not be used beginning in 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, which is a slight increase over the 10 events the U.S. Navy conducts with current schedules. All of these events would occur in the Offshore Area of the Northwest Training Range Complex.

ANTI-SUBMARINE WARFARE TRACKING EXERCISE, SURFACE SHIP: Surface ships do not routinely conduct anti-submarine warfare tracking exercises. However, surface ships occasionally employ mid-frequency active sonar during ship transits through the operating area (usage last for one to one and a half hours).

The U.S. Navy proposes to conduct about 26 training events involving guide-missile destroyers and 39 training events involving guided-missile frigates (108 hours of active sonar) each year on the Northwest Training Range Complex. As proposed, the 26 training events involving guided missile destroyers would produce up to 43 hours of mid-frequency active sonar (from the AN/SQS-53C hull-mounted sonar sonar system) while the 39 training events involving guided-missile frigates would produce up to 65 hours of mid-frequency ative sonar (from the AN/SQS-56 hull-mounted sonar system). This level of training is an increase from the 24 training events (36 hours of active sonar associated with guided-missile destroyers) and 36 training events (54 hours of active sonar associated with guided-missile frigates) the U.S. Navy has conducted each year under current schedules.

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 lasts two to four hours. Training events in which P-3s are used typically last 8 to 12 hours. The U.S. Navy proposes to conduct about 100 of these training events each year in the Northwest Training Range Complex, which is an increase from the 96 training events the U.S. Navy conducts each yar under current schedules.

1.2.3 Anti-Surface Warfare

Anti-Surface Warfare is a type of naval warfare in which aircraft, surface ships, and submarines employ weapons, sensors, and operations directed against “enemy” surface ships or boats. Aircraft-to-surface anti-surface warfare training is conducted using air-launched cruise missiles or other precision guided munitions, aircraft cannon, warships employing torpedoes, naval guns, and surface-to-surface missiles. Submarines also attack surface ships using torpedoes or submarine-launched, anti-ship cruise missiles. Training in anti-surface warfare includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, and submarine missile or torpedo launch events. Training generally involves expenditure of ordnance against a towed target. A sinking exercise (SINKEX) is a specialized training event that provides an opportunity for ship, submarine, and aircraft crews to use multiple weapons systems to deliver live ordnance on a deactivated vessel, which is deliberately sunk.

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. As part of these exercises, maritime patrol aircraft use bombs to attack surfaced submarines and surface craft that would not present a major threat to the aircraft themselves. A single maritime patrol aircraft approaches the target at a low altitude. In most training exercises, it drops inert training ordnance, such as the Bomb Dummy Unit (BDU-45) on a MK-58 smoke float used as the target. 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. P-3C squadrons from Commander, Patrol and Reconaissance Wing-10 (CPRW-10) are required to conduct one live-fire drop per 24-month cycle. CPRW-10 consists of three active duty VP squadrons and one Reserve squadron (VP-69). There are a total of 12 crews in each squadron. One crew will drop live-fire (consisting of four MK-82 500 lb general purpose bombs) while the remaining 11 crews will drop inert ordnance (consisting of four Bomb Dummy Units [BDU-45s]) for a total of 12 drops per squadron per cycle. Accordingly, 96 pieces of ordnance, consisting of eight MK-82 and 88 BDU-45, are dropped annually.

Each of these bombing exercisescan take up to 4 hours to complete. Each year, the U.S. Navy proposes to conduct about 30 events in the Northwest Training Range Complex, which is an increase from the 24 events that occur under current training schedules..

HARM EXERCISE. High-Speed Anti-Radiation (HARM) missile exercises (air-to-surface) are an integral part of EA-6B squadron training. It trains aircrews to conduct electronic attack using HARM missiles, which is the primary weapon for the Suppression of Enemy Air Defenses, and is designed to attack emitting radars. Only non-firing HARMs are used during these training events on the Range Complex. During a typical training event, an EA-6B flying at a high altitude (>10,000 ft.), would receive and identify an electronic signal from a simulated enemy radar. The aircrew would then position themselves for the optimum firing solution and simulate firing a HARM missile at the electronic signal.

These training events are non-firing events that typically last one to two hours. Each year, the U.S. Navy proposes to conduct a total of about 3,000 events in the Northwest Training Range Complex, including those events that occur as part of Strike Warfare Training exercises, which is an increase from the 2,724 events that occur under current training schedules..

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

The vessels used as targets are selected from a list of destroyers, tenders, cutters, frigates, cruisers, tugs, and transports that has been approved for that use by the U.S. Environmental Protection Agency. Examples of missiles that could be fired at the targets include AGM-142 from a B-52 bomber, Walleye AGM-62 from FA-18 aircraft, and a Harpoon from maritime patrol aircraft. Surface ships and submarines may use either torpedoes or Harpoons, surface-to-air missiles in the surface-to-surface mode, and guns. Other weapons and ordnance could include, but are not limited to, bombs, Mavericks, Penguins, and Hellfire.

Each year, the U.S. Navy plans to conduct two sink exercises in the Northwest Training Range Complex, which is an increase from one sink exercise that occurs under current training schedules..

1.2.4 Electronic Combat Operations

Electronic Combat operations consist of air-, land-, and sea-based emitters simulating enemy systems and activating air, surface and submarine electronic support measures and electronic countermeasures systems. Appropriately configured aircraft fly threat profiles against the ships so that crews can be trained to detect electronic signatures of various threat aircraft, or so that they can be trained to detect counter jamming of their own electronic equipment by the simulated threat.

Electronic Combat prevents or reduces the effective use of enemy electronic equipment and ensures the continued use of friendly equipment as well as the command and control of said equipment. Electronic Support provides the capability to intercept, identify, and locate enemy emitters while Electronic Attack employs tactics, such as electronic jamming, to prevent or reduce effective use of enemy electronic equipment and command. 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 to degrade or deny an enemy the ability to defend its forces from attack or recognize an emerging threat early enough to take the necessary defensive actions. Electronic combat training activities typically last one to two hours.

1.2.5 Mine Warfare Training

Mine warfare training involves training Navy personnel to detect, avoid, and neutralize mines to protect Navy ships and submarines, and offensive mine laying in naval operations. Naval mines are self-contained explosive devices placed in water to destroy ships or submarines and are deposited and left in place until triggered by the approach of or a contact with an enemy ship, or are destroyed or removed. Mine warfare training consists of Mine Countermeasures Exercises.

LAND DEMOLITIONS. Land demolitions would continue to occur at two Detonation Training Ranges: Seaplane Base and Bangor. A typical land demolition training exercise has an eight hour duration and involves disrupting inert 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 lbs. per charge at Detonation Training Range Bangor and one-lb 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 (inert) Mark 80 series General Purpose bombs and simulated improvised explosive devices.

The U.S. Navy proposes to conduct about 110 detonations each year in the Explosive Ordnance Disposal ranges in the Northwest Training Range Complex..

MINE COUNTERMEASURES EXERCISE. Mine Countermeasures consists 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 Floral Point. 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. 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.

A typical scenario involves placing a dummy mine shape on the seafloor. Two divers from one of two small boats enter the water and begin searching for the mine shape. When located, they divers mark the mine shape with a buoy. Later, two divers place a C-4 charge on or around the mine. Once the area has been confirmed ot be visually clear of marine mammals and birds, the charge is detonated manually (with a time-delay fuse) or remotely. After the detonation, both boats return to the detonation site. All surface debris, consisting mainly of floats and attached equipment, is retrieved. The divers retrieve debris from the seafloor, which consists mainly of pieces of the mine (the charge is consumed in the explosion). In cases where the mine shape is only disabled, but not destroyed, the mine shape is either loaded into the primary boat (if the mine is small enough) or the mie shape is suspended below the boat.

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 4 mine countermeasures training events each year in the Northwest Training Range Complex, with four detonations each year..

1.2.6 Naval Special Warfare

Naval Special Warfare forces (SEALs and Special Boat Units) train to conduct military activities in five Special Operations mission areas: unconventional warfare, direct action, special reconnaissance, foreign internal defense, and counterterrorism. 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.

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. Tactics and techniques employed include insertion from aircraft by parachute, by rope, or from low, slow-flying helicopters from which personnel jump into the water. Parachute training is required to be conducted on surveyed drop zones to enhance safety. Insertion and extraction methods also employ submarine deliver of personnel into the water, and small inflatable boats.

Insertion and extraction training typically is conducted in the context of additional related exercises, and such as direct action training of naval special warfare personnel, live-fire small arms training, and NSFS spotter training.

Insertion/extraction activities hone individual skills in delivery and withdrawal of personnel and equipment using unconventional methods. Helicopter Rope Suspension Training and parachute training are the principal insertion/extraction methods used by explosive ordnance detonation teams at the Northwest Training Range Complex. Helicopter Rope Suspension Training encompasses Helocast, Special Purpose Insertion and Extraction, rappel, and fast rope exercises. Helocast training involves a helicopter flying slowly and low over the water near a target to allow explosive ordnance disposal team members to jump out one at a time. The technique is typically used for quick insertion to dispose of hazardous floating mines. A special purpose insertion and extraction rigging exercise involves up to eight personnel attached to a rope suspended from a helicopter, allowing the explosive ordnance disposal team to be hoisted from or lowered onto the ground without having to land the helicopter. In fast roping, explosive ordnance disposal team members slide down a rope from a helicopter, which hovers as high as 60 feet off the ground. Personnel from Explosive Ordnance Disposal Mobile Unit-11 detachments conduct Helicopter Rope Suspension Training activities monthly throughout the Seaplane Base using an H-60.

The parachute insertion method is designed to place Special Forces teams into an objective area undetected to conduct clandestine activities, either reconnaissance and surveillance, or direct action type missions. Typical duration of one of these activities is three to five hours. Personnel from Explosive Ordnance Disposal Mobile Unit-11 detachments perform parachute training four days per month at OLF Coupeville and two days per month at Explosive Ordnance Range - Crescent Harbor.

Insertion/Extraction activities also include Search and Rescue training that takes place at the Seaplane Base survival area. This activity involves a helicopter landing and simulated extraction of a survivor (typically one of the helicopter crewmembers). The search and rescue helicopter, which is an H-60, approaches the survivor, finds a suitable landing zone, lands, recovers the survivor, then departs the area with the survivor onboard.

The U.S. Navy plans to conduct 27 of these exercises each year in the Northwest Training Range Complex, which is an increase from the 24 exercises conducted each year under current schedules.

1.2.7 Strike Warfare

Strike Warfare operations include training of fixed-wing fighter/attack aircraft in delivery of precision guided munitions, non-guided munitions, rockets, and other ordnance against land targets in all weather and light conditions. Training events typically involve a simulated strike mission with a flight of four or more aircraft. The strike mission may simulate attacks on “deep targets” (i.e., those geographically distant from friendly ground forces), or may simulate close air support of targets within close range of friendly ground forces. Laser designators from aircraft or ground personnel may be employed for delivery of precision guided munitions. Some strike missions involve no-drop events in which prosecution of targets is simulated, but video footage is often obtained by onboard sensors.

HARM EXERCISE. As discussed previously, High-Speed Anti-Radiation (HARM) missile exercises (air-to-surface) are an integral part of EA-6B squadron training. It trains aircrews to conduct electronic attack using HARM missiles, which is the primary weapon for the Suppression of Enemy Air Defenses, and is designed to attack emitting radars. Only non-firing HARMs are used during these training events on the Range Complex. During a typical training event, an EA-6B flying at a high altitude (>10,000 ft.), would receive and identify an electronic signal from a simulated enemy radar. The aircrew would then position themselves for the optimum firing solution and simulate firing a HARM missile at the electronic signal.

These training events are non-firing events that typically last one to two hours. Each year, the U.S. Navy proposes to conduct a total of about 3,000 events in the Northwest Training Range Complex, including those events that occur as part of HARM exercises, which is an increase from the 2,724 events that occur under current training schedules..

1.2.8 Other Training Activities

The U.S. Navy also proposes to conduct the following suite of additional training activities in the Northwest Training Range Complex:

INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE: Intelligence, surveillance, and reconnaissance training is conducted by maritime patrol aircraft in W-237 and the Pacific Northwest Operatings Area. Activities typically last six hours and involve a crew of 11 personnel. P-3 aircrews use a variety of intelligence gathering and surveillance methods, including visual, infrared, electronic, radar, and acoustic. EP-3 and EA-6B crews conduct intelligence, surveillance, and reconnaissance training as well, but to a lesser extent than P-3C crews. On occasion, small unit special operations forces air, surface, subsurface, and ground intelligence, surveillance, and reconnaissance, activities occur in the Seaplane Base Survival Area. Examples of Special Forces units that have used the Survival Area for ground intelligence, surveillance, and reconaissance training include Navy Reserve Mobile Inshore Undersea Warfare Units, U.S. Army Special Forces, and U.S. Army Intelligence forces.

UNMANNED AERIAL SYSTEM TRAINING AND RESEARCH, DEVELOPMENT, TEST, AND EVALUATION: 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.

Unmanned aerial systems are typically flown at altitudes well above 3,000 ft; these systems may be controlled by pilots at remote locations, just as if the pilot were onboard, or they may fly preplanned, preprogrammed routes. Missions will typically last four to six hours, but vary depending on the training mission that has been scheduled.

These training missions typically occur three times a year for three to four days each, and consist of maritime testing and maritime training. 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.

1.2.9 Range Enhancements

The U.S. Navy proposes to implement the following enhancements to the Northwest Training Range Complex that include development of a portable undersea tracking range, new electronic combat threat simulators and targets, development of a small scale underwater training minefield, and development of air and surface target services.

SMALL SCALE UNDERWATER TRAINING MINEFIELD. The addition of a small scale underwater 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.

NEW ELECTRONIC COMBAT SIMULATORS AND TARGETS. The U.S. Navy plans to install 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.

PORTABLE UNDERWATER TRACKING RANGE. Portable underwater tracking ranges are self-contained, portable, undersea tracking capability that employs modern technologies to support coordinated undersea warfare training for forward deployed naval forces. The U.S. Navy proposes to make a Portable Undersea Tracking Range available in two variants to support shallow and deep water remote activities. These tracking ranges are capable of tracking submarines, surface ships, weapons, targets, and unmanned underwater vehicles and distribute tracking data to processing and display systems onboard ships or at shore sites.

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 equipment that is used to install the range. No on-shore construction would take place.

Operation of this range requires underwater participants transmit their locations via pingers (see “Range Tracking Pingers” below). Each package consists of a hydrophone that receives pinger signals, and a transducer that sends an acoustic “uplink” of locating data to the range boat. The uplink signal is transmitted at 8.8 kilohertz (kHz), 17 kHz, or 40 kHz, at a source level of 190 decibels. The Portable Undersea Tracking Range system also incorporates an underwater voice capability that transmits at 8-11 kHz and a source level of 190 dB. Each of these packages is powered by a D-cell alkaline battery. After the end of the battery life, the electronic packages would be recovered and the anchors would remain on the seafloor. The Navy proposes to deploy this system for 3 months of the year (approximately June – August), and to conduct tracking exercise activities for 10 days per month in an area beyond 3 nm from shore. During each of the 30 days of annual operation, the portable undersea tracking range would be in use for 5 hours each day.

If fishermen, boaters, or whales are observed in an area in which the portable undersea tracking range was deployed, training involving weapons training would be stopped or moved to another location.

RANGE PINGERS. Range tracking pingers would be used on ships, submarines, and anti-submarine warfare targets when anti-submarine warfare tracking exercise is 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% 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.

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

Currently, no air target services exist for the Northwest Training Range Complex so all surface combatant ships complete this training in the Southern California Range Complex. The target system needs to have the capability to support both air-to-air and surface-to-air missile exercises, and include subsonic and supersonic aircraft or drones that can operate from surface to 50,000 feet for Intermediate level training. The aircraft or drones in the target system should be capable of active electronic combat jamming and simulated cruise missile launch capabilities. For Basic level anti-air warfare training, towed targets are required. Air Target services are traditionally used to provide Opposition Force targets.

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.

1.3 Mitigation Measures the U.S. Navy Proposes to Employ on the Northwest Training Range Complex

As required to satisfy the requirements of the Marine Mammal Protection Act of 1972, as amended, 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 of this Opinion; 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 letter of authorization to "take" marine mammals incidental to military readiness activities on the Northwest Training Range Complex and the Permit Division's proposed 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 and, in some cases, sea turtles, are in the vicinity.

1.3.1 Personnel Training – Watchstanders and Lookouts

The use of shipboard lookouts is a critical component of all Navy protective measures. Navy shipboard lookouts (also referred to as "watchstanders") are highly qualified and experienced observers of the marine environment. Their duties require that they report all objects sighted in the water to the Officer of the Deck (e.g., trash, a periscope, marine mammals, sea turtles) and all disturbances (e.g., surface disturbance, discoloration) that may be indicative of a threat to the vessel and its crew. There are personnel serving as lookouts on station at all times (day and night) when a ship or surfaced submarine is moving through the water.

1. All commanding officers, executive officers, lookouts, officers of the deck, junior officers of the deck, maritime patrol aircraft aircrews, and AWS/MIW helicopter crews will complete the NMFS-approved Marine Species Awareness Training (MSAT) by viewing the U.S. Navy MSAT digital versatile disk (DVD). MSAT may also be viewed on-line at https://mmrc.tecquest.net. All bridge watchstanders/lookouts will complete both parts one and two of the MSAT; part two is optional for other personnel. This training addresses the lookout's role in environmental protection, laws governing the protection of marine species, Navy stewardship commitments and general observation information to aid in avoiding interactions with marine species.
2. Navy lookouts will undertake extensive training in order to qualify as a watchstander in accordance with the Lookout Training Handbook (Naval Education Training [NAVEDTRA] 12968-D).
3. Lookout training will include on-the-job instruction under the supervision of a qualified, experienced watchstander. Following successful completion of this supervised training period, lookouts will complete the Personal Qualification Standard Program, certifying that they have demonstrated the necessary skills (such as detection and reporting of partially submerged objects). Personnel being trained as lookouts can be counted among required lookouts as long as supervisors monitor their progress and performance.
4. Lookouts will be trained in the most effective means to ensure quick and effective communication within the command structure in order to facilitate implementation of protective measures if marine species are spotted.

1.3.2 Operating Procedures and Collision Avoidance

1. Prior to major exercises, a Letter of Instruction, Mitigation Measures Message or Environmental Annex to the Operational Order will be issued to further disseminate the personnel training requirement and general marine species protective measures.

2. Commanding Officers will make use of marine species detection cues and information to limit interaction with marine species to the maximum extent possible consistent with safety of the ship.
3. While underway, surface vessels will have at least two lookouts with binoculars; surfaced submarines will have at least one lookout with binoculars. Lookouts already posted for safety of navigation and man-overboard precautions may be used to fill this requirement. As part of their regular duties, lookouts will watch for and report to the officer of the deck the presence of marine mammals and sea turtles.
4. On surface vessels equipped with a multi-function active sensor, pedestal mounted “Big Eye” (20x10) binoculars will be properly installed and in good working order to assist in the detection of marine mammals and sea turtles in the vicinity of the vessel.
5. Personnel on lookout will employ visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D).
6. After sunset and prior to sunrise, lookouts will employ Night Lookouts Techniques in accordance with the Lookout Training Handbook. (NAVEDTRA 12968-D)
7. While in transit, naval vessels will be alert at all times, use extreme caution, and proceed at a “safe speed” so that the vessel can take proper and effective action to avoid a collision with any marine animal and can be stopped within a distance appropriate to the prevailing circumstances and conditions.
8. When marine mammals have been sighted in the area, Navy vessels will increase vigilance and take reasonable and practicable actions to avoid collisions and activities that might result in close interaction of naval assets and marine mammals. Actions may include changing speed and/or direction and are dictated by environmental and other conditions (e.g., safety, weather).
9. Naval vessels will maneuver to keep at least 1,500 ft (457 m) away from any observed whale and avoid approaching whales head-on. This requirement does not apply if a vessel’s safety is threatened, such as when change of course will create an imminent and serious threat to a person, vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver. Restricted maneuverability includes, but is not limited to, situations when vessels are engaged in dredging, submerged training activities, launching and recovering aircraft or landing craft, minesweeping training activities, replenishment while underway and towing training activities that severely restrict a vessel’s ability to deviate course. Vessels will take reasonable steps to alert other vessels in the vicinity of the whale.
10. Where feasible and consistent with mission and safety, vessels will avoid closing to within 200 yd (183 m) of sea turtles and marine mammals other than whales (whales addressed above).
11. Floating weeds and kelp, algal mats, clusters of seabirds, and jellyfish are good indicators of sea turtles and marine mammals. Therefore, where these circumstances are present, the Navy will exercise increased vigilance in watching for sea turtles and marine mammals.
12. Navy aircraft participating in exercises at sea will conduct and maintain, when operationally feasible and safe, surveillance for marine species of concern as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties. Marine mammal

detections will be immediately reported to assigned Aircraft Control Unit for further dissemination to ships in the vicinity of the marine species as appropriate when it is reasonable to conclude that the course of the ship will likely result in a closing of the distance to the detected marine mammal.

13. All vessels will maintain logs and records documenting training activities should they be required for event reconstruction purposes. Logs and records will be kept for a period of 30 days following completion of a major training exercise.

1.3.3 Measures for Specific Training Events

1.3.3.1 Mid-Frequency Active Sonar Training Activities

A. General Maritime Mitigation Measures: Personnel Training

1. All lookouts onboard platforms involved in ASW training events will review the NMFS-approved Marine Species Awareness Training material prior to use of mid-frequency active sonar.
2. All Commanding Officers, Executive Officers, and officers standing watch on the bridge will have reviewed the MSAT material prior to a training event employing the use of mid-frequency active sonar.
3. Navy lookouts will undertake extensive training in order to qualify as a watchstander in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D).
4. Lookout training will include on-the-job instruction under the supervision of a qualified, experienced watchstander. Following successful completion of this supervised training period, lookouts will complete the Personal Qualification Standard program, certifying that they have demonstrated the necessary skills (such as detection and reporting of partially submerged objects). This does not forbid personnel being trained as lookouts from being counted as those listed in previous measures so long as supervisors monitor their progress and performance.
5. Lookouts will be trained in the most effective means to ensure quick and effective communication within the command structure in order to facilitate implementation of mitigation measures if marine species are spotted.

B. General Maritime Mitigation Measures: Lookout and Watchstander Responsibilities

1. On the bridge of surface ships, there will always be at least three people on watch whose duties include observing the water surface around the vessel.
2. All surface ships participating in ASW training events will, in addition to the three personnel on watch noted previously, have at all times during the exercise at least two additional personnel on watch as marine mammal lookouts.

3. Personnel on lookout and officers on watch on the bridge will have at least one set of binoculars available for each person to aid in the detection of marine mammals.

4. On surface vessels equipped with mid-frequency active sonar, pedestal mounted "Big Eye" (20x110) binoculars will be present and in good working order to assist in the detection of marine mammals in the vicinity of the vessel.

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

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

7. Personnel on lookout will be responsible for reporting all objects or anomalies sighted in the water (regardless of the distance from the vessel) to the Officer of the Deck, since any object or disturbance (e.g., trash, periscope, surface disturbance, discoloration) in the water may be indicative of a threat to the vessel and its crew or indicative of a marine species that may need to be avoided as warranted.

C. Operating Procedures

1. A Letter of Instruction, Mitigation Measures Message, or Environmental Annex to the Operational Order will be issued prior to the exercise to further disseminate the personnel training requirement and general marine mammal mitigation measures.

2. Commanding Officers will make use of marine species detection cues and information to limit interaction with marine species to the maximum extent possible consistent with safety of the ship.

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

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

5. Navy aircraft participating in exercises at sea will conduct and maintain, when operationally feasible and safe, surveillance for marine species of concern as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties.

6. Aircraft with deployed sonobuoys will use only the passive capability of sonobuoys when marine mammals are detected within 200 yd (183 m) of the sonobuoy.

7. Marine mammal detections will be immediately reported to assigned Aircraft Control Unit for further dissemination to ships in the vicinity of the marine species as appropriate where it is reasonable to conclude that the course of the ship will likely result in a closing of the distance to the detected marine mammal.

8. Safety Zones—When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) within or closing to inside 1,000 yd (914 m) of the sonar dome (the bow), the ship or submarine will limit active transmission levels to at least 6 decibels (dB) below normal operating levels. (A 6-dB reduction equates to a 75 percent power reduction. The reason is that decibel levels are on a logarithmic scale, not a linear scale. Thus, a 6-dB reduction results in a power level only 25 percent of the original power.)

   a. Ships and submarines will continue to limit maximum transmission levels by this 6-dB factor until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 m) beyond the location of the last detection.

   b. Should a marine mammal be detected within or closing to inside 500 yd (457 m) of the sonar dome, active sonar transmissions will be limited to at least 10 dB below the equipment's normal operating level. (A 10-dB reduction equates to a 90 percent power reduction from normal operating levels.) Ships and submarines will continue to limit maximum ping levels by this 10-dB factor until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 m) beyond the location of the last detection.

   c. Should the marine mammal be detected within or closing to inside 200 yd (183 m) of the sonar dome, active sonar transmissions will cease. Sonar will not resume until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 m) beyond the location of the last detection.

   d. Special conditions applicable for dolphins and porpoises only: If, after conducting an initial maneuver to avoid close quarters with dolphins or porpoises, the Officer of the Deck concludes that dolphins or porpoises are deliberately closing to ride the vessel's bow wave, no further mitigation actions are necessary while the dolphins or porpoises continue to exhibit bow-waveriding behavior.

   e. If the need for power-down should arise as detailed in “Safety Zones” above, the Navy shall follow the requirements as though they were operating at 235 dB — the normal operating level (i.e., the first power-down will be to 229 dB, regardless of at what level above 235 dB sonar was being operated).

9. Prior to start up or restart of active sonar, operators will check that the Safety Zone radius around the sound source is clear of marine mammals.

10. Sonar levels (generally) - Navy will operate sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet tactical training objectives.

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

12. Helicopters will not dip their sonar within 200 yd (183 m) of a marine mammal and will cease pinging if a marine mammal closes within 200 yd (183 m) after pinging has begun.

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

14. Increased vigilance during major ASW training exercises with tactical active sonar when critical conditions are present. Based on lessons learned from strandings in Bahamas 2000, Madeiras 2000, Canaries 2002 and Spain 2006, beaked whales are of particular concern since they have been associated with mid-frequency active sonar training activities. The Navy should avoid planning major ASW training exercises with midfrequency active sonar in areas where they will encounter conditions which, in their aggregate, may contribute to a marine mammal stranding event.

15. The conditions to be considered during exercise planning include:

    a. Areas of at least 3,281-ft (1,000-m) depth near a shoreline where there is a rapid change in bathymetry on the order of 1,000 to 6,000 yd (914 to 5,486 m) occurring across a relatively short horizontal distance (e.g., 5 nm [9 km]).

    b. Cases for which multiple ships or submarines (≥ 3) operating mid-frequency active sonar in the same area over extended periods of time (≥ 6 hours) in close proximity (≤ 10 nm [18 km] apart).

    c. An area surrounded by land masses, separated by less than 35 nm (65 km) and at least 10 nm (18 km) in length, or an embayment, wherein training activities involving multiple ships/subs (≥ 3) employing mid-frequency active sonar near land may produce sound directed toward the channel or embayment that may cut off the lines of egress for marine mammals.

    d. Though not as dominant a condition as bathymetric features, the historical presence of a significant surface duct (i.e., a mixed layer of constant water temperature extending from the sea surface to 100 or more ft [30 or more m]).

If the Major Range Event is to occur in an area where the above conditions exist in their aggregate, these conditions must be fully analyzed in environmental planning documentation. The Navy will increase vigilance by undertaking the following additional mitigation measures:

16. A dedicated aircraft (Navy asset or contracted aircraft) will undertake reconnaissance of the embayment or channel ahead of the exercise participants to detect marine mammals that may be in the area exposed to active sonar. Where practical, advance survey should occur within about 2 hours prior to mid-frequency active sonar use and periodic surveillance should continue for the duration of the exercise. Any unusual conditions (e.g., presence of sensitive species, groups of species milling out of habitat, and any stranded animals) shall be reported to the Office in Tactical Command, who should give consideration to delaying, suspending, or altering the exercise.
17. All safety zone power down requirements described above apply.
18. The post-exercise report must include specific reference to any event conducted in areas where the conditions (in Item 15) exist, with exact location and time/duration of the event, and noting results of surveys conducted.

1.3.3.2 Surface-to-Surface Gunnery (5-inch, 76 mm, 20 mm, 25 mm and 30 mm Explosive Rounds)

1. Lookouts will visually survey for floating weeds and kelp, and algal mats. Intended impact will not be within 600 yd (549 m) of known or observed floating weeds and kelp, and algal mats .
2. For exercises using targets towed by a vessel or aircraft, target-towing vessels/aircraft shall maintain a trained lookout for marine mammals and sea turtles. If a marine mammal or sea turtle is sighted in the vicinity, the tow aircraft/vessel will immediately notify the firing vessel, which will suspend the exercise until the area is clear.
3. A 600-yd (549-m) radius buffer zone will be established around the intended target.
4. From the intended firing position, trained lookouts will survey the buffer zone for marine mammals and sea turtles prior to commencement and during the exercise as long as practicable. Due to the distance between the firing position and the buffer zone, lookouts are only expected to visually detect breaching whales, whale blows, and large pods of dolphins and porpoises.
5. The exercise will be conducted only when the buffer zone is visible and marine mammals and sea turtles are not detected within it.

1.3.3.3 Surface-to-Surface Gunnery (non-explosive rounds)

1. Lookouts will visually survey for floating weeds and kelp, and algal mats. Intended impact will not be within 200 yd (183 m) of known or observed floating weeds and kelp, and algal mats.
2. A 200-yd (183-m) radius buffer zone will be established around the intended target.
3. From the intended firing position, trained lookouts will survey the buffer zone for marine mammals and sea turtles prior to commencement and during the exercise as long as practicable. Due to the distance between the firing position and the buffer zone, lookouts are only expected to visually detect breaching whales, whale blows, and large pods of dolphins and porpoises.
4. If applicable, target towing vessels will maintain a lookout. If a marine mammal or sea turtle is sighted in the vicinity of the exercise, the tow vessel will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.
5. The exercise will be conducted only when the buffer zone is visible and marine mammals and sea turtles are not detected within the target area and the buffer zone.

1.3.3.4 Surface-to-Air Gunnery (explosive and non-explosive rounds)

1. Vessels will orient the geometry of gunnery exercises in order to prevent debris from falling in the area of sighted marine mammals and sea turtles.
2. Vessels will expedite the recovery of any parachute deploying aerial targets to reduce the potential for entanglement of marine mammals and sea turtles.
3. Target towing aircraft will maintain a lookout. If a marine mammal or sea turtle is sighted in the vicinity of the exercise, the tow aircraft will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.

1.3.3.5 Air-to-Surface Gunnery (explosive and non-explosive rounds)

1. If surface vessels are involved, lookouts will visually survey for floating weeds, kelp and algal mats in the target area. Impact will not occur within 200 yd (183 m) of known or observed floating weeds and kelp or algal mats .
2. A 200-yd (183-m) radius buffer zone will be established around the intended target.
3. If surface vessels are involved, lookout(s) will visually survey the buffer zone for marine mammals and sea turtles prior to and during the exercise.
4. Aerial surveillance of the buffer zone for marine mammals and sea turtles will be conducted prior to commencement of the exercise. Aerial surveillance altitude of 500 ft to 1,500 ft (152 to 457 m) is optimum. Aircraft crew/pilot will maintain

visual watch during exercises. Release of ordnance through cloud cover is prohibited: Aircraft must be able to actually see ordnance impact areas.

5. The exercise will be conducted only if marine mammals and sea turtles are not visible within the buffer zone.

1.3.3.6 Small Arms Training (grenades, explosive and non-explosive rounds)

1. Lookouts will visually survey for floating weeds or kelp, algal mats, marine mammals, and sea turtles. Weapons will not be fired in the direction of known or observed floating weeds or kelp, algal mats, marine mammals, or sea turtles.

1.3.3.7 Air-to-Surface At-Sea Bombing Exercises (explosive bombs and rockets)

1. If surface vessels are involved, trained lookouts will survey for floating kelp, marine mammals, and sea turtles. Ordnance will not be targeted to impact within 1,000 yd (914 m) of known or observed floating kelp, sea turtles, or marine mammals.
2. A buffer zone of 1,000-yd (914-m) radius will be established around the intended target.
3. Aircraft will visually survey the target and buffer zone for marine mammals and sea turtles prior to and during the exercise. The survey of the impact area will be made by flying at 1,500 ft (457 m) or lower, if safe to do so, and at the slowest safe speed. Release of ordnance through cloud cover is prohibited: aircraft must be able to actually see ordnance impact areas. Survey aircraft should employ most effective search tactics and capabilities.
4. The exercises will be conducted only if marine mammals and sea turtles are not visible within the buffer zone.

1.3.3.8 Air-to-Surface At-Sea Bombing Exercises (non-explosive bombs and rockets)

1. If surface vessels are involved, trained lookouts will survey for floating kelp, which may be inhabited by immature sea turtles, and for sea turtles and marine mammals. Ordnance shall not be targeted to impact within 1,000 yd (914 m) of known or observed floating kelp, sea turtles, or marine mammals.
2. A 1,000-yd (914-m) radius buffer zone will be established around the intended target.
3. Aircraft will visually survey the target and buffer zone for marine mammals and sea turtles prior to and during the exercise. The survey of the impact area will be made by flying at 1,500 ft (457 m) or lower, if safe to do so, and at the slowest safe speed. Release of ordnance through cloud cover is prohibited: aircraft must be able to actually see ordnance impact areas. Survey aircraft should employ most effective search tactics and capabilities.

4. The exercise will be conducted only if marine mammals and sea turtles are not visible within the buffer zone.

1.3.3.9 Air-to-Surface Missile Exercises (explosive and non-explosive)

1. Ordnance will not be targeted to impact within 1,800 yd (1,646 m) of known or observed floating kelp.
2. Aircraft will visually survey the target area for marine mammals and sea turtles. Visual inspection of the target area will be made by flying at 1,500 ft (457 m) ft or lower, if safe to do so, and at slowest safe speed. Firing or range clearance aircraft must be able to actually see ordnance impact areas. Explosive ordnance shall not be targeted to impact within 1,800 yd (1,646 m) of sighted marine mammals and sea turtles.

1.3.3.10 Underwater Detonations (up to 2.5-lb charges)

To ensure protection of marine mammals and sea turtles during underwater detonation training, the operating area must be determined to be clear of marine mammals and sea turtles prior to detonation. Implementation of the following mitigation measures continue to ensure that marine mammals would not be exposed to temporary threshold shift (TTS), permanent threshold shift (PTS), or injury from physical contact with training mine shapes during training events.

A. Exclusion Zones

All Mine Warfare and Mine Countermeasures Operations involving the use of explosive charges must include exclusion zones for marine mammals and sea turtles to prevent physical and/or acoustic effects to those species. These exclusion zones will extend in a 700-yd (640-m) radius around the detonation site.

B. Pre-Exercise Surveys

For Demolition and Ship Mine Countermeasures Operations, pre-exercise survey will be conducted within 30 minutes prior to the commencement of the scheduled explosive event. The survey may be conducted from the surface, by divers, and/or from the air, and personnel will be alert to the presence of any marine mammal or sea turtle. Should such an animal be present within the survey area, the exercise will be paused until the animal voluntarily leaves the area. The Navy will suspend detonation exercises and ensure the area is clear for a full 30 minutes prior to detonation. Personnel will record marine mammal and sea turtle observations during the exercise.

C. Post-Exercise Surveys

Surveys within the same radius will also be conducted within 30 minutes after the completion of the explosive event.

1.3.4 Reporting

If there is evidence that a marine mammal or sea turtle may have been stranded, injured or killed by the action, Navy training activities will be immediately suspended and the situation immediately reported by the participating unit to the Officer in Charge of the Exercise (OCE), who will follow Navy procedures for reporting the incident to Commander, Pacific Fleet, Commander, Navy Region Southwest, Environmental Director, and the chain-of-command. The situation will also be reported to NMFS.

1.3.5 Mining Training Activities

Mining training activities involve aerial drops of inert training shapes on target points. Aircrews are scored for their ability to accurately hit the target points. Although this operation does not involve live ordnance, marine mammals have the potential to be injured if they are in the immediate vicinity of a target points; therefore, the safety zone shall be clear of marine mammals and sea turtles around the target location. Pre- and post-surveys and reporting requirements outlined for underwater detonations shall be implemented during mining training activities. To the maximum extent feasible, the Navy shall retrieve inert mine shapes dropped during mining training activities.

1.3.6 Sinking Exercise

The selection of sites suitable for Sinking Exercises (SINKEXs) involves a balance of operational suitability, requirements established under the Marine Protection, Research and Sanctuaries Act (MPRSA) permit granted to the Navy (40 Code of Federal Regulations § 229.2), and the identification of areas with a low likelihood of encountering ESA-listed species. To meet operational suitability criteria, locations must be within a reasonable distance of the target vessels' originating location. The locations should also be close to active military bases to allow participating assets access to shore facilities. For safety purposes, these locations should also be in areas that are not generally used by non-military air or watercraft. The MPRSA permit requires vessels to be sunk in waters which are at least 1,000 fathoms (6,000 ft [1,829 m]) deep and at least 50 nm (93 km) from land.

In general, most listed species prefer areas with strong bathymetric gradients and oceanographic fronts for significant biological activity such as feeding and reproduction. Typical locations include the continental shelf and shelf-edge.

1.3.6.1 SINKEX Range Clearance Plan

The Navy has developed range clearance procedures to maximize the probability of sighting any ships or protected species in the vicinity of an exercise, which are as follows:

1. All weapons firing will be conducted during the period 1 hour after official sunrise to 30 minutes before official sunset.
2. Extensive range clearance operations will be conducted in the hours prior to commencement of the exercise, ensuring that no shipping is located within the hazard range of the longest-range weapon being fired for that event.
3. Prior to conducting the exercise, remotely sensed sea surface temperature maps will be reviewed SINKEX and ASM training activities will not be conducted within areas where strong temperature discontinuities are present, thereby

indicating the existence of oceanographic fronts. These areas will be avoided because concentrations of some listed species, or their prey, are known to be associated with these oceanographic features.

4. An exclusion zone with a radius of 1.0 nm (2 km) will be established around each target. An additional buffer of 0.5 nm (1 km) will be added to account for errors, target drift, and animal an additional 0.5 nm (1 km), will be surveyed. Together, the zones extend out 2 nm (4 km) from the target.

5. A series of surveillance over-flights will be conducted within the exclusion and the safety zones, prior to and during the exercise, when feasible. Survey protocol will be as follows:

   a. Overflights within the exclusion zone will be conducted in a manner that optimizes the surface area of the water observed. This may be accomplished through the use of the Navy's Search and Rescue Tactical Aid, which provides the best search altitude, ground speed, and track spacing for the discovery of small, possibly dark objects in the water based on the environmental conditions of the day. These environmental conditions include the angle of sun inclination, amount of daylight, cloud cover, visibility, and sea state.

   b. All visual surveillance activities will be conducted by Navy personnel trained in visual surveillance. At least one member of the mitigation team will have completed the Navy's marine mammal training program for lookouts.

   c. In addition to the overflights, the exclusion zone will be monitored by passive acoustic means, when assets are available. This passive acoustic monitoring will be maintained throughout the exercise. Potential assets include sonobuoys, which can be utilized to detect any vocalizing marine mammals (particularly sperm whales) in the vicinity of the exercise. The sonobuoys will be re-seeded as necessary throughout the exercise. Additionally, passive sonar onboard submarines may be utilized to detect any vocalizing marine mammals in the area. The Officer in Charge of the Exercise (OCE) will be informed of any aural detection of marine mammals and will include this information in the determination of when it is safe to commence the exercise.

   d. On each day of the exercise, aerial surveillance of the exclusion and safety zones will commence 2 hours prior to the first firing.

   e. The results of all visual, aerial, and acoustic searches will be reported immediately to the OCE. No weapons launches or firing will commence until the OCE declares the safety and exclusion zones free of marine mammals and threatened and endangered species.

   f. If a protected species observed within the exclusion zone is diving, firing will be delayed until the animal is re-sighted outside the exclusion zone, or 30 minutes have elapsed. After 30 minutes, if the animal has not been re-sighted it will be assumed to have left the exclusion zone. This is based on a typical dive time of 30 minutes for traveling listed species of concern. The OCE will determine if the listed species is in danger of being adversely affected by commencement of the exercise.

   g. During breaks in the exercise of 30 minutes or more, the exclusion zone will again be surveyed for any protected species. If protected species are sighted within the exclusion zone, the OCE will be notified, and the procedure described above will be followed.

   h. Upon sinking of the vessel, a final surveillance of the exclusion zone will be monitored for 2 hours, or until sunset, to verify that no marine mammals or sea turtles were harmed.

6. Aerial surveillance will be conducted using helicopters or other aircraft based on necessity and availability. The Navy has several types of aircraft capable of performing this task; however, not all types are available for every exercise. For each exercise, the available asset best suited for identifying objects on and near the surface of the ocean will be used. These aircraft will be capable of flying at the slow safe speeds necessary to enable viewing of marine vertebrates with unobstructed, or minimally obstructed, downward and outward visibility. The exclusion and safety zone surveys may be cancelled in the event that a mechanical problem, emergency search and rescue, or other similar and unexpected event preempts the use of one of the aircraft onsite for the exercise.

7. Every attempt will be made to conduct the exercise in sea states that are ideal for marine mammal sighting, Beaufort Sea State 3 or less. In the event of a 4 or above, survey efforts will be increased within the zones. This will be accomplished through the use of an additional aircraft, if available, and conducting tight search patterns.

8. The exercise will not be conducted unless the exclusion zone could be adequately monitored visually.

9. In the event that any marine mammals or sea turtles are observed to be harmed in the area, a detailed description of the animal will be taken, the location noted, and if possible, photos taken. This information will be provided to NMFS via the Navy’s regional environmental coordinator for purposes of identification.

10. An after action report detailing the exercise’s time line, the time the surveys commenced and terminated, amount, and types of all ordnance expended, and the results of survey efforts for each event will be submitted to NMFS.

1.3.7 Mitigation Measures Related to Explosive Source Sonobuoys (AN/SSQ-110A)

1.3.7.1 AN/SSQ-110A Pattern Deployment

1. Crews will conduct visual reconnaissance of the drop area prior to laying their intended sonobuoy pattern. This search should be conducted below 1,500 ft (457 m) at a slow speed when operationally feasible and weather conditions permit. In dual aircraft activities, crews may conduct coordinated area clearances.
2. Crews shall conduct a minimum of 30 minutes of visual and aural monitoring of the search area prior to commanding the first post (source/receiver sonobuoy pair) detonation. This 30 minute observation period may include pattern deployment time.
3. For any part of the briefed pattern where a post will be deployed within 1,000 yds(914 m) of observed marine mammal activity, the Navy will deploy the receiver ONLY and monitor while conducting a visual search. When marine mammals are no longer detected within 1,000 yds (914 m) of the intended post position, the Navy will co-locate the AN/SSQ-110A sonobuoy (source) with the receiver.
4. When operationally feasible, the Navy will conduct continuous visual and aural monitoring of marine mammal activity, including monitoring of their aircraft sensors from first sensor placement to checking off-station and out of RF range of the sensors.

1.3.7.2 AN/SSQ-110A Pattern Employment

1. Aural Detection – If the presence of marine mammals is detected aurally, then that shall cue the Navy aircrew to increase the diligence of their visual surveillance. Subsequently, if no marine mammals are visually detected, then the crew may continue multi-static active search.
2. Visual Detection – If marine mammals are visually detected within 1,000 yds (914 m) of the explosive source sonobuoy (AN/SSQ-110A) intended for use, then that payload will not be detonated. Aircrews may utilize this post once the marine mammals have not been re-sighted for 30 minutes or are observed to have moved outside the 1,000 yd (914 m) safety buffer. Aircrews may shift their multi-static active search to another post, where marine mammals are outside the 1,000 yd (914 m) safety buffer.

1.3.7.3 AN/SSQ-110A Scuttling Sonobuoys

1. Aircrews will make every attempt to manually detonate the unexploded charges at each post in the pattern prior to departing the operations area by using the “Payload 1 Release” command followed by the “Payload 2 Release” command. Aircrews will refrain from using the “Scuttle” command when two payloads remain at a given post. Aircrews will ensure a 1,000 yd (914 m) safety buffer, visually clear of marine mammals, is maintained around each post as is done during active search operations.

2. Aircrews will only leave posts with unexploded charges in the event of a sonobuoy malfunction, an aircraft system malfunction, or when an aircraft must immediately depart the area due to issues such as fuel constraints, inclement weather, and in-flight emergencies. In these cases, the sonobuoy will self-scuttle using the secondary method or tertiary method.
3. The Navy will ensure all payloads are accounted for. Explosive source sonobuoys (AN/SSQ-110A) that cannot be scuttled shall be reported as unexploded ordnance via voice communications while airborne and, then upon landing, via Naval message.
4. Marine mammal monitoring will continue until out of their own aircraft sensor range.

1.3.8 Monitoring: Integrated Comprehensive Monitoring Program

The U.S. Navy is committed to demonstrating environmental stewardship while executing its National Defense mission and is responsible for compliance with federal environmental and natural resources laws and regulations that apply to the marine environment. As part of those responsibilities, an assessment of the long-term and/or population-level effects of Navy training activities as well as the efficacy of mitigation measures is necessary. The Navy is developing an Integrated Comprehensive Monitoring Program (ICMP) for marine species in order to assess the effects of training activities on marine species and investigate population trends in marine species distribution and abundance in various range complexes and geographic locations where Navy training occurs. This program will emphasize active sonar training.

The primary goals of the ICMP are to:

- Monitor Navy training exercises, especially those involving mid-frequency active sonar and underwater detonations, for compliance with the terms and conditions of Biological Opinions or Marine Mammal Protection Act (MMPA) authorizations.
- Estimate the number individuals (primarily marine mammals) exposed to sound levels above current regulatory thresholds.
- Assess the effectiveness of the Navy's marine species mitigation.
- Minimize exposure of protected species (primarily marine mammals) to sound levels from active sonar or sound pressure levels from underwater detonations currently considered to result in harassment.
- Document trends in species distribution and abundance in Navy training areas.
- Add to the knowledge base on potential behavioral and physiological effects to marine species from MFA sonar and underwater detonations.
- Assess the practicality and usefulness of a number of mitigation tools and techniques.

The ICMP will serve as the basis for establishing Implementation Plans (IPs) for training activities as well as geographically based long-term monitoring sites. Training exercise IPs will be focused on shortterm monitoring and mitigation for individual training activities. Implementation will be tailored to the specific logistical constraints for each exercise and include specifics concerning dates, location, spatial extent, appropriate monitoring methods, and reporting protocols. The IP will utilize information specific to the exercise to determine the most effective, logistically and financially feasible means to monitor each training event. Each IP will be developed to ensure compliance with all ESA Section 7 and MMPA authorization requirements.

By using a combination of monitoring techniques or tools appropriate for the species of concern, type of Navy activities conducted in the area, sea state conditions, and the size of the OPAREA, the detection, localization, and observation of marine species can be maximized. This ICMP will evaluate the range of potential monitoring techniques that can be tailored to any Navy range or exercise and the appropriate species of concern. The limitations and benefits to each type of monitoring technique and the type of environment or species of concern that would best be served by the technique will be addressed and a matrix of feasibility, temporal and spatial use, limitations, costs and availability of resources to accommodate the technique will be developed.

The primary tools available for monitoring include the following:

- Visual Observations – Surface vessel, aerial and shore-based surveys, providing data on long term population trends (abundance and distribution) and response of marine species to Navy training activities. Both Navy personnel and independent visual observers will be considered.
- Acoustic Monitoring – Autonomous Acoustic Recorders (moored buoys), High Frequency Acoustic Recording Packages (HARPS), sonobuoys, passive acoustic towed arrays, shipboard passive sonar, and Navy Instrumented Acoustic Ranges can provide presence/absence and movement data which are particularly important for species that are difficult to detect visually or when conditions limit the effectiveness of visual monitoring.
- Photo identification and tagging – Contributes to understanding of movement patterns and stock structure which is important to determine how potential effects may relate to individual stocks or populations. Tagging with sophisticated D-tags may also allow direct monitoring of behaviors not readily apparent to surface observers.
- Oceanographic and environmental data collection – Data to be used for analyzing distribution patterns and developing predictive habitat and density models.

In addition, the ICMP will propose to continue or initiate studies of behavioral response, abundance, distribution, habitat utilization, etc. for species of concern using a variety of methods which may include visual surveys, passive and acoustic monitoring, radar and data logging tags (to record data on acoustics, diving and foraging behavior, and movements). This work will help to build the collective knowledgebase on the geographic and temporal extent of key habitats and provide baseline information to account for natural perturbations such as El Niño or La Niña events as well as establish baseline information to determine the spatial and temporal extent of reactions to Navy training activities, or indirect effects from changes in prey availability and distribution.

The Navy will coordinate with the local NMFS Stranding Coordinator for any unusual marine mammal behavior and any stranding, beached live/dead or floating marine mammals that may occur at any time during or within 24 hours after completion of MFA sonar use associated with ASW training activities. The

Navy will submit a report to the Office of Protected Resources, NMFS, within 120 days of the completion of a Major Exercise. This report must contain a discussion of the nature of the effects, if observed, based on both modeled results of real-time events and sightings of marine mammals.

In combination with previously discussed mitigation and protective measures, exercise-specific implementation plans developed under the ICMP will ensure thorough monitoring and reporting of nwtrc training activities. A Letter of Instruction, Mitigation Measures Message, or Environmental Annex to the Operational Order will be issued prior to each exercise to further disseminate the personnel training requirement and general marine mammal protective measures including monitoring and reporting.

1.3.9 Northwest Training Range Complex Marine Species Monitoring Plan

The Navy is developing a Marine Species Monitoring Plan (MSMP) that provides recommendations for site-specific monitoring for MMPA and ESA listed species (primarily marine mammals) within the NWTRC, including during training exercises. The primary goals of monitoring are to evaluate trends in marine species distribution and abundance in order to assess potential population effects from Navy training activities and determine the effectiveness of the Navy's mitigation measures. The information gained from the monitoring will also allow the Navy to evaluate the models used to predict effects to marine mammals.

By using a combination of monitoring techniques or tools appropriate for the species of concern, type of Navy activities conducted, sea state conditions, and the size of the Range Complex, the detection, localization, and observation of marine mammals and sea turtles can be maximized. The following available monitoring techniques and tools are described in this monitoring plan for monitoring for range events (several days or weeks) and monitoring of population effects such as abundance and distribution (months or years):

- Visual Observations – Vessel-, Aerial- and Shore-based Surveys (for marine mammals and sea turtles) will provide data on population trends (abundance, distribution, and presence) and response of marine species to Navy training activities. Navy lookouts will also record observations of detected marine mammals from Navy ships during appropriate training and test events.
- Acoustic Monitoring – Passive Acoustic Monitoring possibly using towed hydrophone arrays, Autonomous Acoustic Recording buoys and U.S. Navy Instrument Acoustic Range (for marine mammals only) may provide presence/absence data on cryptic species that are difficult to detect visually (beaked whales and minke whales) that could address long term population trends and response to Navy training exercises.
- Additional Methods – Oceanographic Observations and Other Environmental Factors will be obtained during ship-based surveys and satellite remote sensing data. Oceanographic data is important factor that influences the abundance and distribution of prey items and therefore the distribution and movements of marine mammals.

The monitoring plan will be reviewed annually by Navy biologists to determine the effectiveness of the monitoring elements and to consider any new monitoring tools or techniques that may have become available.

1.3.10 Research

The Navy provides a significant amount of funding and support to marine research. The agency provides nearly 18 million dollars annually to universities, research institutions, federal laboratories, private companies, and independent researchers around the world to study marine mammals. The U.S. Navy sponsors 70 percent of all U.S. research concerning the effects of human-generated sound on marine mammals and 50 percent of such research conducted worldwide. Major topics of Navy-supported research include the following:

- Better understanding of marine species distribution and important habitat areas,
- Developing methods to detect and monitor marine species before and during training,
- Understanding the effects of sound on marine mammals, sea turtles, fish, and birds, and
- Developing tools to model and estimate potential effects of sound.

This research is directly applicable to Pacific Fleet training activities, particularly with respect to the investigations of the potential effects of underwater noise sources on marine mammals and other protected species. Proposed training activities employ sonar and underwater explosives, which introduce sound into the marine environment.

The Marine Life Sciences Division of the Office of Naval Research currently coordinates six programs that examine the marine environment and are devoted solely to studying the effects of noise and/or the implementation of technology tools that will assist the Navy in studying and tracking marine mammals. The six programs are as follows:

- Environmental Consequences of Underwater Sound,
- Non-Auditory Biological Effects of Sound on Marine Mammals,
- Effects of Sound on the Marine Environment,
- Sensors and Models for Marine Environmental Monitoring,
- Effects of Sound on Hearing of Marine Animals, and
- Passive Acoustic Detection, Classification, and Tracking of Marine Mammals.

The Navy has also developed the technical reports referenced within this document, which include the Marine Resource Assessments and the Navy OPAREA Density Estimates (NODE) reports. Furthermore, research cruises by the National Marine Fisheries Service and by academic institutions have received funding from the U.S. Navy.

The Navy has sponsored several workshops to evaluate the current state of knowledge and potential for future acoustic monitoring of marine mammals. The workshops brought together acoustic experts and marine biologists from the Navy and other research organizations to present data and information on current acoustic monitoring research efforts and to evaluate the potential for incorporating similar technology and methods on instrumented ranges. However, acoustic detection, identification, localization, and tracking of individual animals still requires a significant amount of research effort to be considered a reliable method for marine mammal monitoring. The Navy supports research efforts on acoustic monitoring and will continue to investigate the feasibility of passive acoustics as a potential mitigation and monitoring tool.

Overall, the Navy will continue to fund ongoing marine mammal research, and is planning to coordinate long term monitoring/studies of marine mammals on various established ranges and operating areas. The Navy will continue to research and contribute to university/external research to improve the state of the science regarding marine species biology and acoustic effects. These efforts include mitigation and monitoring programs; data sharing with NMFS and via the literature for research and development efforts; and future research as described previously.

1.3.11 Coordination and Reporting

The Navy is required to cooperate with the NMFS, and any other Federal, state, or local agency monitoring the impacts of training activities on marine mammals. The Navy will coordinate with the local NMFS Stranding Coordinator for any unusual marine mammal behavior and any stranding, beached live/dead or floating marine mammals that may occur coincident with Navy training activities. Details of required reporting and coordination will be defined in the Letter of Authorization for the NWTRC training and RDT&E activities. It is anticipated the following reporting and coordination may be required for these types of activities:

1. SINKEX, GUNEX, MISSILEX, BOMBEX, and Mine Warfare/ Countermeasures exercises — A yearly report detailing the exercise's timelines, the time the surveys commenced and terminated, amount, and types of all ordnance expended, and the results of marine mammal survey efforts for each event will be submitted to nmfs.
2. IEER exercises — A yearly report detailing the number of exercises along with the hours of associated marine mammal survey and associated marine mammal sightings, number of times deployment was delayed by marine mammal sightings, and the number of total detonated charges and self-scuttled charges will be submitted to NMFS.
3. MFAS/HFAS exercises — The Navy will submit an After Action Report to the Office of Protected Resources, NMFS, within 120 days of the completion of any Major Training or Integrated Unit-Level Exercise (Sustainment Exercise, IAC2, SHAREM). For other ASW exercises, the Navy will submit a yearly summary report. The After Action Reports and the annual reports will, at a minimum, include the following information:
    a. The estimated total number of hours of active sonar operation and the types of sonar utilized in the exercise;

    b. The total number of hours of observation effort (including observation time when active sonar was not operating), if obtainable;

c. All marine mammal sightings (at any distance—not just within a particular distance) to include details of the sighting circumstances;

d. The status of any active sonar sources (what sources were in use) and whether or not they were powered down or shut down as a result of the marine mammal observation; and

e. The platform that the marine mammals were initially sighted from.

4. Comprehensive National Sonar Report — By June 2014, the Navy will submit a draft National Report that analyzes, compares, and summarizes the active sonar data gathered (through November 2013) from the watchstanders and pursuant to the implementation of the Monitoring Plans for the Hawaii Range Complex, the Southern California Range Complex, the Marianas Range Complex, and the Northwest Training Range Complex.

1.4 MMPA Mitigation Requirements for Keyport Range Complex

When the U.S. Navy its proposed military readiness activities on the Keyport Range Complex, the regulations that NMFS' Permits Division proposes require the U.S. Navy to implement mitigation measures that include (but are not limited to) the following:

(a) Marine mammal observers training:

- (1) All range personnel shall be trained in marine mammal recognition.
- (2) Marine mammal observer training shall be conducted by qualified organizations approved by NMFS.
- (b) Lookouts onboard vessels:
  - (1) Vessels on a range shall use lookouts during all hours of range activities.
  - (2) Lookout duties include looking for marine mammals.
  - (3) All sightings of marine mammals shall be reported to the Range Officer in charge of overseeing the activity.
- (c) Visual surveillance shall be conducted just prior to all in-water exercises.
  - (1) Surveillance shall include, as a minimum, monitoring from all participating surface craft and, where available, adjacent shore sites.
  - (2) When cetaceans have been sighted in the vicinity of the operation, all range participants increase vigilance and take reasonable and practicable actions to avoid collisions and activities that may result in close interaction of naval assets and marine mammals.
  - (3) Actions may include changing speed and/or direction, subject to environmental and other conditions (e.g., safety, weather).
- (d) An "exclusion zone" shall be established and surveillance will be conducted to ensure that there are no marine mammals within this exclusion zone prior to the commencement of each in-water exercise.
  - (1) For cetaceans, the exclusion zone shall extend out 1,000 yards (914.4 m) from the intended track of the test unit.

(2) For pinnipeds, the exclusion zone shall extend out 100 yards (91 m) from the intended track of the test unit.

(e) Range craft shall not approach within 100 yards (91 m) of marine mammals, to the extent practicable considering human and vessel safety priorities. This includes marine mammals "hauled-out" on islands, rocks, and other areas such as buoys.

(f) In the event of a collision between a Navy vessel and a marine mammal, NUWC Keyport activities shall notify immediately the Navy chain of Command, which shall notify NMFS immediately.

(g) Passive acoustic monitoring shall be utilized to detect marine mammals in the area before and during activities.

(h) Procedures for reporting marine mammal sightings on the NAVSEA NUWC Keyport Range Complex shall be promulgated, and sightings shall be entered into the Range Operating System and forwarded to NOAA/NMML Platforms of Opportunity Program.

(i) If there is clear evidence that a marine mammal is injured or killed as a result of the proposed Navy RDT&E activities, the Naval activities shall be immediately suspended and the situation immediately reported by personnel involved in the activity to the Ranger Officer, who will follow Navy procedures for reporting the incident to NMFS through the Navy's chain-of-command.

(j) For nighttime RDT&E activities of active acoustic transmissions in the Keyport Range proposed extension area, the Navy shall conduct passive acoustic monitoring within the Agate Pass and south of University Point in southern Port Orchard Reach. If Southern Resident killer whales are detected in the vicinity of the Keyport Range Site, the Range Office shall be notified immediately and the active acoustic sources must be shutdown if killer whales are confirmed to approach at 1,000 yards from the source.

REQUIREMENTS FOR MONITORING AND REPORTING.

(a) The Holder of the Letter of Authorization issued pursuant to § 216.106 of this chapter and § 218.176 for activities described in § 218.170(c) is required to cooperate with the NMFS when monitoring the impacts of the activity on marine mammals.

(b) The Holder of the Authorization must notify NMFS immediately (or as soon as clearance procedures allow) if the specified activity identified in § 218.170(c) is thought to have resulted in the mortality or injury of any marine mammals, or in any take of marine mammals not identified or authorized in § 218.171(c).

(c) The Navy must conduct all monitoring and required reporting under the Letter of Authorization, including abiding by the NAVSEA NUWC Keyport Range Complex Monitoring Plan, which is incorporated herein by reference, and which requires the Navy to implement, at a minimum, the monitoring activities summarized below:

(1) Visual Surveys:

(i) The Holder of this Authorization shall conduct a minimum of 2 special visual surveys per year to monitor HFAS and MFAS respectively at the DBRC Range site.

(ii) For specified events, shore-based and vessel surveys shall be used 1 day prior to and 1-2 days post activity.

  (A) Shore-based Surveys:

    (1) Shore-based monitors shall observe test events that are planned in advance to occur adjacent to near shore areas where there are elevated topography or coastal structures, and shall use binoculars or theodolite to augment other visual survey methods.

    (2) hore-based surveys of the test area and nearby beaches shall be conducted for stranded marine animals following nearshore events. If any distressed, injured or stranded animals are observed, an assessment of the animal's condition (alive, injured, dead, or degree of decomposition) shall be reported immediately to the Navy and the information shall be transmitted immediately to NMFS through the appropriate chain of command.

  (B) essel-based Surveys:

    (1) Vessel-based surveys shall be designed to maximize detections of marine mammals near mission activity event.

    (2) Post-analysis shall focus on how the location, speed and vector of the range craft and the location and direction of the sonar source (e.g. Navy surface vessel) relates to the animal.

    (3) Any other vessels or aircraft observed in the area shall also be documented.

(iii) Surveys shall include the range site with special emphasis given to the particular path of the test run. When conducting a particular survey, the survey team shall collect the following information.

  (A Species identification and group size;

  (B) Location and relative distance from the acoustic source(s);

  (C) The behavior of marine mammals including standard environmental and oceanographic parameters;

  (D) Date, time and visual conditions associated with each observation;

  (E) Direction of travel relative to the active acoustic source; and

  (F) Duration of the observation.

(iv) Animal sightings and relative distance from a particular active acoustic source shall be used post-survey to determine potential received energy (dB re 1 micro Pa-sec). This data shall be used, post-survey, to estimate the number of marine mammals exposed to different received levels (energy based on distance to the source, bathymetry, oceanographic conditions and the type and power of the acoustic source) and their corresponding behavior.

(2) Passive Acoustic Monitoring (PAM):

(i) The Navy shall deploy a hydrophone array in the Keyport Range Complex Study Area for PAM.

(ii) The array shall be utilized during the two special monitoring surveys in DBRC as described in § 218.174(c)(1)(i).

(iii) The array shall have the capability of detecting low frequency vocalizations (<1,000 Hz) for baleen whales and relatively high frequency (up to 30 kHz) for odontocetes.

(iv) Acoustic data collected from the PAM shall be used to detect acoustically active marine mammals as appropriate.

(3) Marine Mammal Observers on range craft or Navy vessels:

(i) Navy Marine mammal observers (NMMOs) may be placed on a range craft or Navy platform during the event being monitored.

(ii) The NMMO must possess expertise in species identification of regional marine mammal species and experience collecting behavioral data.

(iii) NMMOs may be placed alongside existing lookouts during the two specified monitoring events as described in § 218.174(c)(1)(i).

(iv) NMMOs shall inform the lookouts of any marine mammal sighting so that appropriate action may be taken by the chain of command. NMMOs shall schedule their daily observations to duplicate the lookouts' schedule.

(v) NMMOs shall observe from the same height above water as the lookouts, and they shall collect the same data collected by lookouts listed in § 218.174(c)(1)(iii).

(d) The Navy shall complete an Integrated Comprehensive Monitoring Program (ICMP) Plan in 2009. This planning and adaptive management tool shall include:

(1) A method for prioritizing monitoring projects that clearly describes the characteristics of a proposal that factor into its priority.

(2) A method for annually reviewing, with NMFS, monitoring results, Navy R&D, and current science to use for potential modification of mitigation or monitoring methods.

(3) A detailed description of the Monitoring Workshop to be convened in 2011 and how and when Navy/NMFS will subsequently utilize the findings of the Monitoring Workshop to potentially modify subsequent monitoring and mitigation.

(4) An adaptive management plan.

(5) A method for standardizing data collection for NAVSEA NUWC Keyport Range Complex Extension and across range complexes.

(e) Notification of Injured or Dead Marine Mammals - Navy personnel shall ensure that NMFS (regional stranding coordinator) is notified immediately (or as soon as clearance procedures allow) if an injured or dead marine mammal is found during or shortly after, and in the vicinity of, any Navy activities utilizing sonar. The Navy shall provide NMFS with 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).

(f) Annual Keyport Range Complex Monitoring Plan Report - The Navy shall submit a report annually by December 1 describing the implementation and results (through September 1 of the same year) of the Keyport 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 NMMOs collecting marine mammal data pursuant to the Keyport Range Complex Monitoring Plan shall, at a minimum, provide the same marine mammal observation data required in § 218.174(c). The Keyport Range Complex Monitoring Plan Report may be provided to NMFS within a larger report that includes the required Monitoring Plan Reports from Keyport Range Complex and multiple range complexes.

(g) Keyport Range Complex 5-yr Comprehensive Report – The Navy shall submit to NMFS a draft comprehensive report that analyzes and summarizes all of the multi-year marine mammal information gathered during tests involving active acoustic sources for which individual reports are required in § 218.174 (d)-(f). This report will be submitted at the end of the fourth year of the rule (June 2013), covering activities that have occurred through September 1, 2013.

(h) The Navy shall respond to NMFS comments and requests for additional information or clarification on the Keyport Range Complex Extension Comprehensive Report, the Annual Keyport Range Complex Monitoring Plan Report (or the multi-Range Complex Annual Monitoring Report, it that is how the Navy chooses to submit the information) if submitted within 3 months of receipt. The report will be considered final after the Navy has addressed NMFS' comments, or three months after the submittal of the draft if NMFS does not comment by then.

(i) In 2011, the Navy shall convene a Monitoring Workshop in which the Monitoring Workshop participants will be asked to review the Navy's Monitoring Plans and monitoring results and make individual recommendations (to the Navy and NMFS) of ways of improving the Monitoring Plans. The recommendations shall be reviewed by the Navy, in consultation with NMFS, and modifications to the Monitoring Plan shall be made, as appropriate.

1.5 MMPA Mitigation Requirements for Northwest Training Range Complex

When the U.S. Navy its proposed military readiness activities on the Northwest Training Range Complex, the regulations that NMFS' Permits Division proposes to finalize requires the U.S. Navy to implement mitigation measures that include (but are not limited to) the following:

(1) Navy's General SOCAL Maritime Measures for All Training at Sea:

(i) Personnel Training (for all Training Types)

(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.

(ii) 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) Navy's Measures for MFAS Operations

(i) Personnel Training (for MFAS Operations):

(A) All lookouts onboard platforms involved in ASW training events shall review the NMFS-approved Marine Species Awareness Training material prior to use of mid-frequency active sonar.

(B) All COs, XOs, and officers standing watch on the bridge shall have reviewed the Marine Species Awareness Training material prior to a training event employing the use of mid-frequency active sonar.

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

(D) Lookout training shall include on-the-job instruction under the supervision of a qualified, experienced watchstander. 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). 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 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.

(ii) Lookout and Watchstander Responsibilities:

(A) On the bridge of surface ships, there shall 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 shall, 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 shall 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 shall 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 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 Lookouts Techniques in accordance with the Lookout Training Handbook.

(G) Personnel on lookout shall 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.

(iii) 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 1000 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 1000-yd safety zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yds (1829 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 yards (914 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 (457 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 yards (365 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 (457 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.

(3) Navy's Measures for Underwater Detonations

(i) 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.

(ii) 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.

(iii) 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 yds (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 (152 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.

(vii) Air-to-Surface Missile Exercises (explosive and non-explosive):

(A) Ordnance shall not be targeted to impact within 1,800 yds (1646 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 (457 m) feet 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 yds (1646 m) of sighted marine mammals.

(viii) Demolitions, Mine Warfare, and Mine Countermeasures (up to a 2.5-lb NEW charge):

(A) Exclusion Zones – All Demolitions, 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 arc radius around the detonation site.

(B) Pre-Exercise Surveys - For Demolition and Ship Mine Countermeasures Operations, pre-exercise survey 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 a marine mammal be present within the survey area, the exercise shall be paused until the animal voluntarily leaves the area. The Navy shall suspend detonation exercises and ensure the area is clear for a full 30 minutes prior to detonation. Personnel shall record any marine mammal observations during the exercise.

(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 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, Third Fleet, Commander, Navy Region Southwest, Environmental Director, and the chain-of-command. The situation shall also be reported to NMFS.

(ix) Mining Operations - Initial target points shall be briefly surveyed prior to inert ordnance (no live ordnance used) release from an aircraft to ensure the intended drop area is clear of marine mammals. To the extent feasible, the Navy shall retrieve inert mine shapes dropped during Mining Operations.

(x) Sink Exercise:

(A) All weapons firing shall be conducted during the period 1 hour after official sunrise to 30 minutes before official sunset.

(B) An exclusion zone with a radius of 1.5 nm shall be established around each target. This 1.5 nm zone includes a buffer of 0.5 nm to account for errors, target drift, and animal movement. In addition to the 1.5 nm exclusion zone, a further safety zone, which extends from the exclusion zone at 1.5 nm out an additional 0.5 nm, shall be surveyed. Together, the zones (exclusion and safety) extend out 2 nm from the target.

(C) A series of surveillance over-flights shall be conducted within the exclusion and the safety zones, prior to and during the exercise, when feasible. Survey protocol shall be as follows:

(1) Overflights within the exclusion zone shall be conducted in a manner that optimizes the surface area of the water observed. This may be accomplished through the use of the Navy's Search and Rescue Tactical Aid, which provides the best search altitude, ground speed, and track spacing for the discovery of small, possibly dark objects in the water based on the environmental conditions of the day. These environmental conditions include the angle of sun inclination, amount of daylight, cloud cover, visibility, and sea state.

(2) All visual surveillance activities shall be conducted by Navy personnel trained in visual surveillance. At least one member of the mitigation team shall have completed the Navy's marine mammal training program for lookouts.

(3) In addition to the overflights, the exclusion zone shall be monitored by passive acoustic means, when assets are available. This passive acoustic

monitoring would be maintained throughout the exercise. Potential assets include sonobuoys, which can be utilized to detect any vocalizing marine mammals (particularly sperm whales) in the vicinity of the exercise. The sonobuoys shall be re-seeded as necessary throughout the exercise. Additionally, passive sonar onboard submarines may be utilized to detect any vocalizing marine mammals in the area. The OCE would be informed of any aural detection of marine mammals and would include this information in the determination of when it is safe to commence the exercise.

(4) On each day of the exercise, aerial surveillance of the exclusion and safety zones shall commence 2 hours prior to the first firing.

(5) The results of all visual, aerial, and acoustic searches shall be reported immediately to the OCE. No weapons launches or firing may commence until the OCE declares the safety and exclusion zones free of marine mammals.

(6) If a marine mammal is observed within the exclusion zone is diving, firing shall be delayed until the animal is re-sighted outside the exclusion zone, or 30 minutes have elapsed. After 30 minutes, if the animal has not been re-sighted it would be assumed to have left the exclusion zone.

(7) During breaks in the exercise of 30 minutes or more, the exclusion zone shall again be surveyed for any protected species. If marine mammals are sighted within the exclusion zone, the OCE shall be notified, and the procedure described above would be followed.

(8) Upon sinking of the vessel, a final surveillance of the exclusion zone shall be monitored for 2 hours, or until sunset, to verify that no marine mammals were injured.

(D) Aerial surveillance shall be conducted using helicopters or other aircraft based on necessity and availability.

(E) Where practicable, the Navy shall conduct the exercise in sea states that are ideal for marine mammal sighting, i.e., Beaufort Sea State 3 or less. In the event of a Beaufort Sea State 4 or above, survey efforts shall be increased within the zones. This shall be accomplished through the use of an additional aircraft, if available, and conducting tight search patterns.

(F) The exercise shall not be conducted unless the exclusion zone can be adequately monitored visually.

(G) In the event that any marine mammals are observed to be harmed during the exercise, a detailed description of the animal shall be taken, the location noted, and if possible, photos taken. This information shall be provided as soon as practicable to NMFS via the Navy's regional environmental coordinator for purposes of identification (see the Stranding Plan for detail).

(H) An after action report detailing the exercise's time line, the time the surveys commenced and terminated, amount, and types of all ordnance expended, and the results of survey efforts for each event shall be submitted to NMFS.

(xi) Extended Echo Ranging/Improved Extended Echo Ranging and Advanced Extended Echo-ranging (EER/IEER/AEER):

(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 457 m (500 yd) at a slow speed, if operationally feasible and weather conditions permit. In dual aircraft operations, crews are allowed to conduct coordinated area clearances.

(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 914 m (1,000 yd) 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 914 m (1,000 yd) 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 own-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 diligence 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 914 m (1,000 yd) of the explosive source sonobuoy (AN/SSQ-110A/SSQ-125) 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 914 m (1,000 yd) safety buffer. Aircrews may shift their multi-static active search to another post, where marine mammals are outside the 914 m (1,000 yd) 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 914 m (1,000 yd) 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, and 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 can not be scuttled shall be reported as unexploded ordnance via voice communications while airborne, then upon landing via naval message.

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

Monitoring and Reporting – When conducting operations identified in 50 CFR § 218.110(c) and Condtion 4(a), the Holder of the Authorization and any person(s) operating under his authority must implement the following monitoring and reporting measures. All reports should be submitted to the Director, Office of Protected Resources, National Marine Fisheries Service, 1315 East-West Highway, Silver Spring MD 20910 and a copy provided to the Assistant Regional Administrator for Protected Resources, Southwest Regional Office, National Marine Fisheries Service, 501 West Ocean Blvd., Long Beach, CA 90802-4213 .

(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 Letter of Authorization, including abiding by NWTRC Monitoring Plan.

(e) The Navy shall comply with the 2009 Integrated Comprehensive Monitoring Program (ICMP) Plan and continue to improve the program in consultation with NMFS. Changes and improvements to the program made during 2010 (as prescribed in the 2009 ICMP and otherwise deemed appropriate by the Navy and NMFS) will be described in an updated 2010 ICMP and submitted to NMFS by October 31, 2010 for review. An updated 2010 ICMP will be finalized by December 31, 2010.

(f) Annual NWTRC Monitoring Plan Report - The Navy shall submit a report on February 1, 2011 describing the implementation and results (through December 1 of the same year) of the NWTRC Monitoring Plan. Data collection methods will be standardized across range complexes to allow for comparison in different geographic locations. Although additional information will also be gathered, the marine mammal observers (MMOs) collecting marine mammal data pursuant to the NWTRC Monitoring Plan shall, at a minimum, provide the same marine mammal observation data required in the data required in 50 CFR § 218.115(g)(1). The NWTRC Monitoring Plan Report may be provided to NMFS within a larger report that includes the required Monitoring Plan Reports from multiple Range Complexes.

(f) Annual NWTRC Exercise Report - The Navy shall submit an Annual NWTRC Exercise Report on February 1, 2010 (covering data gathered through December 1, 2010). This report shall contain information identified in 50 CFR § 218.115(g)(1) through (5).

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

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

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

(2) SINKEXs - This section shall include the following information for each SINKEX completed that year:

- (i) Exercise information (gathered for each SINKEX):
  - (A Location
  - (B) Date and time exercise began and ended
  - (C) Total hours of observation by watchstanders before, during, and after exercise
  - (D) Total number and types of rounds expended / explosives detonated
  - (E) Number and types of passive acoustic sources used in exercise
  - (F) Total hours of passive acoustic search time
  - (G) Number and types of vessels, aircraft, etc., participating in exercise
  - (H) Wave height in feet (high, low and average during exercise)
  - (I) Narrative description of sensors and platforms utilized for marine mammal detection and timeline illustrating how marine mammal detection was conducted
- (ii) Individual marine mammal observation (by Navy lookouts) information (gathered for each marine mammal sighting)
  - (A) Location of sighting
  - (B) Species (if not possible, indicate whale, dolphin or pinniped)
  - (C) Number of individuals
  - (D) Whether calves were observed
  - (E) Initial detection sensor
  - (F) Length of time observers maintained visual contact with marine mammal
  - (G) Wave height
  - (H) Visibility
  - (I) Whether sighting was before, during, or after detonations/exercise, and how many minutes before or after
  - (J) Distance of marine mammal from actual detonations (or target spot if not yet detonated) – use four categories to define distance: 1) the

modeled injury threshold radius for the largest explosive used in that exercise type in that OPAREA (1 nm for SINKEX in the NWTRC Range Complex); 2) the required exclusion zone (2 nm for SINKEX in the NWTRC Range Complex); (3) the required observation distance (if different than the exclusion zone (2 nm for SINKEX in the NWTRC Range Complex); and (4) greater than the required observed distance. For example, in this case, the observer would indicate if < TBD m, from TBD m – 1 nm, from 1 nm – 2 nm, and > 2 nm.

(K) Observed behavior – Watchstanders will report, in plain language and without trying to categorize in any way, the observed behavior of the animal(s) (such as animal closing to bow ride, paralleling course/speed, floating on surface and not swimming etc.), including speed and direction.

(L) Resulting mitigation implementation – Indicate whether explosive detonations were delayed, ceased, modified, or not modified due to marine mammal presence and for how long.

(M) If observation of a marine mammal occurs while explosives are detonating in the water, indicate munition type in use at time of marine mammal detection.

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

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

(ii) Total expended/detonated rounds (buoys)

(iii) Total number of self-scuttled IEER rounds

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

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

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

(g) NWTRC 5-yr Comprehensive Report - The Navy shall submit to NMFS a draft report that analyzes and summarizes all of the multi-year marine mammal information gathered during ASW and explosive exercises for which annual reports are required (Annual NWTRC Exercise Reports and NWTRC Monitoring Plan Reports). This report will be submitted at the end of the fourth year of the rule (March 2013), covering activities that have occurred through October 1, 2012.

(h) 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 NWTRC, and the Gulf of Alaska.

(i) The Navy shall respond to NMFS comments and requests for additional information or clarification on the NWTRC Range Complex Comprehensive Report, the Comprehensive National ASW report, the Annual NWTRC Range Complex Exercise Report, or the Annual NWTRC 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.

(j) In 2011, the Navy shall convene a Monitoring Workshop in which the Monitoring Workshop participants will be asked to review the Navy's Monitoring Plans and monitoring results and make individual recommendations (to the Navy and NMFS) of ways of improving the Monitoring Plans. The recommendations shall be reviewed by the Navy, in consultation with NMFS, and modifications to the Monitoring Plan shall be made, as appropriate.

2.0 Approach to the Assessment

2.1 Overview of NMFS' Assessment Framework

NMFS uses a series of sequential analyses to assess the effects of federal actions on endangered and threatened species and designated critical habitat. The first analysis identifies those physical, chemical, or biotic aspects of proposed actions that are likely to have individual, interactive, or cumulative direct and indirect effect on the environment (we use the term "potential stressors" for these aspects of an action). As part of this step, we identify the spatial extent of any potential stressors and recognize that 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 of our analyses starts by 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 we conclude that such co-occurrence is likely, we then try to estimate the nature of that co-occurrence (these represent our *exposure analyses*). In this step of our analyses, 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 effects 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[1] to determine whether and how those listed resources are likely to respond given their exposure (these represent our *response analyses*). 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*).

RISK ANALYSES FOR ENDANGERED AND THREATENED SPECIES. Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of listed species depends on the fate of the populations

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[1] Although section 7(a)(2) of the Endangered Species Act of 1973, as amended, requires us to use the best scientific and commercial data available, at this stage of our analyses, we consider all lines of evidence. We summarize how we identify the "best scieitific and commercial data available" in a subsequent subsection titled "Evidence Available for the Consultation"

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

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

We measure risks to listed individuals using the individual's current or expected future reproductive success which integrates survival and longevity with current and 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 individual produce during any reproductive bout, reducing 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, 2000, 2002; Clutton-Brock 1998, Coulson *et al*. 2006, Crowe *et al*. 2004, Fox and Gurevitch 2000, Kotiaho *et al*. 2005, McGraw and Caswell 1996, Newton and Rothery 1997, Oli and Dobson 2003, Reed 2005, Roff 2002, Stearns 1992, Turchin 2003).

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 Stearns 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, Stearns 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 are 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 (= probability of demographic, ecological, or genetic extinction) of the population(s) those individuals represent. Here "significant" also means "clinically or biotically significant" rather than statistically significant.

For "species" (the entity that has been listed as endangered or threatened, not the biological species concept), we are concerned about whether the number of populations that 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.

RISK ANALYSES 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[2]. 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*

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

natural environment, we ask if primary or secondary constituent elements included in the designation (if there are any) or physical, chemical, or biotic phenomena that give the designated area value for the conservation are likely to respond to that exposure.

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

If primary or secondary 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.

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

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

If the conservation value of designated critical habitat in an action area is reduced, the final step of our analyses ask 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, that limited value is our point of reference for our assessment.

2.2 Application of this Approach in this Consultation

The primary stressors associated with the military readiness activities the U.S. Navy proposes to conduct in waters on and adjacent to the Northwest Training Range Complex and the Keyport Range Complex consist of:

1. sound fields produced by the active sonar systems the U.S. Navy would employ during the training activities it proposes;
2. shock waves produced by the underwater detonations the U.S. Navy would employ;
3. sound fields produced by the underwater detonations the U.S. Navy would employ;
4. projectiles associated with firing operations;
5. disturbance produced by the vessels involved in military readiness activities; and
6. the risk of collisions associated with proximity to the vessels involved in those military readiness activities.

The first step of our 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.

2.2.1 Exposure Analyses

As discussed in the introduction to this section of this Opinion, exposure analyses are designed to identify the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence. Our exposure analyses 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 generally relies on an action agency's estimates of the number of marine mammals that might be "taken" (as that term is defined for the purposes of the MMPA). In a small number of consultations, however, NMFS has conducted separate analyses to estimate the number of endangered or threatened marine animals that might be exposed to stressors produced by a proposed action to assess the effect of assumptions in an action agency's model on model estimates. For example, NMFS used a model based on components of Hollings' disc equation (1959) to independently estimate the number of marine mammals that might be exposed to U.S. Navy training activities in a few recent consultations that satisfied the following conditions:

1 the sole or primary stressor was hull-mounted mid-frequency active sonar and

2 data were available on (2a) the density of endangered or threatened animals in an action area, (2b) the ship's speed, (2c) the radial distance at which different received levels would be detected from a source given sound speed profiles, and (2d) the duration of specific training exercises.

These conditions have been met in five of the 23 consultations NMFS has completed on U.S. Navy training since 2002 (for example, opinions on anti-submarine warfare training on the U.S. 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. We could not meet the second condition for the Keyport Range Complex, so we relied on the U.S. Navy's estimates of the number of marine mammals that might be "taken" for our assessment. We could meet both conditions for the Northwest Training Range Complex; however, we consider and present the results of two different 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 method the U.S. Navy used to develop the "take" (as that term is defined pursuant to the MMPA) estimates that were necessary to apply for an authorization to take marine mammals incidental to training activities pursuant to the MMPA and for the effects analyses in the Environmental Impact Statement the U.S. Navy and NMFS' Permits Division prepared for activities the U.S. Navy proposes to conduct in the Northwest Training Range Complex. The incidental "take" the Permits Division proposes to authorize in the proposed 5-year regulations reflect these "take" estimates; and
2. an exposure model NMFS' Endangered Species Division developed 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 activities the U.S. Navy proposes to conduct in the Northwest Training Range Complex (the data necessary to estimate the number of sea turtles that might be exposed to active sonar was not available).

The approach the U.S. Navy and the Permits Division developed 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 their exposure to active sonar or underwater detonations during training activities. Those estimates are a subset of the number of animals that might be exposed to active sonar and a subset of the animals that might respond given exposure, because some responses would not represent "take." As a result, the "take" estimates produced by the U.S. Navy and the Permits Division are not comparable to the exposure estimates we produced using the second approach, although the two approaches might produce similar numbers.

1. U.S. NAVY EXPOSURE ESTIMATES FOR PROPOSED ACTIONS IN THE NORTHWEST TRAINING RANGE COMPLEX. Over the past year, the U.S. Navy updated its approach to estimating the number of marine

mammals that might be exposed to the activities the U.S. Navy plans to conduct on the Northwest Training Range Complex over the five-year period beginning in June 2010. 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; U.S. Navy 2009).

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 the number of marine mammals that would be "taken," the U.S. Navy and NMFS' Permits Division estimated the proportion of a population that is expected to exhibit behavioral response using 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.* 2001, 2003, 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, Department of the Navy 2003), and (3) a suite of studies of the response of baleen whales to low-frequency sound sources (Nowacek *et al.* 2004).

This approach would 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.

2. NMFS' EXPOSURE ESTIMATES USING COMPONENTS OF HOLLING'S DISC EQUATION. Although the models the U.S. Navy used probably overestimates the number of marine mammals that might be "taken" (as that term is defined by the MMPA) by active sonar and underwater detonations, particularly as a result of either noise-induced hearing loss (temporary or permanent threshold shifts) or a broad category of behavioral responses. However, 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 results 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."

As discussed earlier in this section of this Opinion, 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, $N = D \bullet A$ (Buckland *et al.* 1993, 2001), where, for the purposes of our analyses, A is the total area that would be ensonified by active sonar or contained within the shock wave or sound field produced by an underwater detonation.

We relied on published sources of information and information contained in the U.S. Navy's Environmental Impact Statement on the Northwest Training Range Complex (which itself relies on published sources) to estimate the density (D) of endangered and threatened marine mammals in waters off the Pacific Northwest, then we relied on a component of an established ecological model developed by Holling (1959) to estimate A or the ensonified area. Holling (1959) studied predation of small mammals on pine sawflies and found that predation rates increased with increasing densities of prey populations. In that paper, Holling proposed a model that is commonly called the "disc equation" because it describes the path of foraging predators as a moving disc that represents the predator's sensory field (normally with two-dimensions) as it searches for prey (see Figure 1). Although, Holling developed what is commonly called "the disc equation" to describe a predator's functional response to prey densities, a component of his equation estimates the number of prey a predator is likely to encounter during a foraging bout. This component of the disc equation combines the predator's speed (s; units are distance/time), the diameter of the predator's sensory field ($2r$; units are distance; here we use nautical miles), and the time the predator spends searching for prey (T_s; units are distance) to estimate the area searched by a predator (the units (distance/time)(distance)(time) = $(\text{distance})^2$ = area). Because a predator is not likely to detect all prey within an area, a "detectability" variable (denoted *k;* which ranges from 0.0 to 1.0) expresses this limitation. This produces the equation

$$\text{No. prey encountered} = [k(s \bullet 2r \bullet T_s)] \bullet \text{“prey” per unit area}$$

The first component of this equation ($s \bullet 2r \bullet T_s$) provides the ensonified area which, when multiplied by animal density ("prey" per unit area), provides an estimate of the number of animals in an area (Buckland *et al.* 1993, 2001). From this equation, it is easy to see that increasing a predator's speed increases the area the predator searches and, therefore, the number of prey a predator would encounter. Similarly, increasing the detectability of prey or the prey density (number of prey per unit area) would increase the number of "prey" a predator would encounter.

NMFS adapted this component of the Holling's disc equation by treating Navy vessels as the "predators" in the model whose sensory field ($2r$, in square kilometers) represented the sound field of an active sonar system and speed (s) represented 10 knots, and whose search time represented the duration of an exercise (in hours). We treated the different species of endangered or threatened marine mammals as "prey." We assumed the "detectability" of marine animals reflected the amount of time a marine mammal would spend at depths that would bring them into the sound field of an active sonar system (in the case of whales), the amount of time a marine mammal would occur in a "sonar shadow" created by one of the islands (for example, humpback whales that occur in the Maui basin), or the amount of time a pinniped spent in the water (in this case, Guadalupe fur seals). This left us with the equation

$$\text{No. individuals encountered} = [k(s \cdot 2r \cdot T_s)] \cdot \text{density of marine mammal species}$$

For our analyses, we used density estimates for marine mammals that represented the seasons and geographic areas we considered in our models when those data were available.

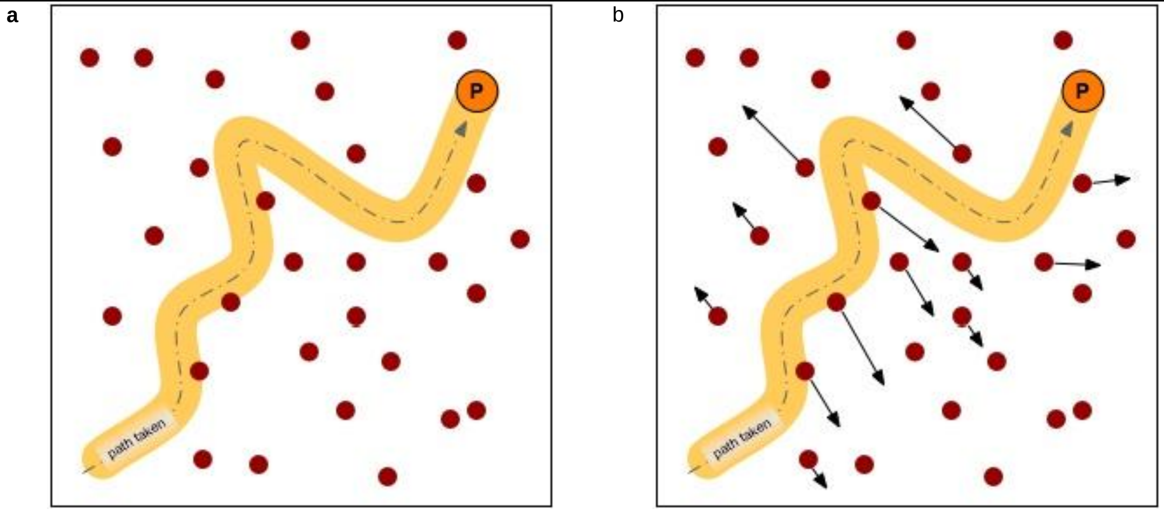

Figure 1. A representation of Hollings disc equation with a predator (denoted P) moving on a path (dashed line) through a field of potential prey (smaller circles). The thick orange line surrounding the predator's path represents the predator's sensory radius; increasing the size of this sensory radius increases the width of the area search per unit time. Similarly, assuming that everything else is equal, increasing a predator's speed would also increase the area the predator searches in a unit of time. The number of prey a predator encounters on a path = (the area searched)(prey density) = (search velocity)(sensory diameter)(time spent searching)(prey density). **Figure 1a** illustrates a situation in which prey do not try to avoid a predator. **Figure 1b** illustrates a situation in which prey actively try to avoid a predator. The exposure models NMFS developed simulated prey avoidance by reducing prey density along a predator's path over time. See text for further explanation.

We used this model to develop and simulate one scenario for this consultation: a scenario that assumed that marine mammal densities never changed and that individual animals did not move during the course of an exercise (this is the closest approximation of the U.S. Navy's models). We developed, but did not use, two other scenarios for this consultation. The first scenario we considered but did not use assumed that marine mammals would try to avoid exposure to active sonar transmissions (for a review of literature supporting this assumption, see *Behavioral Avoidance* in the Response Analyses that we present later in this Opinion), but the data necessary on the rate at which whale densities would change in response to initial or continued exposure or when training activities would actually occur were not available for this consultation so we could reach conclusions based on this scenario. The second we considered but did not use captured temporal changes in animal densities, but the information on the actual timing of the different training activities were not available for this consultation so we could not reach conclusions based on this scenario. As a result, although we developed and considered alternative exposure scenarios for this consultation, we only report the results of one of those exposure scenarios.

The exposure model we developed assumed ship speeds of 10 knots (or 18.25 kilometers per hour), which is the same assumption contained in the Navy's models. The "sensory field" (2r) 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 Environmental Impact Statements for the Northwest Training Range Complex, adjusted to eliminate overlap (U.S. Navy 2009). 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.

2.2.2 Response Analyses

As discussed in the introduction to this section of this Opinion, 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 (Figure 2). Prior to this consultation, we made several major changes to the conceptual model that forms the foundation for our response analyses. First, we constructed our revised model on a model of 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. As a result, 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 conception of "hearing" to include cognitive processing of auditory cues, rather than 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 as 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).

Like our earlier conceptual models (presented in Southall *et al* 2008), this conceptual model begins with acoustic stimuli we focus on in an assessment (Box 1 in Figure 2). In this case, we treat the active sonar and any shock waves or sound fields associated with underwater detonations as separate focal stimuli. The preceding section of our *Approach* described how we estimated the number of animals that are likely to be exposed to those acoustic stimuli associated with the proposed training activities and the nature of that exposure.

The stressors that would be associated with the training activities the U.S. Navy proposes to conduct at the Keyport Range Complex and Northwest Training Range Complex consist of two classes: *processive stressors*, which require high-level cognitive processing of sensory information, and *systemic stressors*, which usually elicit direct physical or physiological responses and, therefore, do not require high-level cognitive processing of sensory information (Anisman and Merali 1999, de Kloet *et al*. 2005, Herman and Cullinan 1997). Disturbance from surface vessels and active sonar would be examples of processive stressors while ship strikes and shock waves associated with underwater detonations would be examples of systemic stressors (the sound field produced by an underwater detonation would be a systemic stressor close to the explosion and a processive stressor further away). As a result, exposures resulting from the proposed training exercises are likely to result in two general classes of responses:

1. responses that are influenced by an animal's assessment of whether a potential stressor poses a threat or risk (see Figure 2: Behavioral Response).
2. responses that are not influenced by the animal's assessment of whether a potential stressor poses a threat or risk (see Figure 2: Physical Damage).

Unlike our earlier conceptual model, our revised model explicitly acknowledges the existence of other acoustic and non-acoustic stimuli in an animal's environment that might diminish the focal stimulus' salience (the line connecting Box 2b. to Box 2) or that might compete for the animal's finite attentional resources, which would affect the salience of the focal stimulus as perceived by the animal (the line connecting Box 2b to Box B1)[3]. Absent information to the contrary, our assessment assume the focal stimulus remains salient regardless of competing stimuli and the limited attentional resources of animals. By extension, we assume that any behavioral change we might observe in an animal would have been caused by the focal stimulus rather than competing stimuli.

If we conclude (or if we assume) that an acoustic stimulus, such as mid-frequency active sonar, was salient, we would then ask how an animal might classify the stimulus as a cue about its environment (Box B2) because an animal's response to a stimulus in its environment will depend upon whether and how the animal converts the stimulus into some information about its environment (Blumstein and Bouskila 1996, Yost 2007). For example, if an animal classifies a stimulus as a "predatory cue," that classification will invoke a suite of candidate physical, physiological, or behavioral responses that are appropriate to being confronted by a predator (this would occur regardless of whether a predator is, in fact, present).

Our revised conceptual model departs from our earlier model and models advanced by the U.S. Navy and others by adopting a more expansive concept of "hearing." Other conceptions of the sensory modality that

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[3] see Blumstein and Bouskila (1996) for more extensive reviews of the literature on how animals process and filter sensory information, which affects the subjective salience of sensory stimuli. See Crick (1984), Dukas (2002), Dukas and Real (19993), and Roitblat (1987) for more extensitve reviews of the literature on attentional processes and the consequences of limited attentional resources.

we call “hearing” have focused on the the mechanical processes associated with structures in the ear that transduce sound pressure waves into vibrations and vibrations to electro-chemical impulses. That conception of hearing resulted in assessments that focus exclusively on active sonar while discounting other acoustic stimuli associated with U.S. Navy training activities that marine animals might also perceive as relevant. That conception of hearing also led to an almost singular focus on the intensity of the sound ─ its received level (in decibels) ─ as an assessment metric and noise-induced hearing loss as an assessment endpoint. Among other considerations, that focus fails to recognize that animals will tend to treat sounds as environmental cues (a stimulus that provides information about an animal’s environment); that animals have to decide which environmental cues they will focus on given that their ability to process those cues is limited; that animals can distinguish not only perceive received levels, they also perceive their distance from a sound source; that both received levels and the spectral qualities of sounds degrade over distance so the sound perceived by a distant received is not the same sound at the source; that animals are more likely to devote attentional resources to those environmental cues that are proximate than cues that are distant.

Our revised conceptual model expands the conception of “hearing” to include a mechanical-cognitive-perceptual processes. That is, it includes the mental processes an animal employs when it analyzes acoustic impulses (see Bregman 1990, Blumstein and Bouskila 1996, Hudspeth 1997, Yost 2007), which includes the processes animals employ to integrate and segregate sounds and auditory streams and the circumstances under which they are likely to devote attentional resources to an acoustic stimulus. As a result of this shift in focus, we have to consider more than the received level of a particular low- or mid-frequency wave form and its effects on the sensitivity of an animal’s ear structure, we also have to distinguish between different auditory scenes; for example, animals will distinguish between sounds from a source that is moving away versus a sound produced by a source that is approaching them, sounds from multiple sources that are all approaching, and sounds from multiple sources that appear to be moving at random, etc

Animals would then combine their perception of the acoustic stimulus with their assessment of the auditory scene (which include other acoustic stimuli), their awareness of their behavioral state, physiological state, reproductive condition, and social circumstances to assess whether the acoustic stimulus poses a risk and the degree of risk it might pose, whether it is impairing their ability to communicate with conspecifics, whether it is impairing their ability to detect predators or prey, etc. We assume that animals would classify an acoustic source differently if the source is moving towards its current position (or projected position), moving away from its current position, moving tangential to its current position, if the source is stationary, or if there are multiple acoustic sources it its auditory field.

This process of “classifying a stimulus” (Box B2) lends meaning to a stimulus and places the animal in a position to decide whether and how to respond to the stimulus (Blumstein and Bouskila 1996). How an animal classifies a stimulus will determine the set of candidate responses that are appropriate. That is, we assume that animals that classified a stimulus as a “predatory cue” would invoke candidate responses that consisted of anti-predator behavior rather than foraging behavior (Bejder *et al*. 2009, Blumstein and Bouskila 1996). We then assume that animals apply one or more behavioral decision rules to the set of candidate responses that are appropriate to the acoustic stimulus as it has been classified (Box B3).

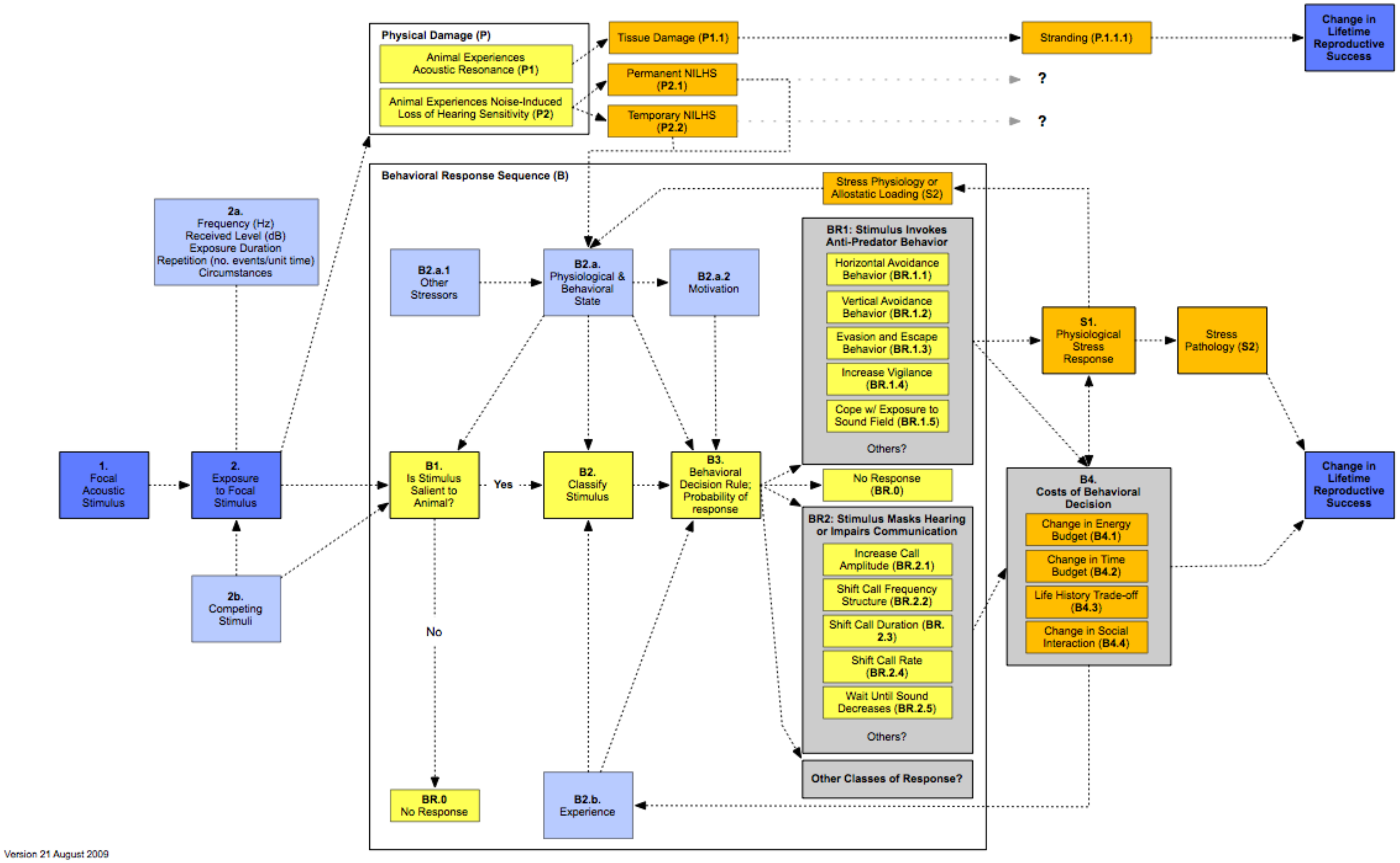

Figure 2. Conceptual model of the potential responses of endangered and threatened species upon being exposed to active sonar and the pathways by which those responses might affect the fitness of individual animals that have been exposed. See text in "Application of this Approach" and "Response Analyses" for an explanation of the model and supporting literature.

Our use of the term “behavioral decision rule” follows Blumstein and Bouskila (1996), Dill (1987), McFarland (1987), and Lima and Dill (1990) and is synonymous with the term “behavioral policy” of McNamara and Houston (1986): the process an animal applies to determine which specific behavior it will select from the set of behaviors that are appropriate to the auditory scene, given its physiological and behavioral state when exposed and its experience. Because we would never know the behavioral policy of an individual, free- ranging animal, we treat this policy as a probability distribution function that matches the vector of candidate behavioral responses.

Once an animal selects a behavioral response from a set of candidate behaviors, we would assume that any change in behavior would represent a shift from an optimal behavioral state (or behavioral act) to a sub-optimal behavioral state (or behavioral act) and that the selection of the sub-optimal behavioral state or act would be accompanied by *canonical costs*, which are reductions in the animal’s expected future reproductive success that would occur when an animal engages in suboptimal behavioral acts (McNamara and Houston 1986). Specifically, canonical costs represent a reduction in current and expected future reproductive success (which integrates survival and longevity with current and future reproductive success) that would occur when an animal engages in a sub-optimal rather than an optimal sequence of behavioral acts; given the pre-existing physiological state of the animal in a finite time interval (Barnard and Hurrst 1996, Houston 1993, McFarland and Sibly 1975, McNamara 1993, McNamara and Houston 1982, 1986, 1996; Nonacs 2001). Canonical costs would generally result from changes in animals’ energy budgets (McEwen and Wingfield 2003, Moberg 2000; Romero 2004, Sapolsky 1990, 1997), time budgets (Frid and Dill 2002, Sutherland 1996), life history trade-offs (Cole 1954, Stearns 1992), changes in social interactions (Sutherland 1996), or combinations of these phenomena (see Box B4 of Figure 2). We assume that an animal would not incur a canonical cost if they adopted an optimal behavioral sequence (see McNamara and Houston 1986 for further treatment and discussion).

This conceptual model does not require us to assume that animals exist in pristine environments; in those circumstances in which animals are regularly or chronically confronted with stress regimes that animals would adapt to by engaging in sub-optimal behavior, we would assume that a change in behavior that resulted from exposure to a particular stressor or stress regime would either contribute to their sub-optimal behavior or would force them to engage in behavior that is even further from optimal.

We used Bayesian analysis to estimate the probability of one or more of the proximate responses identified in Figure 2 given an exposure event from the data that were available. Bayes rule (also called Bayes’ theorem) calculates the probability of an event given prior knowledge of the event’s probability using the equation

$$\mathrm{Prob}(R_i|D) = [\Pr(D|R_i) \times \Pr(R_i)]/\Sigma[\Pr(D|R_j) \times \Pr(R_j)]$$

Where *R* represents the set of mutually exclusive and exhaustive physical, physiological, and behavioral responses (candidate responses) to an exposure with probabilities, $\Pr(R_i)$, $\Pr(R_j)$ represents alternatives to that particular response, and D represents the data on responses. In this formulation, $\Pr(R_i)$ in the numerator, represents the prior probability of a response which we derived from (1) the number of reports in the literature, that is, the number of papers that reported a particular response (here we distinguished between the number of reports for all cetaceans, the number of reports for all odonotocetes, and the number of reports for all mysticetes) and (2) an uninformed prior, which assumed that all responses that had non-zero values were equally probable.

To apply this procedure to our response analyses, we formed the set of candidate responses identified in Figure 2 (see Table 2). Then we identified the number of instances in which animals were reported to have exhibited one or more of those proximate responses based on published studies or studies available as gray literature. 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. We used the resulting posterior probabilities to identify the kind of responses that would be represented by the "take" estimates that were produced by the models the U.S. Navy and the Permits Division used.

Table 2. Grouping of proximate responses (identified in Figure 2) into categories for response analyses

	Proximate Response	Grouping for Bayesian Analyses
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

2.2.3 Risk Analyses

As discussed in the Introduction to this section, the final steps of our analyses — establishing the risks those responses pose to endangered and threatened species or designated critical habitat — normally begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individuals risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the concept of current or expected future reproductive success which, as we described in the preceding sub-section, .integrates survival and longevity with current and 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 individual produce during any reproductive bout, reducing the number of times an individual is likely to reproduce over the reproductive lifespan (in animals that reproduce multiple times), or causing an individual's progeny to experience any of these phenomena.

When individual plants or animals would be expected to experience reductions in their current or expected future reproductive success, we would also 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 Stearns 1992). If we conclude that listed plants or animals are *not* likely to experience reductions in their current or expected future reproductive success, we would conclude our assessment.

If we conclude that listed plants or animals are likely to experience reductions in their current or expected future reproductive success, we would integrate those individuals risks to determine if the number of individuals that experience reduced fitness (or the magnitude of any reductions) is 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 a population's probability of becoming demographically, ecologically, or genetically extinct in 10, 25, 50, or 100 years). For this step of our analyses, we would rely on the population's base condition (established in the *Environmental Baseline* and *Status of Listed Resources* sections of this Opinion) as our point of reference.

Our risk analyses normally conclude by determining whether changes in the viability of one or more population is or is not likely to be sufficient to reduce the viability of the species (measured using probability of demographic, ecological, or genetic extinction in 10, 25, 50, or 100 years) those populations comprise. For these analyses, we combine our knowledge of the patterns that accompanied the decline, collapse, or extinction of populations and species that have experienced these phenomena in the past as well as a suite of population viability models.

Our assessment is designed to establish that a decline, collapse, or extinction of an endangered or threatened species is not likely to occur; we do not conduct these analyses to establish that such an outcome is likely to occur. For this step of our analyses, we would also use the species' status (established in the *Status of the Species* section of this Opinion) as our point of reference.

2.3 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 (for example, Abgrail *et al.* 2008, Bowles *et al.* 1994; Croll *et al.* 1999, 2001; Frankel and Clark 1998; Gisiner 1998, McCauley and Cato 2001; NRC 1994 1996, 2000, 2003, 2005; Norris 1994; Reeves 1992, Richardson *et al.* 1995, Southall *et al*. 2007, Tyack 2000, 2007; Wright *et al.* 2007).

To supplement that body of knowledge, we conducted electronic literature searches using the Library of Congress' *First Search* and *Dissertation Abstracts* databases, SCOPUS, *Web of Science*, and Cambridge Abstract's *Aquatic Sciences and Fisheries Abstracts* (ASFA) database services. The *First Search* databases provide access to general biological literature, master's theses, and doctoral dissertations back to 1980; ASFA provides access to journal articles, magazine articles, and conference proceedings back to 1964. 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*, *Journal of Zoology*, *Marine Mammal Science*), sea turtles (*Copeia*, *Herpetologia*, *Journal of Herpetology*), ecology (*Ambio*, *Bioscience*, *Journal of Animal Ecology*, *Journal of Applied Ecology*, *Journal of the Marine Biological Association of the UK*, *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, Behavioral Ecology and Sociobiology, Ethology*). We manually searched issues of the *Journal of Cetacean Research and Management* and *Reports of the International Whaling Commission*.

Our prior experience demonstrated that electronic searches produce the lowest number of false positive results (references produced by a search that are not relevant) and false negative results (references not produced by a search that are relevant) if we use paired combinations of the keywords: sonar, mid-frequency sonar, acoustic, marine acoustic, military exercises, sound, and noise paired with the keywords cetacean, dolphin, marine mammal, pinniped, porpoise, sea turtle, seal, and whale. To expand these searches, we modified these keyword pairs with the keywords effect, impact, mortality event, response, behavior (including the spelling "behaviour" as well as "behavior"), stranding, unusual mortality event. To collect data for our exposure analyses, we used the keyword: encounter rate paired with marine mammal, cetacean, and whale.

We supplemented the results of these electronic searches by acquiring all of the references we had gathered that, based on a reading of their titles or abstracts, appeared to comply with the keywords presented in the preceding paragraph. If a reference's title did not allow us to eliminate it as irrelevant to this inquiry, we acquired it. We continued this process until we gathered all (100 percent) of the relevant references cited by the introduction and discussion sections of the relevant papers, articles, books, and, reports and all of the references cited in the materials and methods, and results sections of those documents. We did not conduct hand searches of published journals for this consultation. We organized the results of these searches using commercial bibliographic software.

To supplement our searches, we examined the literature that was cited in documents and any articles we collected through our electronic searches. If, based on a reading of the title or abstract of a reference, the reference appeared to comply with the keywords presented in the preceding paragraph, we acquired the reference. If a reference's title did not allow us to eliminate it as irrelevant to this inquiry, we acquired it. We continued this process until we identified all (100 percent) of the relevant references cited by the introduction and discussion sections of the relevant papers, articles, books, and, reports and all of the references cited in the materials and methods, and results sections of those documents. We did not conduct hand searches of published journals for this consultation. We organized the results of these searches using commercial bibliographic software.

From each document, we extracted the following: when the information for the study or report was collected, the study design, which species the study gathered information on, the sample size, acoustic source(s) associated with the study (noting whether it was part of the study design or was correlated with an observation), other stressors associated with the study, study objectives, and study results, by species. We estimated the probability of responses from the following information: the known or putative stimulus; exposure profiles (intensity, frequency, duration of exposure, and nature) where information is available; and the entire distribution of responses exhibited by the individuals that have been exposed. Because the response of individual animals to stressors will often vary with time (for example, no responses may be apparent for minutes or hours followed by sudden responses and vice versa) we also noted any temporal differences in responses to an exposure.

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 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).

2.4 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 U.S. Navy's use of active sonar failed to consider the "cumulative impact" (in the NEPA sense of the term) of active sonar on the ocean environment and its organisms, particularly endangered and threatened species and critical habitat that has been designated for them (for example, see NRDC 2007 and Ocean Mammal Institute 2007). 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).

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 syneristic 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 being our assessments by either qualitatively or quantitatively accumulate 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.

2.5 **Action Area**

The action area for this biological opinion encompasses waters within and adjacent to the U.S. Navy proposes to conduct in waters on and adjacent to the Northwest Training Range Complex and the Keyport Range Complex (see Figures 1, 2, and 3). The Keyport Range Site is located in Kitsap County and includes portions of Liberty Bay and Port Orchard Reach (also known as the Port Orchard Narrows). The Dabob Bay Range Complex is located in Hood Canal and Dabob Bay, in Jefferson and Kitsap counties. The Quinault Underwater Tracking Range is located in the Pacific Ocean off the coast of Jefferson County.

The Northwest Training Range Complex consists of two primary components: the Offshore Area and the Inshore Area (see Figures 4 and 5). 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 Ccomplex 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[1], 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.

3.0 Status of Listed Resources

NMFS has determined that the following species and critical habitat designations may occur in this action area for the readiness activities the U.S. Navy proposes to conduct in the Northwest Training Range Complex and the Keyport Range Complex:

Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
North Pacific right whale	*Eubalaena japonica*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Southern resident killer whale	*Orcinus orca*	Endangered
Steller sea lion (eastern population)	*Eumetopias jubatus*	Threatened
Green sea turtle	*Chelonia mydas*	Threatened
		Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Loggerhead sea turtle	*Caretta caretta*	Threatened
Olive ridley sea turtle	*Lepidochelys olivacea*	Threatened
		Endangered
Bocaccio	*Sebastes paucispinus*	Endangered
Canary rockfish	*Sebastes pinniger*	Threatened
Yelloweye rockfish	*Sebastes ruberrimus*	Threatened
Green sturgeon	*Acipenser medirostris*	Threatened
Pacific eulachon (southern population)	*Thaleichthys pacificus*	Threatened
Chinook salmon (Puget Sound)	*Oncorhynchus tshawytscha*	Threatened
Chinook salmon (Lower Columbia River)		Threatened
Chinook salmon (California Costal)		Threatened
Chum salmon (Columbia River)	*Oncorhynchus keta*	Threatened
Chum salmon (Hood Canal summer run)		Threatened
Coho salmon (Central California Coast)	*Oncorhynchus kisutch*	Endangered
Coho salmon (Lower Columbia River)		Threatened
Coho salmon (Oregon Coast)		Threatened
Coho salmon (Southern Oregon Northern Coastal California)		Threatened
Steelhead (Lower Columbia River)	*Onchorynchus mykiss*	Endangered

Steelhead (Northern California)	Threatened
Steelhead (Central California Coastal)	Threatened
Steelhead (Puget Sound)	Threatened

Critical Habitat

Southern resident killer whales	portions of the north Pacific Ocean and Puget Sound
Steller sea lion (eastern population)	portions of the eastern north Pacific Ocean
Green sturgeon (southern population)	
Chinook salmon (Puget Sound)	portions of the eastern north Pacific Ocean
Chinook salmon (Lower Columbia River)	
Chinook salmon (California Costal)	
Chum salmon (Columbia River)	
Chum salmon (Hood Canal summer run)	
Coho salmon (Central California Coast)	
Coho salmon (Southern Oregon Northern Coastal California)	
Steelhead (Lower Columbia River)	
Steelhead (Northern California)	
Steelhead (Central California Coast)	

3.1 Species and Critical Habitat Not Considered Further in this Opinion

As described in the *Approach to the Assessment* section of this Opinion, NMFS uses two criteria to identify those endangered or threatened species or critical habitat that are not likely to be adversely affected by the activities the U.S. Navy proposes to conduct in waters on and adjacent to the Keyport Range Complex and the Northwest Training Range Complex. The first criterion was *exposure* or some reasonable expectation of a co-occurrence between one or more potential stressor associated with the U.S. 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 U.S. Navy's activities, we must also conclude that the listed species or designated critical habitat are not likely to be affected by those activities.

The second criterion is the probability of a *response* given exposure. For endangered or threatened species, we consider the *susceptibility*:of the species that may be exposed; for example, species that are exposed to sound field produced by active sonar, but are not likely to exhibit physical, physiological, or behavioral responses given that exposure (at the combination of sound pressure levels and distances associated with an exposure) are also not likely to be adversely affected by the sonar. For designated critical habitat, we consider the *susceptibility* of the constituent elements or the physical, chemical, or biotic resources whose quantity, quality, or availability make the designated critical habitat valuable for an endangered or threatened species. If we conclude that 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 a stressor and a stressor is not likely to exclude listed individuals from designated critical habitat, we would conclude that the stressor may affect, but is not likely to adversely affect the designated critical habitat.

We applied these criteria to the species listed at the beginning of this section; this subsection summarizes the results of those evaluations.

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.

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, Green *et al*. 1992, Macaskie and Forrester 1962), 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.

LOGGERHEAD SEA TURTLE. Loggerhead sea turtles occur along the coasts of British Columbia and the States of Washington, Oregon, and northernmost California (Bowlby *et al*. 1994, Green *et al*. 1992, Macaskie and Forrester 1962), 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.

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 (Bowlby *et al*. 1994, Green *et al*. 1992, Macaskie and Forrester 1962), 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 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.

GEORGIA BASIN BOCACCIO. The Bocaccio that occur in the Georgia Basin are listed as an endangered "species," which, in this case, means a distinct population segment (74 Federal Register 18516). 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.

Georgia Basin bocaccio would not be exposed to most of the training activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex because, with the exception of 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.

The distribution of Georgia Basin bocaccio overlaps with the locations the U.S. Navy's underwater detonation sites in Puiget 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). At those depths, Georgia Basin bocaccio are not likely to be exposed to pressure waves or sound field produced by the 2.5-pound charges the U.S. Navy proposes to use during mine countermeasures training. As a result, we conclude that Georgia Basin bocaccio 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.

GEORGIA BASIN CANARY ROCKFISH. Canary rockfish that occur in the Georgia Basin are listed as a threatened "species" (74 Federal Register 18516). The listing includes canary rockfish 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.

Like bocaccio, Georgia Basin canary rockfish would not be exposed to most of the training activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex because, with the exception of 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.

The distribution of Georgia Basin canary rockfish overlaps with the locations the U.S. Navy's underwater detonation sites in Puiget 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 canary rockfish primarily inhabit waters 50 to 250 meters (160 and 820 feet) deep and may occur at depths of 425 meters (1,400 feet). At those depths, Georgia Basin canary rockfish are not likely to be exposed to pressure waves or sound field produced by the 2.5-pound charges the U.S. Navy proposes to use during mine countermeasures training. As a result, we conclude that Georgia Basin canary rockfish 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.

GEORGIA BASIN YELLOWEYE ROCKFISH. The yelloweye rockfish that occur in the Georgia Basin are listed as a threatened “species” (74 Federal Register 18516). The listing includes yelloweye rockfish 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 (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.

Like bocaccio and canary rockfish, Georgia Basin yelloweye rockfish would not be exposed to most of the training activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex because, with the exception of 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.

Like the two rockfish we have just discussed, the distribution of Georgia Basin yelloweye rockfish overlaps with the locations the U.S. Navy’s underwater detonation sites in Puiget 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 yelloweye rockfish primarily inhabit waters that are 91 to 180 meters deep (300 to 580 feet), but they may occur in waters 50 to 475 meters (160 and 1,400 feet) deep. At those depths, Georgia Basin yelloweye rockfish are not likely to be exposed to pressure waves or sound field produced by the 2.5-pound charges the U.S. Navy proposes to use during mine countermeasures training. As a result, we conclude that Georgia Basin yelloweye rockfish 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 FOR SOUTHERN RESIDENT KILLER WHALES. Critical habitat that has been designated for southern resident killer whales 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 latutide 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. kongitude; (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 does not include waters offshore of the Washington coast, Hood Canal or Dabob Bay, the Keyport Range Complex, Sinclair Inlet (near Bremerton), Ostrich Bay and Oyster Bay, portions of Whidbey Island and Navy Operating Area 3 (north and west of Whidbey Island). However, the proposed expansion of the Keyport Range Complex includes ares that have been designated as critical habitat for southern resident killer whales. As a result, we assume that these portions of critical habitat would be exposed to the research, development, test, or evaluation activities the U.S. Navy proposes to conduct on the Keyport Range Complex (or the Quinault Underwater Tracking Range, Dabob Bay Range Complex, Hood Canal operating areas, or the Keyport units of the Range Complex).

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 Keyport or Northwest Training Range Complexes and these stressors are not likely to exclude southern resident killer whales from designated critical habitat, so those activities may affect, but 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.

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 basepoint 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 Keyport 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 Keyport Range Complex. Therefore, the activities the U.S. Navy proposes to conduct on the Keyport Range Complex are not likely to affect critical habitat that has been designated for the eastern population of Steller sea lions.

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.

CRITICAL HABITAT FOR GREEN STURGEON (SOUTHERN POPULATION). 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 Keyport or Northwest Training Range Complexes 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 Keyport or Northwest Training Range Complexes may affect, but 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.

CRITICAL HABITAT FOR CHINOOK SALMON (PUGET SOUND). NMFS designated critical habitat for Puget Sound Chinook salmon on September 2, 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 bankfull 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 Keyport or Northwest Training Range Complexes 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 Keyport or Northwest Training Range Complexes may affect, but 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.

CRITICAL HABITAT FOR CHINOOK SALMON (LOWER COLUMBIA RIVER). 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 Keyport or Northwest Training Range Complexes 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 Keyport or Northwest Training Range Complexes may affect, but 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.

CRITICAL HABITAT FOR CHINOOK SALMON (CALIFORNIA COSTAL). NMFS designated critical habitat for California coastal chinook salmon 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, 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 California coastal chinook salmon 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.

In total, California Coastal Chinook salmon occupy 45 watersheds (freshwater and estuarine). The total area of habitat designated as critical includes about 1,500 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 45 watershed reviewed in NMFS' assessment of critical habitat for California coastal chinook salmon, eight watersheds received a low rating of conservation value, 10 received a medium rating, and 27 received a high rating of conservation value for the species.

Critical habitat for California coastal chinook salmon consists of limited quantity and quality summer and winter rearing habitat, as well as marginal spawning habitat. Compared to historical conditions, there are fewer pools, limited cover, and reduced habitat complexity. The limited instream cover that does exist is provided mainly by large cobble and overhanging vegetation. Instream large woody debris, needed for foraging sites, cover, and velocity refuges is especially lacking in most of the streams throughout the basin. NMFS has determined that these degraded habitat conditions are, in part, the result of many human-induced factors affecting critical habitat including dam construction, agricultural and mining activities, urbanization, stream channelization, water diversion, and logging, among others.

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 Keyport or Northwest Training Range Complexes and these stressors are not likely to exclude California coastal chinook salmon from designated critical habitat, so the military readiness activities the U.S. Navy proposes to conduct on the Keyport or Northwest Training Range Complexes may affect, but are not likely to adversely affect the designated critical habitat for California coastal chinook salmon. As a result, we will not consider this critical habitat in greater detail in the remainder of this Opinion.

CRITICAL HABITAT FOR CHUM SALMON (COLUMBIA RIVER). NMFS designated critical habitat for Columbia River chum salmon on September 2, 2005 (70 FR 52630). The designated 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 bankfull 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.

Of 21 subbasins reviewed in NMFS' assessment of critical habitat for the Columbia River chum salmon, three subbasins were rated as having a medium conservation value, no subbasins were rated as low, and the majority of subbasins (18), were rated as having a high conservation value to Columbia River chum salmon. The major factors limiting recovery for Columbia River chum salmon are altered channel form and stability in tributaries, excessive sediment in tributary spawning gravels, altered stream flow in tributaries and the mainstem Columbia River, loss of some tributary habitat types, and harassment of spawners in the tributaries and mainstem.

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 Keyport or Northwest Training Range Complexes and these stressors are not likely to exclude Columbia River chum salmon from designated critical habitat, so the military readiness activities the U.S. Navy proposes to conduct on the Keyport or Northwest Training Range Complexes may affect, but are not likely to adversely 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.

CRITICAL HABITAT FOR CHUM SALMON (HOOD CANAL SUMMER RUN). 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. This also includes about 8 miles of habitat that was unoccupied at the time of the designation Finch, Anderson and Chimacum creeks (69 FR 74572; 70 FR 52630), but has recently been re-seeded. Chimacum Creek, however, has been naturally recolonized since at least 2007 (T. Johnson, pers. comm., Jan. 2010). 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 bankfull 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 Keyport or Northwest Training Range Complexes 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 Keyport or Northwest Training Range Complexes may affect, but 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.

CRITICAL HABITAT FOR COHO SALMON (CENTRAL CALIFORNIA COAST). 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 Keyport or Northwest Training Range Complexes 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 Keyport or Northwest Training Range Complexes may affect, but 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.

CRITICAL HABITAT FOR COHO SALMON (SOUTHERN OREGON NORTHERN COASTAL CALIFORNIA). NMFS designated critical habitat for Southern Oregon/Northern California 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% 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 Keyport or Northwest Training Range Complexes 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 Keyport or Northwest Training Range Complexes may affect, but 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.

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.

In total, Lower Columbia River steelhead occupy 32 watersheds. The total area of habitat designated as critical includes about 2,340 miles of stream habitat. 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. Of the 32 watersheds reviewed in NMFS' assessment of critical habitat for Lower Columbia River steelhead, two watersheds received a low rating of conservation value, 11 received a medium rating, and 26 received a high rating of conservation value for the species. Limiting factors identified for Lower Columbia River steelhead include: degraded floodplain and steam channel structure and function, reduced access to spawning or rearing habitat, altered stream flow in tributaries, excessive sediment and elevated water temperatures in tributaries, and hatchery impacts.

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 Keyport or Northwest Training Range Complexes and these stressors are not likely to exclude Lower Columbia River steelhead from designated critical habitat, so the military readiness activities the U.S. Navy proposes to conduct on the Keyport or Northwest Training Range Complexes may affect, but are not likely to adversely 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.

CRITICAL HABITAT FOR STEELHEAD (NORTHERN CALIFORNIA). 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 Keyport or Northwest Training Range Complexes 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 Keyport or Northwest Training Range Complexes may affect, but 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.

CRITICAL HABITAT FOR STEELHEAD (CENTRAL CALIFORNIA COAST). 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 Keyport or Northwest Training Range Complexes 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 Keyport or Northwest Training Range Complexes may affect, but 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.

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. Threats posed by the direct and indirect effects of global climatic change is 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 3).

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 *et al.* 2001, McCarthy *et al.* 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% since the 1950s.

Table 3. 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 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 temperature 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.* 1986, 1990 and Weinrich 2001); 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 and influences the abundance of marine mammal prey such as zooplankton and fish. In the 1970s and 1980s, the North Atlantic

Oscillation Index was positive and sea surface temperatures increased. These increases 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.* 2003). In the late 1980s and 1990s, the NAO 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 (Pershing *et al.* 2001, Drinkwater *et al.* 2003). 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.* 2003).

Although the NAO 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.* 2003) 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 oceans currents, the future climates that are forecast place sea turtles at substantially greater risk of extinction than they already face.

3.3 Introduction to this Status of Listed Species

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 and adjacent to the Keyport Range Complex and 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 foundation for our assessment of the how the different species are likely to respond to sounds produced by detonations.

More detailed background information on the status of these species and critical habitat can be found in a number of published documents including a status report on large whales prepared by Perry *et al.* (1999) and recovery plans for sea turtles (NMFS and USFWS 1998a, 1998b, 1998c, 1998d, and 1998e). 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.* (1999), NRC (1994, 1996, 2000, 2003, 2005), and Richardson *et al.* (1995) provide information on the potential and probable effects of active sonar on the marine animals considered in this Opinion.

3.3.1 Blue whale

Distribution

Blue whales are found along the coastal shelves of North America and South America (Rice 1974; Donovan 1984; Clarke 1980) in the North Pacific Ocean. In the North Pacific Ocean, blue 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. 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 (Gambell 1985).

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, Wenzel *et al.*1988, Yochem and Leatherwood 1985, Gagnon and Clark 1993). Blue whales have been observed frequently off eastern Canada, particularly in waters off Newfoundland, during the winter. In the summer month, 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 *et al*. 1987). In the eastern north Atlantic Ocean, blue whales have been observed off the Azores Islands, although Reiner *et al*. (1993) do not consider them common in that area.

In 1992, the U.S. Navy conducted an extensive acoustic survey of the North Atlantic 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 Hawai’ian Islands and off Midway Island in the western edge of the Hawai’ian Archipelago (Barlow *et al*. 1994b; 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 Hawai’ian Islands. Nishiwaki (1966) reported that blue whales occur in the Aleutian Islands and in the Gulf of Alaska, although blue whales have not been observed off Alaska since 1987 (Leatherwood *et al*. 1982;

Stewart *et al*. 1987; Forney and Brownell 1996). No distributional information exists for the western region of the North Pacific.

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.

Historical catch records suggest that “true” blue whales and “pygmy” blue whale (*B. m. brevicada*) may be geographically distinct (Brownell and Donaghue 1994, Kato *et al*. 1995). The distribution of the “pygmy” blue whale is north of the Antarctic Convergence, while that of the “true” blue whale is south of the Convergence in the austral summer (Kato *et al*. 1995). “True” blue whales occur mainly in the higher latitudes, where their distribution in mid-summer overlaps with that of the minke whale (*Balaenoptera acutorostrata*). During austral summers, “true” blue whales are found close to edge of Antarctic ice (south of 58° S) with concentrations between 60°-80° E and 66°-70° S (Kasamatsu *et al*. 1996).

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 Cole (1957, Futuyma (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 more than there may be more than one blue whale population in the Pacific Ocean (Gilpatrick *et al*. 1997, Barlow *et al*. 1995, Mizroch *et al*. 1984a, Ohsumi and Wada 1974). 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 (the southern whales forage off California; Sears *et al*.1987; Barlow *et al*.1997; Calambokidis *et al*. 1990). In addition, a population of blue whales that has distinct vocalizations inhabits the northeast Pacific from the Gulf of Alaska to waters off Central America (Calambokidis *et al*. 1999, Mate *et al*. 1999, Gregr *et al*. 2000; Stafford *et al*. 1999, 2001). We assume that this latter population is the one affected by the activities considered in this Opinion.

A population or "stock" of endangered blue whales occurs in waters surrounding the Hawaiian archipelago (from the main Hawaiian Islands west to at least Midway Island), although blue whales are rarely reported from Hawai'ian waters. The only reliable report of this species in the central North Pacific was a sighting made from a scientific research vessel about 400 km northeast of Hawaii in January 1964 (NMFS 1998). However, acoustic monitoring has recorded blue whales off Oahu and the Midway Islands much more recently (Barlow *et al*. 1994, McDonald and Fox 1999, Northrop *et al.* 1971; Thompson and Friedl 1982).

The recordings made off Oahu showed bimodal peaks throughout the year, suggesting that the animals were migrating into the area during summer and winter (Thompson and Friedl 1982; McDonald and Fox 1999). Twelve aerial surveys were flown within 25 nm^2 of the main Hawaiian Islands from 1993-1998 and no blue whales were sighted. Nevertheless, blue whale vocalizations that have been recorded in these waters suggest that the occurrence of blue whales in these waters may be higher than blue whale sightings. There are no reports of blue whales strandings in Hawaiian waters.

The International Whaling Commission also groups all of the blue whales in the North Atlantic Ocean into one "stock" and groups blue whales in the Southern Hemisphere into six "stocks" (Donovan 1991), which are presumed to follow the feeding distribution of the whales.

Threats to the Species

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 1920), 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 whale and probably hunt blue whales as well (Perry *et al*. 1999).

ANTHROPOGENIC THREATS. Two human activities are known to threaten blue whales: whaling and shipping. Historically, whaling represented the greatest threat to every population of fin whales and was ultimately responsible for listing fin 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 (Tønnessen and Johnsen 1982, Cherfas 1989). In 1864, explosive harpoons and steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species. Before fin whales became the focus of whaling operations, populations of blue whales had already become commercially extinct (IWC 1995).

From 1889 to 1965, whalers killed about 5,761 blue whales in the North Pacific Ocean (NMFS 1998). Evidence of a population decline were evident 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.* 1984a).

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 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 *et al.* 1997). 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 *et al.* 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, Macfarlane 1981). The number of blue whales struck and killed by ships is unknown because the whales do not always strand or examinations of blue whales that have stranded did not identify the traumas that could have been caused by ship collisions. In the California/Mexico stock, annual incidental mortality due to ship strikes averaged 0.2 whales during 1991B1995 (Barlow *et al.* 1997), but we cannot determine if this reflects the actual number of blue whales struck and killed by ships.

Status

Blue whales were listed as endangered under the ESA in 1973. Blue whales are listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). 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 consisted of 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; U. S. Department of Commerce 1983). 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 between 1,400 and 1,900. Barlow and Calambokidis (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 (review by 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 (c.v. 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, Allee effects, among others, that cause their population size to become a threat in and of itself) or if blue whales might are 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).

Diving and Social Behavior

Generally, blue whales make 5-20 shallow dives at 12-20 second intervals followed by a deep dive of 3-30 minutes (Mackintosh 1965; Leatherwood *et al.* 1976; Maser *et al.* 1981; Yochem and Leatherwood 1985; Strong 1990; Croll *et al.* 1999). Croll *et al.* (1999) found that the dive depths of blue whales foraging off the coast of California during the day averaged 132 m (433 ft) with a maximum recorded depth of 204 m (672 ft) and a mean dive duration of 7.2 minutes. Nighttime dives are generally less than 50 m (165 ft) in depth (Croll *et al.* 1999).

Blue whales are usually found swimming alone or in groups of two or three (Ruud 1956, Slijper 1962, Nemoto 1964, Mackintosh 1965, Pike and MacAskie 1969, Aguayo 1974). However, larger foraging aggregations and aggregations mixed with other species like fin whales are regularly reported (Schoenherr 1991, Fiedler *et al.* 1998). Little is known of the mating behavior of blue whales.

Vocalizations and Hearing

The vocalizations that have been identified for blue whales include a variety of sounds described as low frequency moans or long pulses (Cummings and Thompson 1971, 1977; Edds 1982, Thompson and Friedl 1982; Edds-Walton 1997). Blue whales produce a variety of low frequency sounds in the 10-100 Hz band (Cummings and Thompson 1971, Edds 1982, Thompson and Friedl 1982, McDonald *et al.* 1995, Clark and Fristrup 1997, Rivers 1997). The most typical signals are very long, patterned sequences of tonal infrasonic sounds in the 15-40 Hz range. The sounds last several tens of seconds. Estimated source levels are as high as 180-190 dB (Cummings and Thompson 1971). Ketten (1997) reports the frequencies of maximum energy between 12 and 18 Hz. In temperate waters, intense bouts of long patterned sounds are very common from fall through spring, but these also occur to a lesser extent during the summer in high latitude feeding areas. Short sequences of rapid calls in the 30-90 Hz band are associated with animals in social groups. The seasonality and structure of long patterned sounds suggest that these sounds are male displays for attracting females, competing with other males, or both. The context for the 30-90 Hz calls suggests that they are communicative but not related to a reproductive function. Vocalizations attributed to blue whales have been recorded in presumed foraging areas, along migration routes, and during the presumed breeding season (Beamish and Mitchell 1971; Cummings and Thompson 1971, 1977, 1994; Cummings and Fish 1972; Thompson *et al.* 1996; Rivers 1997; Tyack and Clark 1997; Clark *et al.* 1998).

Blue whale moans within the low frequency range of 12.5-200 Hz, with pulse duration up to 36 seconds, have been recorded off Chile (Cummings and Thompson 1971). A short, 390 Hz pulse also is produced during the moan. One estimate of the overall source level was as high as 188 dB, with most energy in the 1/3-octave bands centered at 20, 25, and 31.5 Hz, and also included secondary components estimates near 50 and 63 Hz (Cummings and Thompson 1971).

As with other vocalizations produced by baleen whales, the function of blue whale vocalizations is unknown, although there are numerous hypotheses (which include include: maintenance of inter-individual distance, species and individual recognition, contextual information transmission, maintenance of social organization, location of topographic features, and location of prey resources; see the review by Thompson *et al.* 1992 for more information on these hypotheses). Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long-distance communication occurs (Payne and Webb 1971, Edds-Walton 1997). 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.

3.3.2 Fin whale

Distribution

Fin whales are distributed widely in every ocean except the Arctic Ocean. 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 1985).

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, Spitzbergen, 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 1985).

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 1985).

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.

In the Atlantic Ocean, Clark (1995) reported a general southward pattern of fin whale migration in the fall from the Labrador and Newfoundland region, south past Bermuda, and into the West Indies. The overall distribution may be based on prey availability, and fin whales are found throughout the action area for this consultation in most months of the year. 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. 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: *Balaoptera physalus physalus* (Linnaeus 1758) occurs in the North Atlantic Ocean while *B. p.* *quoyi* (Fischer 1829) occurs in the Southern Ocean. These subspecies and the North Pacifc fin whales appear to be organized into separate populations, although the published literature on the population structure of fin whales does not demonstrates a lack of concensus on the population structure of fin whales.

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 whales populations (as used in this Opinion, “populations” are isolated demographically, meaning, they are driven more by internal dynamics — birth and death processes — than by the geographic redistribution of individuals through immigration or emigration. Some usages of the term “stock” are synonymous with this definition of “population” while other usages of “stock” do not).

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 demonstrate that individual fin whales migrate between management units (Mitchell 1974; Gunnlaugsson and Sigurjónsson 1989), which suggests that these management units are not geographically isolated populations.

The recovery plan that has been drafted for fin whales treats the fin whales that occur off the Atlantic Coast of the U.S. as a single population that overlaps with the population the International Whaling Commission’s Nova Scotia management unit (NMFS 2007). Individuals from this “population” of fin whales occur in the action area for this consultation.

Threats to the Species

NATURAL THREATS. Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggest annual natural mortality rates may range from 0.04 to 0.06 (based on studies of northeast Atlantic fin whales). The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in fin whales and may be preventing some fin whale stocks from recovering from whaling (Lambertsen 1992, as cited in Perry *et al*. 1999). Killer whale or shark attacks may injure or kill very young or sick whales (Perry *et al*. 1999).

ANTHROPOGENIC THREATS. Three human activities are known to threaten fin whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of fin whales and was ultimately responsible for listing fin whales as an endangered species. As early as the mid-seventeenth century, the Japanese were capturing fin, blue (*Balaenoptera musculus*), and other large whales using a fairly primitive open-water netting technique (Tønnessen and Johnsen 1982, Cherfas 1989). In 1864, explosive harpoons and steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species. After blue whales were depleted in most areas, fin whales became the focus of whaling operations and more than 700,000 fin whales were landed in the Southern Hemisphere alone between 1904 and 1979 (IWC 1995).

As its legacy, whaling has reduced fin whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push fin whales closer to extinction. Otherwise, whaling currently does not threaten every fin whale population, although it may threaten specific populations. In the Antarctic Ocean, fin whales are hunted by Japanese whalers who have been allowed to kill up to 10 fin whales each year for the 2005-2006 and 2006-2007 seasons under an Antarctic Special Permit. The Japanese whalers plan to kill 50 fin whales per year starting in the 2007-2008 season and continuing for the next 12 years.

Fin whales are also hunted in subsistence fisheries off West Greenland. In 2004, 5 males and 6 females were killed and landed; 2 other fin whales were struck and lost in the same year. In 2003 2 males and 4 females were landed and 2 other fin whales 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 (IWC 2005), however, the IWC's Scientific Committee recommended limiting the number of fin whale killed in this fishery to 1 to 4 individuals until accurate population estimates are produced.

Despite anecdotal observations from fishermen which suggest that large whales swim through their nets rather than get caught in them (NMFS 2000), fin whales have been entangled by fishing gear off Newfoundland and Labrador in small numbers: a total of 14 fin whales are reported to have been captured in coastal fisheries in those two provinces between 1969 and 1990 (Lien 1994, Perkins and Beamish 1979). Of these 14 fin whales, 7 are known to have died as a result of that capture, although most of the animals that died were less than 15 meters in length (Lien 1994). Between 1999 and 2005, there were 10 confirmed reports of fin whales being entangled in fishing gear 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, Fin whales were injured in 1 of the entanglements and killed in 3 entanglements. These data suggest that, despite their size and strength, fin whales are likely to be entangled and, in some cases, killed by gear used in modern fisheries.

Fin whales are also killed and injured in collisions with vessels more frequently than any other whale. Of 92 fin whales that stranded along the Atlantic Coast of the U.S. between 1975 and 1996, 31 (33%) showed evidence of collisions with ships (Laist *et al*. 2001). Between 1999 and 2005, there were 15 reports of fin 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 which were reported as having resulted in the death of 11 fin whales.

Ship strikes were identified as a known or potential cause of death in 8 (20%) of 39 fin whales that stranded on the coast of Italy in the Mediterranean Sea between 1986 and 1997 (Laist *et al*. 2001). Throughout the Mediterranean Sea, 46 of the 287 fin whales that are recorded to have stranded between 1897 and 2001 were confirmed to died from injuries sustained by ship strikes (Panigada *et al*. 2006). Most of these fin whales (n = 43), were killed between 1972 and 2001 and the highest percentage (37 of 45 or ~82%) killed in the Ligurian Sea and adjacent waters, where the Pelagos Sanctuary for Marine Mammals was established. In addition to these ship strikes, there are numerous reports of fin whales being injured as result of ship strikes off the Atlantic coast of France and the United Kingdom (Jensen and Silber 2003).

Status

Fin whales were listed as endangered under the ESA in 1970. In 1976, the IWC protected fin whales from commercial whaling (Allen 1980). Fin whales are listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). 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 fin whales.

It is difficult to assess the current status of fin whales because (1) there is no general agreement on the size of the fin whale population prior to whaling and (2) estimates of the current size of the different fin whale populations vary widely. We may never know the size of the fin whale population prior to whaling. Chapman (1976) estimated the “original” population size of fin whales off Nova Scotia as 1,200 and 2,400 off Newfoundland, although he offered no explanation or reasoning to support that estimate. Sergeant (1977) suggested that between 30,000 and 50,000 fin whales once populated the North Atlantic Ocean based on assumptions about catch levels during the whaling period. Sigurjónsson (1995) estimated that between 50,000 and 100,000 fin whales once populated the North Atlantic, although he provided no data or evidence to support that estimate. More recently, Palumbi and Roman (2006) estimated that about 360,000 fin whales (95% confidence interval = 249,000 - 481,000) populated the North Atlantic Ocean before whaling based on mutation rates and estimates of genetic diversity.

Similarly, estimates of the current size of the different fin whale populations and estimates of their global abundance also vary widely. The draft recovery plan for fin whales accepts a minimum population estimate of 2,362 fin whales for the North Atlantic Ocean (NMFS 2007); however, the recovery plan also states that this estimate, which is based on on shipboard and aerial surveys conducted in the Georges Bank and Gulf of St. Lawrence in 1999 is the “best” estimate of the size of this fin whale population (NMFS 2006, 2007). However, based on data produced by surveys conducted between 1978-1982 and other data gathered between 1966 and 1989, Hain *et al*. (1992) estimated that the population of fin whales in the western North Atlantic Ocean (specifically, between Cape Hatteras, North Carolina, and Nova Scotia) numbered about 1,500 whales in the winter and 5,000 whales in the spring and summer. Because authors do not always reconcile “new” estimates with earlier estimates, it is not clear whether the current “best” estimate represents a refinement of the estimate that was based on older data or whether the fin whale population in the North Atlantic has declined by about 50% since the early 1980s.

The East Greenland-Iceland fin whale population was estimated at 10,000 animals (95 % confidence interval = 7,600 - 14,200), based on surveys conducted in 1987 and 1989 (Buckland *et al*. 1992). The number of eastern Atlantic fin whales, which includes the British Isles-Spain-Portugal population, has been estimated at 17,000 animals (95% confidence interval = 10,400 -28,900; Buckland *et al*. 1992). These estimates are both more than 15 years old and the data available do not allow us to determine if they remain valid.

Forcada *et al*. (1996) estimated the fin whale population in the western Mediterranean numbered 3,583 individuals (standard error = 967; 95% confidence interval = 2,130-6,027). This is similar to a more recent estimate published by Notarbartolo-di-Sciara *et al*. (2003). Within the Ligurian Sea, which includes the Pelagos Sanctuary for Marine Mammals and the Gulf of Lions, the fin whale population was estimated to number 901 (standard error = 196.1) whales. (Forcada *et al*. 1995).

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, 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 percentage of time fin whales spend at the surface varies. Some authors have reported that fin whales make 5-20 shallow dives with each of these dive lasting 13-20 seconds followed by a deep dive lasting between 1.5 and 15 minutes (Gambell 1985). Other authors have reported that the fin whale’s most common dives last between 2 and 6 minutes, with 2 to 8 blows between dives (Hain *et al*. 1992, Watkins 1981).

In waters off the Atlantic Coast of the U.S. individual fin whales or pairs represented about 75% of the fin whales observed during the Cetacean and Turtle Assessment Program (Hain *et al*. 1992). Individual whales or groups of less than five individuals represented about 90% of the observations (out of 2,065 observations of fin whales, the mean group size was 2.9, the modal value was 1, and the range was 1 – 65 individuals; Hain *et al*. 1992).

Vocalizations and Hearing

The sounds fin whales produce underwater are one of the most studied *Balaenoptera* sounds. Fin whales produce a variety of low-frequency sounds in the 10-200 Hz band (Watkins 1981; Watkins *et al.* 1987a; Edds 1988; Thompson *et al.* 1992). The most typical signals are long, patterned sequences of short duration (0.5-2s) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton 1964). Estimated source levels are as high as 190 dB (Patterson and Hamilton 1964; Watkins *et al.* 1987a; Thompson *et al.* 1992; McDonald *et al.* 1995). In temperate waters intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Short sequences of rapid pulses in the 20-70 Hz band are associated with animals in social groups (McDonald *et al.* 1995, Clark personal communication, McDonald personal communication). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

During the breeding season, fin whales produce a series of pulses in a regularly repeating pattern. These bouts of pulsing may last for longer than one day (Tyack 1999). The seasonality and stereotype of the bouts of patterned sounds suggest that these sounds are male reproductive displays (Watkins *et al.* 1987a), while the individual counter-calling data of McDonald *et al.* (1995) suggest that the more variable calls are contact calls. Some authors feel there are geographic differences in the frequency, duration and repetition of the pulses (Thompson *et al.* 1992).

As with other vocalizations produced by baleen whales, the function of fin whale vocalizations is unknown, although there are numerous hypotheses (which include include: maintenance of inter-individual distance, species and individual recognition, contextual information transmission, maintenance of social organization, location of topographic features, and location of prey resources; see the review by Thompson *et al.* 1992 for more information on these hypotheses). Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by fin whales have the potential to travel over long distances, and it is possible that long-distance communication occurs in fin whales (Payne and Webb 1971; Edds-Walton 1997). Also, there is speculation that the sounds may function for long-range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and 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.

3.3.3 Humpback Whale

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 reproduce and give birth to calves) and cooler, temperate or sub-Arctic waters in summer months (where they feed). In their summer foraging areas and winter calving areas, humpback whales tend to occupy shallower, coastal waters; during their seasonal migrations, however, humpback whales disperse widely in deep, pelagic waters and tend to avoid shallower coastal 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 1991b). These whales migrate to Hawai'i, southern Japan, the Mariana Islands, and Mexico during the winter.

In the Atlantic Ocean, humpback whales range from the mid-Atlantic bight, the Gulf of Maine, across the southern coast of Greenland and Iceland, and along coast of Norway in the Barents Sea. These humpback whales migrate to the western coast of Africa and the Caribbean Sea during the winter.

In the Southern Ocean, humpback whales occur in waters off Antarctica. These whales migrate to the waters off Venezuela, Brazil, southern Africa, western and eastern Australia, New Zealand, and islands in the southwest Pacific during the austral winter. A separate population of humpback whales appears to reside in the Arabian Sea in the Indian Ocean off the coasts of Oman, Pakistan, and India (Mikhalev 1997).

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 OCEAN. NMFS’ Stock Assessment Reports recognize four “stocks” or populations of humpback whales in the North Pacific Ocean, based on genetic and photo-identification studies: two Eastern North Pacific stocks, one Central North Pacific stock, and one Western Pacific stock (Hill and DeMaster 1998). The first two of these “stocks” are based on where these humpback whales winter: the central North Pacific “stock” winters in the waters around

Hawai'i while the eastern North Pacific "stock" (also called the California-Oregon-Washington-Mexico stock) winters along coasts of Central America and Mexico. However, Calambokidis *et al*. (1997) identified humpback whales from Southeast Alaska (central North Pacific), the California-Oregon-Washington (eastern North Pacific), and Ogasawara Islands (Japan, Western Pacific) groups in the Hawai'ian Islands during the winter; humpback whales from the Kodiak Island, Southeast Alaska, and British Columbia groups in the Ogasawara Islands; and whales from the British Columbia, Southeast Alaska, Prince William Sound, and Shumagin-Aleutian Islands groups in Mexico.

Herman (1979), however, presented extensive evidence and various lines of reasoning to conclude that the humpback whales associated with the main Hawai'ian Islands immigrated to those waters only in the past 200 years. Winn and Reichley (1985) identified genetic exchange between the humpback whales that winter off Hawai'i and those that winter off Mexico (with further mixing on feeding areas in Alaska) and suggested that the humpback whales that winter in Hawai'i may have emigrated from wintering areas in Mexico. Based on these patterns of movement, we conclude that the various "stocks" of humpback whales are not true populations or, at least, they represent populations that experience substantial levels of immigration and emigration.

A "population" of humpback whales winters in an area extending from the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands (Rice 1998). Based on whaling records, humpback whales wintering in this area have also occurred in the southern Marianas through the month of May (Eldredge 1991). There are several recent records of humpback whales in the Mariana Islands, at Guam, Rota, and Saipan during January through March (Darling and Mori 1993; Eldredge 1991, 2003; Taitano 1991). During the 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 2007, Calambokidis 1997, 2001).

Between 2004 and 2006, an international group of whale researchers coordinated their surveys to conduct a comprehensive assessment of the population structure, levels of abundance, and status of humpback whales in the North Pacific (Calambokidis *et al*. 2008). That effort identified a total of 7,971 unique individuals from photographs taken during close approaches. Based on the data collected during that study, Calambokidis *et al*. (2008) estimated the rates of exchange among humpback whales in different areas in the Hawai'ian Islands that are presented in Table 3 (which appears on the following page).

NORTH ATLANTIC OCEAN. In the Atlantic Ocean, humpback whales aggregate in four feeding areas in the summer months: (1) Gulf of Maine, eastern Canada, (2) west Greenland, (3) Iceland and (4) Norway (Katona and Beard 1990, Smith *et al.* 1999). The principal breeding range for these whales lies from the Antilles and northern Venezuela to Cuba (Winn *et al.* 1975, Balcomb and Nichols 1982, Whitehead and Moore 1982). The largest contemporary breeding aggregations occur off the Greater Antilles where humpback whales from all of the North Atlantic feeding areas have been identified from photographs (Katona and Beard 1990, Clapham *et al.* 1993b, Mattila *et al.* 1994, Palsbøll *et al.* 1997, Smith *et al.* 1999, Stevick *et al.* 2003a). Historically, an important breeding aggregation was located in the eastern Caribbean based on the important humpback whale fisheries this region supported (Mitchell and Reeves 1983, Reeves *et al.* 2001, Smith and Reeves 2003). Although sightings persist in those areas, modern humpback whale abundance appears to be low (Winn *et al.* 1975, Levenson and Leapley 1978, Swartz *et al.* 2003). Winter aggregations also occur at the Cape Verde Islands in the Eastern North Atlantic (Reiner *et al.* 1996, Reeves *et al.* 2002, Moore *et al.* 2003). In another example of the "open" structure of humpback whale populations, an individual humpback whale migrated from the Indian Ocean to the South Atlantic Ocean and demonstrated that individual whales may migrate from one ocean basin to another (Pomilla and Rosenbaum 2005).

INDIAN OCEAN. As discussed previously, a separate population of humpback whales appears to reside in the Arabian Sea in the Indian Ocean off the coasts of Oman, Pakistan, and India (Mikhalev 1997).

Threats to the Species

NATURAL THREATS. There is limited information on natural phenomena that kill or injure humpback whales. We know that humpback whales are killed by orcas (Dolphin 1989, Florez-González *et al*. 1984, Whitehead and Glass 1985) and are probably killed by false killer whales and sharks. Because 7 female and 7 male humpback whales stranded on the beaches of Cape Cod and had died from toxin produced by dinoflagellates between November 1987 and January 1988, we also know that adult and juvenile humpback whales are killed by naturally-produced biotoxins (Geraci *et al*. 1989).

Other natural sources of mortality, however, remain largely unknown. Similarly, we do not know whether and to what degree natural mortality limits or restricts patterns of growth or variability in humpback whale populations.

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 humpback whales and was ultimately responsible for listing humpback whales as an endangered species. From 1900 to 1965, nearly 30,000 whales were taken in modern whaling operations of the Pacific Ocean. Prior to that, an unknown number of humpback whales were taken (Perry *et al.* 1999). In 1965, the International Whaling Commission banned commercial hunting of humpback whales in the Pacific Ocean. As its legacy, whaling has reduced humpback whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push these whales closer to extinction.

Humpback whales are also killed or injured during interactions with commercial fishing gear, although the evidence available suggests that these interactions on humpback whale populations may not have significant, adverse consequence for humpback whale populations. Like fin whales, humpback whales have been entangled by fishing gear off Newfoundland and Labrador, Canada: a total of 595 humpback whales are reported to have been captured in coastal fisheries in those two provinces between 1969 and 1990 (Lien 1994, Perkins and Beamish 1979). Of these whales, 94 are known to have died as a result of that capture, although, like fin whales, most of the animals that died were smaller: less than 12 meters in length (Lien 1994). These data suggest that, despite their size and strength, fin whales are likely to be entangled and, in some cases, killed by gear used in modern fisheries.

In 1991, a humpback whale was observed entangled in longline gear and released alive (Hill *et al.* 1997). In 1995, a humpback whale in Maui waters was found trailing numerous lines (not fishery-related) and entangled in mooring lines. The whale was successfully released, but subsequently stranded and was attacked and killed by tiger sharks in the surf zone. Also in 1996, a vessel from Pacific Missile Range Facility in Hawaii rescued an entangled humpback, removing two crab pot floats from the whale; the gear was traced to a recreational fisherman in southeast Alaska.

The whale was successfully released, but subsequently became entrapped and was attacked and killed by tiger sharks in the surf zone.

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 reports, 95 entanglements were confirmed resulting in the injury of 11 humpback whales and the death of 9 whales. No information is available on the number of humpback whales that have been killed or seriously injured by interactions with fishing fleets outside of U.S. waters.

The number of humpback whales killed by ship strikes is exceeded only by fin whales (Jensen and Silber 2003). On the Pacific coast, a humpback whale is killed about every other year by ship strikes (Barlow *et al*. 1997). The humpback whale calf that was found stranded on Oahu with evidence of vessel collision (propeller cuts) in 1996 suggests that ship collisions might kill adults, juvenile, and calves (NMFS unpublished data). Of 123 humpback whales that stranded along the Atlantic Coast of the U.S. between 1975 and 1996, 10 (8.1%) 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 which were reported as having resulted in the death of 7 humpback whales. Despite several literature searches, we did not identify information on the number of humpback whales killed or seriously injured by ship strikes outside of U.S. waters.

In addition to ship strikes in North America and Hawai'i, there are several reports of humpback whales being injured as result of ship strikes off the Antarctic Peninsula, in the Caribbean Sea, the Mediterranean Sea, off Australia, Bay of Bengal (Indian Ocean), Brazil, New Zealand, Peru, South Africa,

Status

Humpback whales were listed as endangered under the ESA in 1973. Humpback whales are listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). 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 humpback whales.

It is difficult to assess the current status of humpback whales for the same reasons that it is difficult to assess the status of fin whales: (1) there is no general agreement on the size of the humpback whale population prior to whaling and (2) estimates of the current size of the different humpback whale populations vary widely and produce estimates that are not always comparable to one another, although robust estimates of humpback whale populations in the western North Atlantic have been published. We may never know the size of the humpback whale population prior to whaling.

Winn and Reichley (1985) argued that the global population of humpback whales consisted of at least 150,000 whales in the early 1900s, with the largest population historically occurring in the Southern Ocean. Based on analyses of mutation rates and estimates of genetic diversity, Palumbi and Roman (2006) concluded that there may have been as many as 240,000 (95% confidence interval = 156,000 – 401,000) humpback whales in the North

Atlantic before whaling began. In the western North Atlantic between Davis Strait, Iceland and the West Indies, Mitchell and Reeves (1983) estimated there were at least 4,685 humpback whales in 1865 based on available whaling records (although the authors note that this does not represent a “pre-exploitation estimate” because whalers from Greenland, the Gulf of St. Lawrence, New England, and the Caribbean Sea had been hunting humpback whales before 1865).

Estimates of the number of humpback whales occurring in the different populations that inhabit the Northern Pacific population have risen over time. In the 1980s, estimates ranged from 1,407 to 2,100 (Baker 1985; Darling and Morowitz 1986; Baker and Herman 1987), while recent estimates place the population size at about 6,000 whales (standard error = 474) in the North Pacific (Calambokidis *et al.* 1997; Cerchio 1998; Mobley *et al.* 1999). Based on data collected between 1980 and 1983, Baker and Herman (1987) used a capture-recapture methodology to produce a population estimate of 1,407 whales (95% confidence interval = 1,113 - 1,701). More recently, (Calambokidis *et al.* 1997) relied on resightings estimated from photographic records of individuals to produce an estimate of 6,010 humpback whales occurred in the North Pacific Ocean. Because the estimates produced by the different methodologies are not directly comparable, it is not clear which of these estimates is more accurate or if the change from 1,407 to 6,000 individuals results from a real increase in the size of the humpback whale population, sampling bias in one or both studies, or assumptions in the methods used to produce estimates from the individuals that were sampled. Since the last of these estimates was published almost 12 years ago, we do not know if the estimates represent current population sizes.

Stevick *et al*. (2003) estimated the size of the North Atlantic humpback whale population between 1979 and 1993 by applying statistical analyses that are commonly used in capture-recapture studies to individual humpback whales that were identified based on natural markings. Between 1979 and 1993, they estimated that the North Atlantic populations (what they call the “West Indies breeding population”) consisted of between 5,930 and 12,580 individual whales. The best estimate they produced (11,570; 95% confidence interval = 10,290 -13,390) was based on samples from 1992 and 1993. If we assume that this population has grown according to the instantaneous rate of increase Stevick *et al*. (2003) estimated for this population ($r = 0.0311$), this would lead us to estimate that this population might consist of about 18,400 individual whales in 2007-2008.

As discussed previously, between 2004 and 2006, an international group of whale researchers coordinated their surveys to conduct a comprehensive assessment of the population structure, levels of abundance, and status of humpback whales in the North Pacific (Calambokidis *et al*. 2008). That effort identified a total of 7,971 unique individuals from photographs taken during close approaches. Of this total,, 4,516 individuals were identified at wintering regions in at least one of the three seasons in which the study surveyed wintering area and 4,328 individuals were identified at least once at feeding areas in one of the two years in which the study surveyed feeding areas. Based on the results of that effort, Calambokidis *et al*. (2008) estimated that the current population of humpback whales in the North Pacific Ocean consisted of about 18,300 whales, not counting calves. Almost half of the humpback whales that were estimated to occur in wintering areas, or about 8,000 humpback whales, occupy the Hawai’ian Islands during the winter months.

Regardless of which of these estimates, if any, most closely correspond to the actual size and trend of the humpback whale population, all of these estimates suggest that the global population of humpback whales consists of tens of thousands of individuals, that the North Atlantic population consists of at least 2,000 individuals and the North Pacific population consists of about 18,000 individuals. Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, humpback 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, Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that humpback whales will have elevated extinction probabilities because of exogenous threats caused by anthropogenic activities (primarily whaling, entanglement, and ship strikes) and natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) rather than endogenous threats caused by the small size of their population.

Diving and Social Behavior

In Hawai’ian waters, humpback whales remain almost exclusively within the 1820 m isobath and usually within waters depths less than 182 meters. Maximum diving depths are approximately 150 m (492 ft) (but usually <60 m [197 ft]), with a very deep dive (240 m [787 ft]) recorded off Bermuda (Hamilton *et al.* 1997). They may remain submerged for up to 21 min (Dolphin 1987). Dives on feeding grounds ranged from 2.1-5.1 min in the north Atlantic (Goodyear unpublished manuscript). In southeast Alaska average dive times were 2.8 min for feeding whales, 3.0min for non-feeding whales, and 4.3 min for resting whales (Dolphin 1987). In the Gulf of California humpback whale dive times averaged 3.5 min (Strong 1989). Because most humpback prey is likely found above 300 m depths most humpback dives are probably relatively shallow.

In a review of the social behavior of humpback whales, Clapham (1986) reported that they form small, unstable social groups during the breeding season. During the feeding season they form small groups that occasionally aggregate on concentrations of food. Feeding groups are sometimes stable for long-periods of times. There is good evidence of some territoriality on feeding (Clapham 1994, 1996), and calving areas (Tyack 1981). In calving areas, males sing long complex songs directed towards females, other males or both. The breeding season can best be described as a floating lek or male dominance polygyny (Clapham 1996). Intermale competition for proximity to females can be intense as expected by the sex ratio on the breeding grounds which may be as high as 2.4:1.

Vocalizations and Hearing

Humpback whales produce at least three kinds of vocalization: (1) complex songs with components ranging from at least 20Hz B 4 kHz with estimated source levels from 144 B 174 dB, which are mostly produced by males on breeding areas (Payne 1970, Winn *et al.* 1970, Richardson *et al.* 1995); (2) social sounds in breeding areas that extend from 50 Hz B more than 10 kHz with most energy below 3 kHz (Tyack and Whitehead 1983, Richardson *et al.* 1995); and (3) vocalizations in foraging areas that are less frequent, but tend to be 20Hz B 2 kHz with estimated sources levels in excess of 175 dB re 1 μPa-m (Thompson *et al.* 1986, Richardson *et al.* 1995). Sounds that investigators associate with aggressive behavior in male humpback whales are very different from songs; they extend from 50 Hz to 10 kHz (or higher), with most energy in components below 3 kHz (Tyack 1983, Silber 1986). These sounds appear to have an effective range of up to 9 kilometers (Tyack and Whitehead 1983). A general description of the anatomy of the ear for cetaceans is provided in the description of the fin whale above; that description is also applicable to humpback whales.

In summary, humpback whales produce at least three kinds of sounds:

1. Complex songs with components ranging from at least 20 Hz–4 kHz with estimated source levels from 144 – 174 dB; these are mostly sung by males on the breeding grounds (Frazer and Mercado 2000; U.S. Navy 2006a; Payne 1970; Winn *et al.* 1970a; Richardson *et al.* 1995)
2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3 kHz (Tyack and Whitehead 1983, Richardson *et al.* 1995); and
3 Feeding area vocalizations that are less frequent, but tend to be 20 Hz–2 kHz with estimated sources levels in excess of 175 dB re 1 μPa-m (Thompson *et al.* 1986; Richardson *et al.* 1995).

Helwig *et al.* (2000) produced a mathematical model of a humpback whale’s hearing sensitivity based on the anatomy of the whale’s ear. Based on that model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7kHz to 10kHz, with a maximum sensitivity between 2 and 6kHz.

3.3.4 Sei Whale

Distribution

Sei whales occur in every ocean except the Arctic Ocean. 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.* 1999). Sei whales are often associated with deeper waters and areas along the continental shelf edge (Hain *et al*. 1985); however, this general offshore pattern of sei whale distribution is disrupted during occasional incursions into more shallow and inshore waters (Waring *et al.* 2004).

In the western Atlantic Ocean, sei whales occur from Labrador, Nova Scotia,and Labrador in the summer months and migrate south to Florida, the Gulf of Mexico, and the northern Caribbean (Gambell 1985, Mead 1977). 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 (Jonsgård and Darling 1974, Gambell 1985).

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 (Masaki 1977; Gambell 1985). Horwood (1987) reported that 75 - 85% of the North Pacific population of sei whales resides east of 180° longitude.

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 largely unknown because there are so few data on this species. The International Whaling Commission's Scientific Committee groups all of the sei whales in the entire North Pacific Ocean into one population (Donovan 1991). However, some mark-recapture, catch distribution, and morphological research suggest more than one "stock" of sei whales may exist in the Pacific: one between 175°W and 155°W longitude, and another east of 155°W longitude (Masaki 1977); however, the amount of movement between these "stocks" suggests that they probably do not represent demographically-isolated populations as we use this concept in this Opinion.

Mitchell and Chapman (1977) divided sei whales in the western North Atlantic in two populations, one that occupies the Nova Scotian Shelf and a second that occupies the Labrador Sea. Sei whales are most common on Georges Bank and into the Gulf of Maine and the Bay of Fundy during spring and summer, primarily in deeper waters. There are occasional influxes of sei whales further into Gulf of Maine waters, presumably in conjunction with years of high copepod abundance inshore. Sei whales are occasionally seen feeding in association with right whales in the southern Gulf of Maine and in the Bay of Fundy.

Threats to the Species

NATURAL THREATS. Sei whales appear to compete with blue, fin, and right whales for prey and that competition may limit the total abundance of each of the species (Rice 1974, Scarff 1986). As discussed previously in the narratives for fin and right whales, the foraging areas of right and sei whales in the western north Atlantic Ocean overlap and both whales feed preferentially on copepods (Mitchell 1975). In the Southern Ocean, the sei whale population was reported to have increased in size after whalers had reduced the number of blue and fin whales in the region (IWC 1974); as these populations increase, the intensity of competition between these species should increase as well and the larger whales are most likely to prevail in that competition.

ANTHROPOGENIC THREATS. Two human activities are known to threaten sei whales: whaling and shipping. Historically, whaling represented the greatest threat to every population of sei whales and was ultimately responsible for listing sei whales as an endangered species. From 1910 to 1975, approximately 74,215 sei whales were caught in the entire North Pacific Ocean (Horwood 1987, Perry *et al.* 1999). 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 to 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.

In the North Atlantic Ocean, sei whales were hunted from land stations in Norway and Iceland in the early- to mid-1880s, when blue whales started to become more scarce. In the late 1890s, whalers began hunting sei whales in Davis Strait and off the coasts of Newfoundland. In the early 1900s, whalers from land stations on the Outer Hebrides and Shetland Islands started to hunt sei whales. Between 1966 and 1972, whalers from land stations on the east coast of Nova Scotia engaged in extensive hunts of sei whales on the Nova Scotia shelf, killing about 825 sei whales (Mitchell and Chapman 1977).

Sei whales are occasionally killed in collisions with vessels. Of 3 sei whales that stranded along the Atlantic Coast of the U.S. between 1975 and 1996, 2 showed evidence of collisions with ships (Laist *et al*. 2001). Between 1999 and 2005, there were 3 reports of sei 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). Two of these ship strikes were reported as having resulted in the death of the sei whale.

Status

Sei whales were listed as endangered under the ESA in 1973. In the North Pacific, the International Whaling Commission began management of commercial taking of sei whales in 1970, and fin whales were given full protection in 1976 (Allen 1980). Sei whales are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act. They are listed as endangered under the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). Critical habitat has not been designated for sei whales.

Prior to commercial whaling, sei whales in the north Pacific are estimated to have numbered 42,000 individuals (Tillman 1977), although 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 or 38,000 whales by 1967, and reduced again to 20,600 to 23,700 whales by 1973. 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 and 1969, after which the sei whale population declined rapidly (Mizroch *et al.* 1984). When commercial whaling for sei whales ended in 1974, the population of sei whales in the North Pacific had been reduced to between 7,260 and 12,620 animals (Tillman 1977). In the same year, the north Atlantic population of sei whales was estimated to number about 2,078 individuals, including 965 whales in the Labrador Sea group and 870 whales in the Nova Scotia group (IWC 1977, Mitchell and Chapman 1977).

About 50 sei whales are estimated to occur in the North Pacific “stock” with another 77 sei whales in the Hawaiian “stock” (Lowry *et al*. 2007). The abundance of sei whales in the Atlantic Ocean remains unknown (Lowry *et al*. 2007). In California waters, only one confirmed and five possible sei whale sightings were recorded during 1991, 1992, and 1993 aerial and ship surveys (Carretta and Forney 1993, Mangels and Gerrodette 1994). No sightings were confirmed off Washington and Oregon during recent aerial surveys. Several researchers have suggested that the recovery of right whales in the northern hemisphere has been slowed by other whales that compete with right whales for food. Mitchell (1975) analyzed trophic interactions among baleen whales in the western north Atlantic and noted that the foraging grounds of right whales overlapped with the foraging grounds of sei whales and both preferentially feed on copepods.

Like blue whales, the information available on the status and trend of sei whales do not allow us to reach any conclusions about the extinction risks facing sei whales as a species, or particular populations of sei whales. With the limited data available on sei 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, Allee effects, among others, that cause their population size to become a threat in and of itself) or if sei whales might are 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). However, sei whales have historically exhibited sudden increases in abundance in particular areas followed by sudden decreases in number. Several authors have reported "invasion years" in which large numbers of sei whales appeared off areas like Norway and Scotland, followed the next year by sudden decreases in population numbers (Jonsgård and Darling 1974).

With the evidence available, we do not know if this year-to-year variation still occurs in sei whales. However, if sei whales exist as a fraction of their historic population sizes, large amounts of variation in their abundance would increase the extinction probabilities of individual populations (Fagan and Holmes 2006, Fagan *et al*. 1999, 2001).

Diving and Social Behavior

Generally, sei whales make 5-20 shallow dives of 20-30 sec duration followed by a deep dive of up to 15 min (Gambell 1985). 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 1985).

Vocalizations and Hearing

There is a limited amount of information on the vocal behavior of sei whales. McDonald *et al*. (2005) recorded sei whale vocalizations off the Antarctic Peninsula that included broadband sounds in the 100-600 Hz range with 1.5 second duration and tonal and upsweep call in the 200-600 Hz range 1-3 second duration. During visual and acoustic surveys conducted in the Hawai'ian Islands in 2002, Rankin and Barlow (2007) recorded 107 sei whale vocalizations, which they classified as two variations of low-frequency downswept calls. The first variation consisted of sweeps from 100 Hz to 44 Hz, over 1.0 seconds. The second variation, which was more common (105 out of 107) consisted of low frequency calls which swept from 39 Hz to 21 Hz over 1.3 seconds. These vocalization are different from sounds attributed to sei whales in the Atlantic and Southern Oceans but are similar to sounds that had previously been attributed to fin whales in Hawaiian waters.

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

3.3.5 Southern Resident Killer Whale

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 2005, Bureau of Reclamation 2008).

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 (Heimlich-Boran 1988, Felleman *et al*. 1991, 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 (Heimlich-Boran 1988, Felleman *et al*. 1991, Olson 1998, Ford *et al*. 2000).

The local movements of southern resident killer whales usually follows the distribution of salmon, which are their preferred prey (Heimlich-Boran 1986a, 1988, 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, K.C. Balcomb, unpublished data).

Population Structure

Southern resident killer whales consists 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.

Threats to the Species

NATURAL THREATS. Southern resident killer whales like many wild animal populations (Nettles, 1992), experience highest mortality in the first year age class (Olesiuk *et al*. 1990; Krahn *et al*. 2002), 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 (Scheffer and Slipp 1948, Pike and MacAskie 1969, Olesiuk *et al*. 1990, Baird 2001). Until 1970, about 25 percent of the killer whales that were captured for aquaria had bullet scars (Hoyt 1990). The effect of these attacks on individual whales or the population itself remains unknown. 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). Estimates of historic run sizes vary from 10-16 million fish (Northwest Power Planning Council 1986) to 7-30 million fish (Williams *et al*. 1999) with chinook salmon being the predominant species. Since 1938, annual runs have totaled just 750,000 to 3.2 million fish (Oregon Department of Fisheries and Wildlife and Washington Department of Fisheries and Wildlife 2002). Returns during the 1990s averaged only 1.1 million salmon (including hatchery fish), representing a decline of 90 percent or more from historical levels. As another example, substantial numbers of chinook salmon from California's Central Valley historically migrated northward to Oregon, Washington, and British Columbia (Yoshiyama *et al*. 1998), and, therefore, may have been available as a significant dietary item for southern resident killer whales. Winter-run Chinook salmon were listed as endangered in 1989

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 (see further discussion below).

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 (Blane and Jackson 1994, Evans *et al.* 1992, 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels is 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 2002, Félix 2001, Magalhães *et al.* 2002, Richter *et al.* 2003, Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams *et al.* 2002). 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% during the last of the three time periods (2001 to 2003). At the same time, Holt *et al*. (2007) 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.

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 have been documented in southern resident killer whales (Ross 2006, Ross *et al*. 2000, Yitalo *et al*. 2001, Herman *et al*. 2005). Although the consequences of these pollutants on the fitness of individuals 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.

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 *et al*. 2006) —including stochastic sex determination (Lande *et al*. 2003) — and the effects of 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, population's 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 (Dahlheim and Heyning 1999, Baird 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 et al. 2000, Ford 2002). 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.

Mean pod size varies among populations, but often ranges from 2 to 15 animals (Kasuya 1971, Condy *et al*. 1978, Mikhalev *et al*. 1981, Braham and Dahlheim 1982, Dahlheim *et al*. 1982, Baird and Dill 1996). 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 (Dahlheim and Heyning 1999, Baird 2000, Ford *et al*. 2000).

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*. 1990a). 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 (Schevill and Watkins 1966, Ford 1989, 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 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, Miller 2002). 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 killer foraging and traveling (Ford 1989, Miller 2002).

3.3.6 Sperm Whale

Distribution

Sperm whales occur in every ocean except the Arctic Ocean. Sperm whales are found throughout the North Pacific and are distributed broadly from tropical and temperate waters to the Bering Sea as far north as Cape Navarin. Mature, female, and immature sperm whales of both sexes are found in more temperate and tropical waters from the equator to around 45˚ N throughout the year. These groups of adult females and immature sperm whales are rarely found at latitudes higher than 50˚ N and 50˚ S (Reeves and Whitehead 1997). Sexually mature males join these groups throughout the winter. During the summer, mature male sperm whales are thought to move north into the Aleutian Islands, Gulf of Alaska, and the Bering Sea.

In the western Atlantic Ocean, sperm whales are distributed in a distinct seasonal cycle, concentrated east-northeast of Cape Hatteras in winter and shifting northward in spring when whales are found throughout the Mid-Atlantic Bight. Distribution extends further northward to areas north of Georges Bank and the Northeast Channel region in summer and then south of New England in fall, back to the Mid-Atlantic Bight.

In the eastern Atlantic Ocean, mature male sperm whales have been recorded as far north as Spitsbergen (Oien, 1990). Recent observations of sperm whales and stranding events involving sperm whales from the eastern North Atlantic suggest that solitary and paired mature male sperm whales predominantly occur in waters off Iceland, the Faroe Islands, and the Norwegian Sea (Gunnlaugsson and Sigurjonsson 1990, Oien 1990, Christensen *et al.* 1992).

In the Mediterranean Sea sperm whales are found from the Alboran Sea to the Levant Basin, mostly over steep slope and deep offshore waters. Sperm whales are rarely sighted in the Sicilian Channel, and are vagrant in the northern Adriatic and Aegean Seas (Notarbartolo di Sciara and Demma 1997). In the Italian seas sperm whales are more frequently associated with the continental slope off western Liguria, western Sardinia, northern and eastern Sicily, and both coasts of Calabria.

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Sperm whales commonly concentrate around oceanic islands in areas of upwelling, and along the outer continental shelf and mid-ocean waters. Because they inhabit deeper pelagic waters, their distribution does not include the broad continental shelf of the Eastern Bering Sea and these whales generally remain offshore in the eastern Aleutian Islands, Gulf of Alaska, and the Bering Sea.

Sperm whales have a strong preference for the 3,280 feet (1,000 meters) depth contour and seaward. Berzin (1971) reported that they are restricted to waters deeper than 300 meters (984 feet), while Watkins (1977) and Reeves and Whitehead (1997) reported that they are usually not found in waters less than 1,000 meters (3,281 feet) deep. While deep water is their typical habitat, sperm whales have been observed near Long Island, New York, in water between 41-55 meters (135-180 feet; Scott and Sadove 1997). When they are found relatively close to shore, sperm whales are usually associated with sharp increases in bottom depth where upwelling occurs and biological production is high, implying the presence of a good food supply (Clarke 1956).

Population Structure

The population structure of sperm whales is largely unknown. Lyrholm and Gyllenstein (1998) reported moderate, but statistically significant, differences in sperm whale mitochondrial (mtDNA) between ocean basins, although sperm whales throughout the world appear to be homogenous genetically (Whitehead 2003). Genetic studies also suggest that sperm whales of both genders commonly move across ocean basins and that males, but not females, often breed in ocean basins that are different from the one in which they were born (Whitehead, 2003).

Sperm whales may not form "populations" as that term is normally conceived. Jaquet (1996) outlined a hierarchical social and spatial structure that includes temporary clusters of animals, family units of 10 or 12 females and their young, groups of about 20 animals that remain together for hours or days, "aggregations" and "super-aggregations" of 40 or more whales, and "concentrations" that include 1,000 or more animals (Peterson 1986, Whitehead and Wiegart 1990, Whitehead *et al.* 1991). The "family unit" forms the foundation for sperm whale society and most females probably spend their entire life in the same family unit (Whitehead 2002). The dynamic nature of these relationships and the large spatial areas they are believed to occupy might complicate or preclude attempts to apply traditional population concepts, which tend to rely on group fidelity to geographic distributions that are relatively static over time.

Atlantic Ocean

Based on harvests of tagged sperm whales or sperm whales with other distinctive marking, sperm whales in the North Atlantic Ocean appear to represent a single population, with the possible exception of the sperm whales that appear to reside in the Gulf of Mexico. Mitchell (1975) reported one sperm whale that was tagged on the Scotian Shelf and killed about 7 years later off Spain. Donovan (1991) reported five to six handheld harpoons from the Azore sperm whale fishery that were recovered from whales killed off northwest Spain, with another Azorean harpoon recovered from a male sperm whale killed off Iceland (Martin 1982). These patterns suggest that at least some sperm whales migrate across the North Atlantic Ocean.

Female and immature animals stay in Atlantic temperate or tropical waters year round. In the western North Atlantic, groups of female and immature sperm whales concentrate in the Caribbean Sea (Gosho *et al.* 1984) and south of New England in continental-slope and deep-ocean waters along the eastern United States (Blaylock *et al.* 1995). In eastern Atlantic waters, groups of female and immature sperm whales aggregate in waters off the Azores, Madeira, Canary, and Cape Verde Islands (Tomilin 1967).

Several investigators have suggested that the sperm whales that occupy the northern Gulf of Mexico are distinct from sperm whales elsewhere in the North Atlantic Ocean (Schmidly 1981, Fritts 1983, and Hansen *et al.* 1995), although the International Whaling Commission groups does not treat these sperm whales as a separate population or "stock."

In the Mediterranean Sea sperm whales are found from the Alboran Sea to the Levant Basin, mostly over steep slope and deep offshore waters. Sperm whales are rarely sighted in the Sicilian Channel, and are vagrant in the northern Adriatic and Aegean Seas (Notarbartolo di Sciara and Demma 1997). In the Italian seas sperm whales are more frequently associated with the continental slope off western Liguria, western Sardinia, northern and eastern Sicily, and both coasts of Calabria.

Bayed and Beaubrun (1987) suggested that the frequent observation of neonates in the Mediterranean Sea and the scarcity of sperm whale sightings from the Gibraltar area may be evidence of a resident population of sperm whales in the Mediterranean.

Indian Ocean

In the Northern Indian Ocean the International Whaling Commission recognized differences between sperm whales in the northern and southern Indian Ocean (Donovan 1991). Little is known about the Northern Indian Ocean population of sperm whales (Perry *et al.* 1999).

Pacific Ocean

Several authors have proposed population structures that recognize at least three sperm whales populations in the North Pacific for management purposes (Kasuya 1991, Bannister and Mitchell 1980). At the same time, the IWC's Scientific Committee designated two sperm whale stocks in the North Pacific: a western and eastern stock or population (Donovan 1991). The line separating these populations has been debated since their acceptance by the IWC's Scientific Committee. For stock assessment purposes, NMFS recognizes three discrete population centers of sperm whales in the Pacific: (1) Alaska, (2) California-Oregon-Washington, and (3) Hawai'i.

Sperm whales are widely distributed throughout the Hawai'ian Islands throughout the year and are the most abundanct large whale in waters off Hawai'i during the summer and fall (Rice 1960, Shallenberger 1981, Lee 1993, and Mobley *et al.* 2000). Sperm whale clicks recorded from hydrophones off Oahu confirm the presence of sperm whales near the Hawai'ian Islands throughout the year (Thompson and Friedl 1982). The primary area of occurrence for the sperm whale is seaward of the shelf break in the Hawai'ian Islands.

Sperm whales have been sighted in the Kauai Channel, the Alenuihaha Channel between Maui and the island of Hawai'i, and off the island of Hawai'i (Lee 1993, Mobley *et al.*1999, Forney *et al.* 2000). Additionally, the sounds of sperm whales have been recorded throughout the year off Oahu (Thompson and Friedl 1982). Twenty-one sperm whales were sighted during aerial surveys conducted in Hawai'ian waters conducted from 1993 through 1998. Sperm whales sighted during the survey tended to be on the outer edge of a 50 - 70 km distance from the Hawai'ian Islands, indicating that presence may increase with distance from shore. However, from the results of these surveys, NMFS has calculated a minimum abundance of sperm whales within 46 km of Hawai'i to be 43 individuals (Forney *et al.* 2000).

Southern Ocean

Sperm whales south of the equator are generally treated as a single "population," although the International Whaling Commission divides these whales into nine different divisions that are based more on evaluations of whaling captures than the biology of sperm whales (Donovan 1991). Several authors, however, have argued that the sperm whales that occur off the Galapagos Islands, mainland Ecuador, and northern Peru are geographically distinct from other sperm whales in the Southern Hemisphere (Rice 1977, Wade and Gerrodette 1993, and Dufault and Whitehead 1995).

Threats to the Species

NATURAL THREATS. Sperm whales are hunted by killer whales (*Orcinus orca*), false killer whales (*Pseudorca crassidens*), and short-finned pilot whales (*Globicephala melas*; Arnbom *et al.* 1987, Palacios and Mate 1996, Rice 1989, Weller *et al.* 1996, Whitehead 1995). Sperm whales have been observed with bleeding wounds on their heads and tail flukes after attacks by these species (Arnbom *et al.* 1987, Dufault and Whitehead 1995). In October 1997, 25 killer whales were documented to have attacked a group of mature sperm whales off Point Conception, California (personal communication from K Roberts cited in Perry *et al.* 1999) and successfully killing one of these mature sperm whales. Sperm whales have also been reported to have papilloma virus (Lambertson *et al.* 1987).

Studies on sperm whales in the North Pacific and North Atlantic Oceans have demonstrated that sperm whales are infected by calciviruses and papillomavirus (Smith and Latham 1978, Lambertsen *et al.* 1987). In some instances, these diseases have been demonstrated to affect 10 percent of the sperm whales sampled (Lambertsen *et al.* 1987).

ANTHROPOGENIC THREATS. Three human activities are known to threaten sperm whales: whaling, entanglement in fishing gear, and shipping. Historically, whaling represented the greatest threat to every population of sperm whales and was ultimately responsible for listing sperm whales as an endangered species. Sperm whales were hunted all over the world during the 1800s, largely for its spermaceti oil and ambergris. Harvesting of sperm whales subsided by 1880 when petroleum replaced the need for sperm whale oil (Whitehead 2003).

The actual number of sperm whales killed by whalers remains unknown and some of the estimates of harvest numbers are contradictory. Between 1800 and 1900, the International Whaling Commission estimated that nearly 250,000 sperm whales were killed globally by whalers. From 1910 to 1982, another 700,000 sperm whales were killed globally by whalers (IWC Statistics 1959-1983). These estimates are substantially higher than a more recent estimate produced by Caretta *et al.* (2005), however, who estimated that at least 436,000 sperm whales were killed by whalers between 1800 and 1987. Hill and DeMaster (1999) concluded that about 258,000 sperm whales were harvested in the North Pacific between 1947 and 1987 by commercial whalers. They reported that catches in the North Pacific increased until 1968, when 16,357 sperm whales were harvested, then declined after 1968 because of harvest limits imposed by the IWC. Perry *et al.* (1999) estimated that, on average, more than 20,000 sperm whales were harvested in the Southern Hemisphere each year between 1956 and 1976.

These reports probably underestimate the actual number of sperm whales that were killed by whalers, particularly because they could not have incorporated realistic estimates of the number of sperm whales killed by Soviet whaling fleets, which often went unreported. Between 1947 and 1973, Soviet whaling fleets engaged in illegal whaling in the Indian, North Pacific, and southern Oceans. In the Southern Hemisphere, these whalers killed an estimated 100,000 whales that they did not report to the International Whaling Commission (Yablokov *et al.* 1998). Illegal catches in the Northern Hemisphere (primarily in the North Pacific) were smaller but still caused sperm whales to disappear from large areas of the North Pacific Ocean (Yablokov and Zemsky 2000).

In addition to large and illegal harvests of sperm whales, Soviet whalers had disproportionate effect on sperm whale populations because they commonly killed adult females in any reproductive condition (pregnant or lactating) as well as immature sperm whales of either gender.

When the International Whaling Commission introduced the International Observer Scheme in 1972, the IWC relaxed regulations that limited the minimum length of sperm whales that could be caught from 11.6 meters to 9.2 meters out of a concern that too many male sperm whales were being caught so reducing this size limit would encourage fleets to catch more females. Unfortunately, the IWC's decision had been based on data from the Soviet fleets who commonly reported female sperm whales as males. As a result, the new regulations allowed the Soviet whalers to continue their harvests of female and immature sperm whales legally, with substantial consequences for sperm whale populations. Berzin noted in a report he wrote in 1977, "the result of this was that some breeding areas for sperm whales became deserts" (Berzin 2007).

Although the International Whaling Commission protected sperm whales from commercial harvest in 1981, whaling operations along the Japanese coast continued to hunt sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). More recently, the Japanese Whaling Association began hunting sperm whales for research. In 2000, the Japanese Whaling Association announced that it planned to kill 10 sperm whales in the Pacific Ocean for research, which was the first time sperm whales have been hunted since the international ban on commercial whaling. Despite protests from the U.S. government and members of the IWC, the Japanese government harvested 5 sperm whales and 43 Bryde's whales in the last six months of 2000. According to the Japanese Institute of Cetacean Research (Institute of Cetacean Research undated), another 5 sperm whales were killed for research in 2002 – 2003. The consequences of these deaths on the status and trend of sperm whales remains uncertain, given that they probably have not recovered from the legacy of whaling; however, the renewal of a program that intentionally targets and kills sperm whales before we can be certain they recovered from a history of over-harvest places this species at risk in the foreseeable future.

Sperm whales are still hunted for subsistence purposes by whalers from Lamalera, Indonesia, which is on the south coast of the island of Lembata and from Lamakera on the islands of Solor. These whalers hunt in a traditional manner: with bamboo spears and using small wooden outriggers, 10–12 m long and 2 m wide, constructed without nails and with sails woven from palm fronds. The animals are killed by the harpooner leaping onto the back of the animal from the boat to drive in the harpoon. The maximum number of sperm whales killed by these hunters in any given year was 56 sperm whales killed in 1969.

In U.S. waters in the Pacific Ocean, sperm whales are known to have been incidentally captured only in drift gillnet operations, which killed or seriously injured an average of 9 sperm whales per year from 1991 - 1995 (Barlow *et al.* 1997). Interactions between longline fisheries and sperm whales in the Gulf of Alaska have been reported over the past decade (Rice 1989, Hill and DeMaster 1999). Observers aboard Alaskan sablefish and halibut longline vessels have documented sperm whales feeding on fish caught in longline gear in the Gulf of Alaska. During 1997, the first entanglement of a sperm whale in Alaska's longline fishery was recorded, although the animal was not seriously injured (Hill and DeMaster 1998). The available evidence does not indicate sperm whales are being killed or seriously injured as a result of these interactions, although the nature and extent of interactions between sperm whales and long-line gear is not yet clear.

Sperm whales are also killed by ship strikes. In May 1994 a sperm whale that had been struck by a ship was observed south of Nova Scotia (Reeves and Whitehead 1997) and in May 2000 a merchant ship reported a strike in Block

Canyon (NMFS, unpublished data), which is a major pathway for sperm whales entering southern New England continental shelf waters in pursuit of migrating squid (CeTAP 1982, Scott and Sadove 1997).

Status

Sperm whales were listed as endangered under the ESA in 1973. Sperm whales have been protected from commercial harvest by the International Whaling Commission since 1981, although the Japanese continued to harvest sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). 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 sperm whales.

The status and trend of sperm whales at the time of this summary is largely unknown. Hill and DeMaster (1999) and Angliss and Lodge (2004) reported that estimates for population abundance, status, and trends for sperm whales off the coast of Alaska were not available when they prepared the Stock Assessment Report for marine mammals off Alaska. Similarly, No information was available to support estimates of sperm whales status and trends in the western North Atlantic Ocean (Waring *et al.* 2004), the Indian Ocean (Perry *et al.* 1999), or the Mediterranean Sea.

Nevertheless, several authors and organizations have published "best estimates" of the global abundance of sperm whales or their abundance in different geographic areas. Based on historic whaling data,190,000 sperm whales were estimated to have been in the entire North Atlantic, but the IWC considers data that produced this estimate unreliable (Perry *et al.* 1999). Whitehead (2002) estimated that prior to whaling sperm whales numbered around 1,110,000 and that the current global abundance of sperm whales is around 360,000 (coefficient of variation = 0.36) whales. Whitehead's current population estimate (2002) is about 20% of past global abundance estimates which were based on historic whaling data.

Waring *et al.* (2007) concluded that the best estimate of the number of sperm whales along the Atlantic coast of the U.S. was 4,029 (coefficient of variation = 0.38) in 1998 and 4,804 (coefficient of variation = 0.38) in 2004, with a minimum estimate of 3,539 sperm whales in the western North Atlantic Ocean.

Barlow and Taylor (2005) derived two estimates of sperm whale abundance in a 7.8 million km^2 study area in the northeastern temperate Pacific: when they used acoustic detection methods they produced an estimate of 32,100 sperm whales (coefficient of variation = 0.36); when they used visual surveys, they produced an estimate of 26,300 sperm whales (coefficient of variation = 0.81). Caretta *et al.* (2005) concluded that the most precise estimate of sperm whale abundance off California, Oregon, and Washington was 1,233 (coefficient of variation = 0.41; based on ship surveys conducted in the summer and fall of 1996 and 2001). Their best estimate of the abundance of sperm whales in Hawai'i was 7,082 sperm whales (coefficient of variation = 0.30) based on ship-board surveys conducted in 2002.

Mark and recapture data from sperm whales led Whitehead and his co-workers to conclude that sperm whale numbers off the Galapagos Islands decreased by about 20% a year between 1985 and 1995 (Whitehead *et al.* 1997). In 1985 Whitehead *et al.* (1997) estimated there were about 4,000 female and immature sperm whales, whereas in 1995 they estimated that there were only a few hundred. They suggested that sperm whales migrated to waters off the

Central and South American mainland to feed in productive waters of the Humboldt Current, which had been depopulated of sperm whales as a result of intensive whaling.

The information available on the status and trend of sperm whales do not allow us to make definitive statement about the extinction risks facing sperm whales as a species or particular populations of sperm whales. However, the evidence available suggests that sperm whale populations probably exhibit the dynamics of small populations, causing their population dynamics to become a threat in and of itself. The number of sperm whales killed by Soviet whaling fleets in the 1960s and 1970s would have substantial and adverse consequence for sperm whale populations and their ability to recover from the effects of whaling on their population. The number of adult female killed by Soviet whaling fleets, including pregnant and lactating females whose death would also have resulted in the death of their calves, would have had a devastating effect on sperm whale populations. In addition to decimating their population size, whaling would have skewed sex ratios in their populations, created gaps in the age structure of their populations, and would have had lasting and adverse effect on the ability of these populations to recover (for example, see Whitehead 2003).

Populations of sperm whales could not have recovered from the overharvests of adult females and immature whales in the 30 to 40 years that have passed since the end of whaling, but the information available does not allow us to determine whether and to what degree those populations might have stabilized or whether they have begun the process of recovering from the effects of whaling. Absent information to the contrary, we assume that sperm whales will have elevated extinction probabilities because of both exogenous threats caused by anthropogenic activities (primarily whaling, entanglement, and ship strikes) 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 caused by the legacy of overharvests of adult females and immature whales on their populations (that is, a population with a disproportion of adult males and older animals coupled with a small percentage of juvenile whales that recruit into the adult population).

Diving and Social Behavior

Sperm whales are probably the deepest and longest diving mammal: they can dive to depths of at least 2000 meters (6562 ft), and may remain submerged for an hour or more (Watkins *et al.* 1993). Typical foraging dives last 40 min and descend to about 400 m followed by about 8 min of resting at the surface (Gordon 1987; Papastavrou *et al.* 1989). However, dives of over 2 hr and as deep as 3,000 m have been recorded (Clarke 1976; Watkins *et al.* 1985). Descent rates recorded from echo-sounders were approximately 1.7m/sec and nearly vertical (Goold and Jones 1995). There are no data on diurnal differences in dive depths in sperm whales. However, like most diving vertebrates for which there are data (e.g. rorqual whales, fur seals, chinstrap penguins), sperm whales probably make relatively shallow dives at night when organisms from the ocean's deep scattering layers move toward the ocean's surface.

Adult, female sperm whales and their young form highly-social groups that have dialects specific to the group (Weilgart and Whitehead 1997), cooperate to defend young (Whitehead 1996) and nurse young calves (Reeves and Whitehead 1997). Adult and sub-adult male sperm whales are commonly solitary, although they will cooperate during feeding.

Vocalizations and Hearing

Sperm whales produce loud broad-band clicks from about 0.1 to 20 kHz (Weilgart and Whitehead 1993, 1997; Goold and Jones 1995). These have source levels estimated at 171 dB re 1 μPa (Levenson 1974). Current evidence suggests that the disproportionately large head of the sperm whale is an adaptation to produce these vocalizations (Norris and Harvey 1972; Cranford 1992; but see Clarke 1979). This suggests that the production of these loud low frequency clicks is extremely important to the survival of individual sperm whales. The function of these vocalizations is relatively well-studied (Weilgart and Whitehead 1993, 1997; Goold and Jones 1995). Long series of monotonous regularly spaced clicks are associated with feeding and are thought to be produced for echolocation. Distinctive, short, patterned series of clicks, called codas, are associated with social behavior and intragroup interactions; they are thought to facilitate intra-specific communication, perhaps to maintain social cohesion with the group (Weilgart and Whitehead 1993).

A general description of the anatomy of the ear for cetaceans is provided in the description of the blue whale above. The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate (Carder and Ridgway 1990). These data suggest that neonatal sperm whales respond to sounds from 2.5-60 kHz. Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975; Watkins *et al.* 1985). 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). Sperm whales have moved out of areas after the start of air gun seismic testing (Davis *et al.* 1995). Seismic air guns produce loud, broadband, impulsive noise (source levels are on the order of 250 dB) with "shots" every 15 seconds, 240 shots per hour, 24 hours per day during active tests. 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* 1999). Furthermore, because of their apparent role as important predators of mesopelagic squid and fish, changing the abundance of sperm whales should affect the distribution and abundance of other marine species.

3.3.7 Steller Sea Lion (eastern population)

Distribution

Steller sea lions are distributed around the rim of the North Pacific Ocean from the Channel Islands off Southern California to northern Hokkaido, Japan. In the Bering Sea, the northernmost major rookery is on Walrus Island in the Pribilof Island group. The northernmost major haulout is on Hall Island off the northwestern tip of St. Matthew Island. Their distribution also extends northward from the western end of the Aleutian chain to sites along the eastern shore of the Kamchatka Peninsula. Their distribution is probably centered in the Gulf of Alaska and the Aleutian Islands (NMFS 1992).

Within their range, land sites used by Steller sea lions are referred to as rookeries and haulouts. Rookeries are used by adult sea lions for pupping, nursing, and mating during the reproductive season (generally from late May to early July). Haulouts are used by all ages classes of both genders but are generally not where sea lions reproduce. Sea lions move on and offshore for feeding excursions. At the end of the reproductive season, some females may move with their pups to other haulout sites and males may "migrate" to distant foraging locations (Spaulding 1964). Sea lions may make semi-permanent or permanent one-way movements from one site to another (Chumbley *et al*. 1997, their Table 7; Burkanov *et al*. unpublished report [cited in Loughlin 1997]). Calkins and Pitcher (1982) reported movements in Alaska of up to1,500 km. They also describe wide dispersion of young animals after weaning, with the majority of those animals returning to the site of birth as they reach reproductive age.

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, Gisiner 1985). During the breeding season some juveniles and non-breeding adults occur at or near the rookeries, but most are on haulouts.

After the breeding season, adult male Steller sea lions disperse widely. Outside of the period from May though August, males that breed in California move north after the breeding season and are rarely seen in California or Oregon (Mate 1973).

Population Structure

Four levels of social structure have been identified among resident killer whales: the matriline, which is the most important and basic social unit and represents a stable, hierarchical group in individuals connected through maternal descent (Baird 2000, Ford *et al*. 2000, Ford 2002, Ford and Ellis 2002). Groups of related matrilines are known as pods, which are less cohesive than matrilines. Clans are the next level of social structure and are composed of pods with similar vocal dialects and a common but older maternal heritage (Ford 1991, Ford *et al*. 2000, Yurk *et al*. 2002). Southern Resident killer whales consist of three pods belonging to one clan (the J-Clan; Ford *et al*. 2000).

Threats to the Species

NATURAL THREATS. Killer whales and sharks prey on Steller sea lions, and given the reduced abundance of sea lions at multiple sites these successful predators may exacerbate the decline in local areas (e.g., Barrett-Lennard *et al*. 1995). Research suggests that the transient (migratory) killer whales may rely on marine mammal prey to a greater extent than *resident* and *offshore* killer whales (Barrett-Lennard *et al*. 1995; Matkin et al. 2002; Heise 2003; Krahn et al. 2004a). According to observations in the Gulf of Alaska, Steller sea lions may be a preferred prey in this region where researches observed 79 percent of the killer whale attacks were on Steller sea lions.

Changes in sea-surface temperatures in the North Pacific Ocean and changes in the structure and composition of the fish fauna on the North Pacific is also believed to place limits on the size of the Steller sea lions population. A shift from a cold to a warm regime that occurred in 1976-1977 was associated with dramatic changes in the structure and composition of the invertebrate and fish communities as well as the distribution of individual species in the North Pacific ocean and Bering Sea (Brodeur and Ware 1992; Beamish 1993; Francis and Hare 1994; Miller *et al*. 1994; Hollowed and Wooster 1992, 1995; Wyllie-Echeverria and Wooster 1998). Many populations of groundfish, particularly pollock, Atka mackerel, cod and various flatfish species increased in abundance as a result of strong year-classes spawned in the mid- to late 1970s. This changes in the abundance of are believed to have reduced the carrying capacity of the North Pacific Ocean for Steller sea lions.

ANTHROPOGENIC THREATS. Historically, Steller sea lions and other pinnipeds were seen as nuisances to the fishing industry and management agencies because they damaged catch and fishing gear and were thought to compete for fish (Mathisen 1959). Sea lion numbers were reduced through bounty programs, controlled hunts, and indiscriminate shooting. Steller sea lions were also killed for bait in the crab fishery. Government sanctioned control measures and harvests stopped in 1972 with the passage of the Marine Mammal Protection Act.

Commercial fisheries for groundfish (including fisheries for Atka mackerel, walleye pollock, and Pacific cod), herring, crab, shrimp, and Pacific salmon interact with Steller sea lions in a wide variety of ways, including operational conflicts (e.g., incidental kill, gear conflicts, sea lion removal of catch) and biological conflicts (e.g., competition for prey). Several parties and several biological opinions issued by NMFS have claimed that these fisheries compete with Steller sea lions for food, although the fishing industry has vigorously disputed this claim for almost two decades. One side of this dispute that asserts that the fisheries adversely affect Steller sea lions by (a) competing with sea lions for prey, particularly, walleye pollock, and (b) affecting the structure of the fish community in ways that reduce the availability of alternative prey (see for example Alaska Sea Grant 1993, NRC 1996). The other side of this dispute asserts that Steller sea lions may be harmed by diets that are dominated by walleye pollock (Rosen and Trites 2000). Others suggest that the fisheries are not the primary or a contributing cause of the Steller sea lion's decline at all; instead, they point to environmental changes (the regime shift that was discussed previously) and increased predation (primarily by killer whales) as the causative agents (for example, see Saulitis et al. 2000).

Steller sea lions are also harassed during research targeting sea lions and incidentlal 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

Steller sea lions were listed as threatened under the Endangered Species Act on November 26, 1990 (55 FR 49204). These sea lions were listed after the U.S. population declined by about 64 percent over three decades. In 1997, the species was split into two separate populations based on demographic and genetic differences (Bickham *et al*. 1996, Loughlin 1997), the western population was reclassified as endangered while the eastern population remained threatened (62 FR 30772). Critical habitat for both of these species was designated on August 27, 1993 (58 FR 45269).

Numbers of Steller sea lions declined dramatically throughout much of the species' range, beginning in the mid- to late 1970s (Braham *et al*. 1980, Merrick *et al*. 1987, NMFS 1992, NMFS 1995). For two decades prior to the decline, the estimated total population was 250,000 to 300,000 animals (Kenyon and Rice 1961, Loughlin *et al*. 1984). The population estimate declined by 50-60 percent to about 116,000 animals by 1989 (NMFS 1992), and by an additional 15 percents by 1994.

The decline has generally been restricted to the western population of Steller sea lions which had declined by about 5 percent per year during the 1990s. Counts for this population have fallen from 109,880 animals in the late 1970s to 22,167 animals in 1996, a decline of 80% (NMFS 1995). Over the same time interval, the eastern population has remained stable or increased by several percent per year, in Southeast Alaska (Sease and Loughlin 1999), in British Columbia, Canada (P. Olesiuk, Department of Fisheries and Oceans, unpublished data), and in Oregon (R. Brown, Oregon Department of Fish and Wildlife, unpublished data). Counts in Russian territories have also declined and are currently estimated to be about one-third of historic levels (NMFS 1992).

Impacts of human activity on this species

Of the two listed populations of Steller sea lions, the western population has the greatest risk of extinction. The endangered western population of Steller sea lions has declined by about 90 percent since the early 1970s and has declined dramatically throughout its range. This population is declining for many reasons and may now face threats that are different from the ones that caused the population’s initial decline. From the 1950s through the 1980s, animals from this population were killed intentionally and unintentionally by fishers, in commercial harvests, and in subsistence harvests which may have begun to destabilize the population. The harvest of over 45,000 pups from 1963 to 1972 probably changed the number of animals that recruited into the adult, breeding population (western population) and contributed to local population trends in the 1960s through the early 1980s in the Gulf of Alaska and the eastern Aleutian Islands. Similarly, subsistence harvests prior to the 1990s were not measured but may have contributed to population decline in localized areas where such harvests were concentrated.

At the same time, portions of the North Pacific Ocean have undergone major changes in temperatures that have probably contributed to a shift in the trophic structure of the fish community in the Aleutian Islands, Bering Sea, and Gulf of Alaska. This shift may explain the shift from marine systems dominated by herring and capelin to systems dominated by pollack and flatfish. At the same time, the Bering Sea, Aleutian Islands, and Gulf of Alaska ecosystems have experienced the development and expansion of major fisheries for essential sea lion prey. The fisheries have also contributed to changes in the trophic structure of these ecosystems, but as is the case with natural changes, the extent of fisheries-related effects on the ecosystems at large can not be determined. With respect to Steller sea lions, however, fisheries target important prey resources at times and in areas where sea lions forage. The actual causes or the contribution of multiple causes has been, and continues to be, subject to extensive debate.

Population viability analyses have been conducted by Merrick and York (1994) and York *et al*. (1996). The results of these analyses indicate that the next 20 years may be crucial for the western population of Steller sea lions, if the rates of decline observed in 1985 to 1989 or 1994 continue. Within two decades, it is possible that the number of adult females in the Kenai-to-Kiska region could drop to less than 5,000. Once the western population of Steller sea lions crosses this threshold, the small population size, by itself, could accelerate the population’s decline to extinction. Extinction rates for rookeries or clusters of rookeries could increase sharply in 40 to 50 years and Steller sea lions could become extinct throughout the entire Kenai-to-Kiska region in the next 100-120 years.

Diving and Social Behavior

Kenyon (1952) reported that Steller sea lions were hooked on fishing lines at depths of 183 meters. Unpublished information from NMFS’ National Marine Mammal Laboratory suggests that Steller sea lions generally feed at shallow depths, but will dive to depths of 277 meters.

Because of their polygynous breeding behavior, in which individual, adult male sea lions will breed with a large number of adult females, Steller sea lions have clearly-defined social interactions. As a result, Steller sea lions are gregarious on rookeries and haulouts and are often found in groups at sea. King (1983 in Croll *et al.* 1999) reported rafts of several hundred Steller sea lions adjacent to haulouts.

Vocalizations and hearing

Gentry (1970) and Sandegren (1970) described a suite of sounds that Steller sea lions form while on their rookeries and haulouts. These sounds include threat displays, vocal exchanges between mothers and pups, and a series of roars and hisses. Poulter (1971) reported that Steller sea lions produce clicks, growls, and bleats underwater.

Kastelein *et al*. (2005) also described the underwater vocalizations of Steller sea lions, which include belches, barks, and clicks. The underwater audiogram of the male Steller sea lion in their study had a maximum hearing sensitivity at 77 dB RL at 1 kHz. His range of best hearing, at 10 dB from the maximum sensitivity, was between 1 and 16 kHz. His average pre-stimulus responses occurred at low frequency signals. The female Steller sea lion's maximum hearing sensitivity, at 73 dB RL, occurred at 25 kHz. These authors concluded that low frequency sounds are audible to Steller sea lions.

3.3.8 Leatherback Sea Turtle

Distribution

Leatherback 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.

Leatherback sea turtles are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Morreale *et al.* 1994, Eckert 1998, Eckert 1999a). In a single year, a leatherback may swim more than 10,000 kilometers (Eckert 1998). In the North Atlantic Ocean, leatherback turtles regularly occur in deep waters (>328 ft), and an aerial survey study in the north Atlantic sighted leatherback turtles in water depths ranging from 3 to 13,618 ft, with a median sighting depth of 131.6 ft (CeTAP 1982). This same study found leatherbacks in waters ranging from 7 to 27.2°C. In the Pacific Ocean, leatherback turtles have the most extensive range of any living reptile and have been reported in all pelagic waters of the Pacific between 71°N and 47°S latitude and in all other major pelagic ocean habitats (NMFS and USFWS 1998). Leatherback turtles lead a completely pelagic existence, foraging widely in temperate waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. Males are rarely observed near nesting areas, and it has been hypothesized that leatherback sea turtles probably mate outside of tropical waters, before females swim to their nesting beaches (Eckert and Eckert 1988).

Leatherback turtles are uncommon in the insular Pacific Ocean, but individual leatherback turtles are sometimes encountered in deep water and prominent archipelagoes. To a large extent, the oceanic distribution of leatherback turtles may reflect the distribution and abundance of their macroplanktonic prey, which includes medusae, siphonophores, and salpae in temperate and boreal latitudes (NMFS and USFWS 1996). There is little information available on their diet in subarctic waters.

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.

Threats to the Species

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.

ANTHROPOGENIC 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 (NMFS and USFWS 1997).

The foremost threat is the number of leatherback turtles killed or injured in fisheries. Spotila (2000) 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% mortality rate (or 33% 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 (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 (NMFS 2008A). 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 are 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 (Castroviejo *et al.* 1994; Graff 1995). 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 *et al.* 1998). Observers on shrimp trawlers operating in the northeastern region of Venezuela documented the capture of six leatherbacks from 13,600 trawls (Marcano and Alio, 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% (Eckert and Lien, 1999). 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 (NMFS 2001). 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% of the eggs laid have been harvested. Eckert (1996) and Spotila *et al.* (1996) 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.

Status

The leatherback turtles are listed as endangered under the ESA throughout the species' global range. Increases in the number of nesting females have been noted at some sites in the Atlantic Ocean, but these are far outweighed by local extinctions, especially of island populations, and the demise of populations throughout the Pacific, such as in Malaysia and Mexico. Spotila *et al.* (1996) estimated the global population of female leatherback turtles to be only 34,500 (confidence limits: 26,200 to 42,900) nesting females; however, the eastern Pacific population has continued to decline since that estimate, leading some researchers to conclude that the leatherback is now on the verge of extinction in the Pacific Ocean (e.g. Spotila *et al.* 1996, Spotila, *et al.* 2000).

Globally, leatherback turtle populations have been decimated worldwide. In 1980, the global leatherback population was estimated at approximately 115,000 adult females (Pritchard 1982). By 1995, this global population (of adult females) is estimated to have declined to 34,500 (Spotila *et al.* 1996). Populations have declined in Mexico, Costa Rica, Malaysia, India, Sri Lanka, Thailand, Trinidad, Tobago, and Papua New Guinea. Throughout the Pacific, leatherbacks are seriously declining at all major nesting beaches.

In the Atlantic and Caribbean, the largest nesting assemblages of leatherbacks are found in the U.S. Virgin Islands, Puerto Rico, and Florida. Since the early 1980s, nesting data has been collected at these locations. Populations in the eastern Atlantic (*i.e.* off Africa) and Caribbean appear to be stable; however, information regarding the status of the entire leatherback population in the Atlantic is lacking and it is certain that some nesting populations (*e.g.*, St. John and St. Thomas, U.S. Virgin Islands) have been extirpated (NMFS and USFWS 1995). Data collected in southeast Florida clearly indicate increasing numbers of nests for the past twenty years (9.1-11.5% increase), although it is critical to note that there was also an increase in the survey area in Florida over time (NMFS 2001). However, the largest leatherback rookery in the western North Atlantic remains along the northern coast of South America in French Guiana and Suriname. Recent information suggests that Western Atlantic populations declined from 18,800 nesting females in 1996 (Spotila *et al.* 1996) to 15,000 nesting females by 2000 (Spotila, personal communication *cited in* NMFS 2001). The nesting population of leatherback turtles in the Suriname-French Guiana trans-boundary region has been declining since 1992 (Chevalier and Girondot, 1998). Poaching and fishing gear interactions are believed to be the major contributors to the decline of leatherbacks in the area.

Leatherback sea turtles appear to be in a critical state of decline in the North Pacific Ocean. The leatherback population that nests along the east Pacific Ocean was estimated to be over 91,000 adults in 1980 (Spotila 1996), but is now estimated to number less than 3,000 total adult and subadult animals (Spotila 2000). Leatherback turtles have experienced major declines at all major Pacific basin rookeries. At Mexiquillo, Michoacan, Mexico, Sarti *et al.* (1996) reported an average annual decline in nesting of about 23% between 1984 and 1996. The total number of females nesting on the Pacific coast of Mexico during the 1995-1996 season was estimated at fewer than 1,000. Less than 700 females are estimated for Central America (Spotila 2000). In the western Pacific, the decline is equally severe. Current nestings at Terengganu, Malaysia represent 1% of the levels recorded in the 1950s (Chan and Liew 1996).

While Spotila *et al.* (1996) indicated that turtles may have been shifting their nesting from French Guiana to Suriname due to beach erosion, analyses show that the overall area trend in number of nests has been negative since 1987 at a rate of 15.0 -17.3 % per year (NMFS 2001). If turtles are not nesting elsewhere, it appears that the Western

Atlantic portion of the population is being subjected to mortality beyond sustainable levels, resulting in a continued decline in numbers of nesting females.

Based on published estimates of nesting female abundance, leatherback populations are declining at all major Pacific basin nesting beaches, particularly in the last two decades (Spotila *et al.* 1996, NMFS and USFWS 1998, Spotila *et al.* 2000). Declines in nesting populations have been documented through systematic beach counts or surveys in Malaysia (Rantau Abang, Terengganu), Mexico and Costa Rica. In other leatherback nesting areas, such as Papua New Guinea, Indonesia, and the Solomon Islands, there have been no systematic consistent nesting surveys, so it is difficult to assess the status and trends of leatherback turtles at these beaches. In all areas where leatherback nesting has been documented, however, current nesting populations are reported by scientists, government officials, and local observers to be well below abundance levels of several decades ago. The collapse of these nesting populations was most likely precipitated by a tremendous overharvest of eggs coupled with incidental mortality from fishing (Sarti *et al.* 1996, Eckert, 1997).

Based on recent modeling efforts, some authors concluded that leatherback turtle populations cannot withstand more than a 1% human-related mortality level which translates to 150 nesting females (Spotila *et al.* 1996). As noted previously, there are many human-related sources of mortality to leatherbacks; every year, 1,800 leatherback turtles are expected to be captured or killed as a result of federally-managed activities in the U.S. (this total includes both lethal and non-lethal take). An unknown number of leatherbacks are captured or killed in fisheries managed by states. Spotila *et al.* (1996) recommended not only reducing fishery-related mortalities, but also advocated protecting eggs and hatchlings. Zug and Parham (1996) point out that a combination of the loss of long-lived adults in fishery-related mortalities and a lack of recruitment stemming from elimination of annual influxes of hatchlings because of intense egg harvesting has caused the sharp decline in leatherback populations.

For several years, NMFS' biological opinions have established that leatherback populations currently face high probabilities of extinction as a result of both environmental and demographic stochasticity. Demographic stochasticity, which is chance variation in the birth or death of an individual of the population, is facilitated by the increases in mortality rates of leatherback populations resulting from the premature deaths of individual sea turtles associated with human activities (either removal of eggs or adult females that are killed on nesting beaches or that die as a result of being captured in fisheries) or incidental capture and mortality of individuals in various fisheries.

In the Pacific Ocean, leatherback sea turtles are critically endangered as a direct consequence of a historical combination of overexploitation and habitat loss. The information available suggests that leatherback sea turtles have high probabilities of becoming extinct in the Pacific Ocean unless they are protected from the combined threats of entanglements in fishing gear, overharvests, and loss of their nesting habitat. The limited data available suggests that leatherback sea turtles exist at population sizes small enough to be classified as “small” populations (that is, populations that exhibit population dynamics that increase the extinction probabilities of the species or several of its populations) as evidenced by biases in the male to female ratios in the Pacific. The status of leatherback sea turtles in the Atlantic Ocean remains uncertain.

Diving and Social Behavior

The maximum dive depths for post-nesting female leatherback turtles in the Caribbean have been recorded at 475 meters and over 1,000 meters, with routine dives recorded at between 50 and 84 meters. The maximum dive length recorded for such female leatherback turtles was 37.4 minutes, while routine dives ranged from 4 -14.5 minutes (*in* Lutcavage and Lutz 1997). Leatherback turtles also appear to spend almost the entire portion of each dive traveling to and from maximum depth, suggesting that maximum exploitation of the water column is of paramount importance to the leatherback (Eckert *et al.* 1989).

A total of six adult female leatherback turtles from Playa Grande, Costa Rica were monitored at sea during their internesting intervals and during the 1995 through 1998 nesting seasons. The turtles dived continuously for the majority of their time at sea, spending 57 - 68% of their time submerged. Mean dive depth was 19 ± 1 meters and the mean dive duration was 7.4 ± 0.6 minutes (Southwood *et al.* 1999). Similarly, Eckert (1999) placed transmitters on nine leatherback females nesting at Mexiquillo Beach and recorded dive behavior during the nesting season. The majority of the dives were less than 150 meters depth, although maximum depths ranged from 132 meters to over 750 meters. Although the dive durations varied between individuals, the majority of them made a large proportion of very short dives (less than two minutes), although Eckert (1999) speculates that these short duration dives most likely represent just surfacing activity after each dive. Excluding these short dives, five of the turtles had dive durations greater than 24 minutes, while three others had dive durations between 12 - 16 minutes.

Migrating leatherback turtles also spend a majority of time at sea submerged, and they display a pattern of continual diving (Standora *et al.* 1984, *cited in* Southwood *et al.* 1999). Based on depth profiles of four leatherbacks tagged and tracked from Monterey Bay, California in 2000 and 2001, using satellite-linked dive recorders, most of the dives were to depths of less than 100 meters and most of the time was spent shallower than 80 meters. Based on preliminary analyses of the data, 75-90% of the time the leatherback turtles were at depths less than 80 meters.

Vocalizations and Hearing

There is no information on the vocalizations or hearing of leatherback sea turtles. However, we assume that their hearing sensitivities will be similar to those of green and loggerhead sea turtle: their best hearing sensitivity will be in the low frequency range: from 200 to 400 Hz with rapid declines for tones at lower and higher frequencies. Their hearing will probably have a practical upper limit of about 1000 Hz (Bartol *et al.* 1999, Ridgway *et al.* 1969).

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) the latter has sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Peterson 1966).

Chinook Salmon

Chinook salmon are the largest of the Pacific salmon and historically ranged from the Ventura River in California to Point Hope, Alaska in North America, and in northeastern Asia from Hokkaido, Japan to the Anadyr River in Russia (Healey 1991). In addition, chinook salmon have been reported in the Canadian Beaufort Sea (McPhail and Lindsey

1970). 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 general life history and 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.

Ocean Distribution and Abundance

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.

Life history information

Chinook salmon exhibit diverse and complex life history strategies. Two generalized freshwater life-history types were initially described by Gilbert (1912): “stream-type” chinook salmon reside in freshwater for a year or more following emergence, whereas “ocean-type” chinook salmon migrate to the ocean within their first year.

The generalized life history of chinook salmon involves incubation, hatching, and emergence in freshwater, migration to the ocean, and subsequent initiation of maturation and return to freshwater for completion of maturation and spawning. Juvenile rearing in freshwater can be minimal or extended. Additionally, some male chinook salmon mature in freshwater, thereby foregoing emigration to the ocean.

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, over-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

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 1976, 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 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, 1994, Popper 2008).

3.3.09 Puget Sound chinook salmon

Puget Sound chinook salmon include all runs of chinook salmon in the Puget Sound region from the North Fork Nooksack River to the Elwha River on the Olympic Peninsula. Chinook salmon in this area generally have an "ocean-type" life history. Thirty-six hatchery populations were included as part of the species and five were considered essential for this species' recovery, including spring chinook from Kendall Creek, the North Fork Stillaguamish River, White River, and Dungeness River, and fall run fish from the Elwha River.

Listing status

Puget Sound chinook salmon were listed as threatened under the ESA in 1999. Critical habitat designated for this species was designated on September 2, 2005.

Population status and trends

The largest recorded harvest of this species occurred in 1908, when the run-size for Puget Sound chinook salmon was estimated at 690,000 fish (in 1908, both ocean harvests and hatchery production were negligible). Between 1992 and 1996, the average run-size of natural chinook salmon runs in North Puget Sound was about 13,000 fish. With few exceptions, these runs represented short- and long-term declines.

3.3.10 Lower Columbia River chinook salmon

Lower Columbia River chinook salmon includes all native populations from the mouth of the Columbia River to the crest of the Cascade Range, excluding populations above Willamette Falls. The Cowlitz, Kalama, Lewis, White Salmon, and Klickitat Rivers are the major river systems on the Washington side, and the lower Willamette and Sandy Rivers are foremost on the Oregon side. 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.

Fall-run fish form the majority of these chinook salmon, which tend to migrate north once they reach the ocean. This is supported by recoveries of coded-wire-tags for lower Columbia River chinook salmon, which tend to be recovered off the British Columbia and Washington coasts, with a small proportion recovered in Alaskan waters.

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. "Tule" fall chinook salmon in the Wind and Little White Salmon Rivers are included in this species, but not introduced "upriver bright" fall-chinook salmon populations in the Wind, White Salmon, and Klickitat Rivers.

There is some question whether any natural-origin spring chinook salmon remain in this species. Fourteen hatchery populations were included in the species; one was considered essential for recovery (Cowlitz River spring chinook) but was not listed.

Listing status

Lower Columbia River chinook salmon were listed as threatened under the ESA in 1999. Critical habitat designated for this species was designated on September 2, 2005 (70 FR 2630).

Population status and trends

There are no reliable estimates of the historic abundance of Lower Columbia River chinook salmon, but experts generally agree that naturally-spawning populations of this species have declined dramatically over the last century. By the 1990s, spawning runs of this species have been sustained by hatchery production. For example, between 1991 and 1995, estimated escapements of this species have included 29,000 natural spawners and 37,000 hatchery spawners and about 68% of the natural spawners were first-generation hatchery strays (PFMC 1996).

3.3.11 California Coastal 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 September 16, 1999 (64 FR 50393), and they retained their threatened status on June 28, 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 (CDFG 1965 *in* 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. (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.

Chum Salmon

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) (Randall *et al.* 1987).

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 1976, 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, 1994, Popper 2008).

3.3.12 Columbia River Chum Salmon

Columbia River chum salmon includes all natural-origin chum salmon in the Columbia River and its tributaries in Washington and Oregon. The species consists of three populations: Grays River, Hardy, and Hamilton Creek in Washington State.

Listing status

Columbia River chum salmon were listed as threatened on March 25, 1999 (64 FR 14508). Critical habitat for this species was designated on September 2, 2005.

Population status and trends

Columbia River chum salmon abundance is probably less than 1% of historical levels, and the species has lost some (perhaps much) of its original genetic diversity. Average annual natural escapement to the index spawning areas was approximately 1,300 fish from 1990 through 1998 (Johnson *et al.* 1997).

3.3.13 Hood Canal Summer-run Chum Salmon

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.

Listing status

Hood Canal summer-run chum salmon were listed as endangered under the ESA on March 25, 1999. Critical habitat for this species was designated on September 2, 2005.

Population status and trends

Of the sixteen spawning populations of summer chum that are included in this species, seven are considered to be “functionally extinct” (Skokomish, Finch Creek, Anderson Creek, Dewatto, Tahuya, Big Beef Creek, and Chimicum). The remaining nine populations are well distributed throughout the range of the species except for the eastern side of Hood Canal; those populations are among the least productive (Johnson *et al.* 1997).

Coho Salmon

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 1976, 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, 1994, Popper 2008).

3.3.14 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.

Listing status

Central California coast coho salmon were listed as endangered under the ESA on June 28, 2005. Critical habitat for this species was designated on May 5, 1999(64 FR 24049).

Population status and trends

Historically, central California coho salmon were known to have occurred in 186 streams along the central coast of California. Spawning populations of these coho salmon have been extirpated from 71 (53 percent) of the 133 streams for which recent data are available. Based on this evidence e assume that spawning populations of this species has become extirpated from at least half of its historic distribution.

Although some of the spawning populations that remain are estimated to number in the hundreds, most of these populations have some cohorts that number in the tens of individuals; their loss would create gaps in the number of cohorts that represent a spawning population that are equivalentr to the loss of year-classes of age-structured populations. The largest cohorts of several other spawning populations ─ for example at Olema, Noyo, and Scott Creeks ─ are estimated to number less than 200 individuals while the smaller cohorts are estimated to number about 23 (Olema Creek), 59 (Noyo Creek), 9 (Scott Creek) individuals with declining trends. These sizes are small enough to leave these cohorts with high risks of declining to zero in the short term. None of the remaining spawning populations of central California coastal coho salmon are large enough to “rescue” the spawning populations that have been extirpated or that are on the brink of being extirpated.

The combination of the threats facing this species of coho salmon (habitat loss and landscape alteration associated with the urban, suburban, and exurban centers of the San Francisco Bay region; water pollution, competition and predation by exotic species) and the species’ status and trend , this species faces severe and imminent risks of extinction in the near future.

3.3.15 Southern Oregon/Northern California Coast Coho Salmon

Southern Oregon/Northern California coasts coho salmon (SONCC) consists of all naturally spawning populations of coho salmon that reside below long-term, naturally impassible barriers in streams between Punta Gorda, California and Cape Blanco, Oregon. The geographic area of the listed species encompasses five of the seven hatchery stocks reared and released within the species’ range of the species although none of the hatchery populations are listed. The three major river systems supporting SONCC coho are the Rogue, Klamath (including the Trinity), and Eel rivers.

Listing status

SONCC coho salmon were listed as endangered under the ESA on June 28, 2005. Critical habitat for this species was designated on May 5, 1999(64 FR 24049).

Population status and trends

Of the 396 streams within the range of the California portion of the SONCC species that were identified as once having coho salmon runs, recent survey information is available for 115 streams (29 percent). Of these 115 streams, 73 (64 percent) still support coho salmon runs while 42 (36 percent) have lost their coho salmon runs. The rivers and tributaries in the California portion of the SONCC species were estimated to have average recent run sizes of 7,080 natural spawners and 17,156 hatchery returns, with 4,480 identified as native fish occurring in tributaries having little history of supplementation with non-native fish (Brown *et al.* 1994).

Steelhead

Five threatened or endangered species of steelhead are known to occur in the action area for this consultation. Unlike Pacific salmon, steelhead are capable of spawning more than once before death (iteroparity). However, steelhead rarely spawn more than twice before dying; most that do so are females (August 9, 1996, 61 FR 41542). Biologically, steelhead can be divided into two basic run-types: the stream-maturing type, or summer steelhead, enters fresh water in a sexually immature condition and requires several months in freshwater to mature and spawn and the ocean-maturing type, or winter steelhead, enters fresh water with well-developed gonads and spawns shortly after river entry (August 9, 1996, 61 FR 41542; Burgner *et al*. 1992). Variations in migration timing exist between populations. Some river basins have both summer and winter steelhead, while others only have one run-type.

Ocean Distribution and Abundance

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 (NMFS 1999a).

General life history information

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 (Meehan and Bjornn 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 (Bell 1991), and the timing of spawning overlaps between populations regardless of run type (Busby *et al*. 1996).

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 1973). 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, then migrate 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).

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 1976, 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, 1994, Popper 2008).

3.3.16 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% hatchery; 3,500 wild summer steelhead).

3.3.17 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 52630).

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 4400 adults in the 1930's to an average of 30 wild adults in 1996.

3.3.18 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; excluded is the Sacramento-San Joaquin River Basin of the Central Valley of 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 52630).

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% of historical abundanced. There are no recent estimates of abundance for this species.

3.3.19 Green sturgeon

Distribution

The green sturgeon, *Acipenser medirostris*, is an anadromous species inhabiting Asian and American shorelines of the northern Pacific Ocean (Moyle 2002; Antonenko *et al*. 2003). In North America, green sturgeon occur from the Bering Sea to Ensenada, Mexico.

The southern population of green sturgeon, which spawns in the Sacramento River watershed, has been listed as a threatened species. Individuals from this population have been documented to occur from San Pablo Bay, California, to as far north as Gray's Harbor, Washington, and as far south as Santa Cruz, California (Chadwick 1959; Miller 1972).

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, NMFS 2006). Green sturgeon occur throughout the upper Sacramento River and have been reported to occur in the Feather River as well. 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).

Threats to the Species

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; Lackey 2009).

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). Klamath River green sturgeon have been central to members of the Yurok Tribe for thousands of years, whose fishery for green sturgeon is integral to the tribe’s culture (Van Eenennaam *et al*. 2001). From 1994 to 2003 the Yurok gill-net fishery harvested an average of 238 fish annually (D.C. Hillemeier, unpublished data); other 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 2001). 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

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.

Vocalizations and Hearing

We do not have specific information on hearing in green sturgeon. However, 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*. (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 a 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.

3.3.20 Pacific Eulachon (southern population)

Distribution

Eulachon, *Thaleichthys pacificus*, 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 (Hubbs 1925, Schultz and DeLacy 1935, McAllister 1963, Scott and Crossman 1973, Willson *et al*. 2006). 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, Monaco *et al*. 1990). 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 (74 FR 10857).

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) (Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife 2001). Historically, there may have been a population in the Klamath River (74 FR 10857).

Threats to the Species

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 (74 FR 10860).

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). In Canada, bycatch of eulachon in shrimp fisheries has been significant enough to cause the Canadian Department of Fisheries and Oceans to close the fishery in some years (DFO, 2008).

Status

The southern population of eulachon was listed as threatened on 18 March 2010 (74 FR 10857). Critical habitat has not been designated for this species.

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 species in the family Salmonidae have similar auditory systems and hearing sensitivities (Popper 1976, 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 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, 1994, Popper 2008).

4.0 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 biological opinion includes the effects of several activities that affect the survival and recovery of endangered whales in the action area.

A number of human activities have contributed to the current status of populations of large whales and sea turtles in the action area. Some of those activities, most notably commercial whaling, occurred extensively in the past, ended, and no longer appear to affect these whale populations, although the effects of these reductions likely persist today. Other human activities are ongoing and appear to continue to affect populations of endangered and threatened whale and sea turtle. 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.

4.1 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 Keyport Range Complex and most of the training associated with the Northwest Training Range Complex occurs 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 (U.S. Geological Survey 1979). 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, Puya llup, 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 metres (510 ft), with a maximum depth of 420 meters (1,400 ft). Its surface area is approximately 6,800 square kilometres (2,600 sq mi). The Fraser River accounts for 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 sometimes known as the Salish Sea). Of this total, about four million (57 per cent) people lived in the United States and three million (43 per cent) 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 Regional District and King County 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, which is a foraging destination for blue whales and fin whales and which might support a resident population of blue whales (Burtenshaw *et al*. 2004), are also important for the continued persistence and recovery of blue whales.

4.2 Stressors

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 (Lambertson *et al.*

1986). A well-documented observation of killer whales attacking a blue whale off Baja, California, demonstrates 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.

Targeted Hunts

Southern resident killer whales were once shot deliberately in Washington and British Columbia (Scheffer and Slipp 1948, Pike and MacAskie 1969, Olesiuk *et al*. 1990, Baird 2001). Until 1970, about 25 percent of the killer whales that were captured for aquaria had bullet scars (Hoyt 1990). The effect of these attacks on individual whales or the population itself remains unknown. 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.

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 (see Table 4). 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.

As we discussed in the *Status of the Species* section of this Opinion, 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 *et al*. 2006) — 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

Salmon are incidentally caught in several fisheries that operate in the action area, including groundfish fisheries that operate off the coasts of Washington, Oregon, and California; 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

Table 4. Number of marine mammals reported to have been killed or injured in collisions with ships in the the Puget Sound Region (after Douglas et al. 2008, Jensen and Silber 2004, Laist et al. 2001)

Year	Species	Location	State/Province	Outcome
1973	Killer whale (offshore)	Strait of Georgia	British Columbia	Serious injury
1989	Blue whale	Tacoma	Washington	Dead
1995	Killer whale, northern resident	not reported	British Columbia	Non-fatal injury
1998	Killer whale, southern resident	Haro Strait	British Columbia	Non-fatal strike
1999	Fin whale	not reported	British Columbia	Dead
2002	Fin whale	Puget Sound	Washington	Dead
2002	Fin whale	Puget Sound	Washington	Dead
2002	Fin whale	Puget Sound	Washington	Dead
2002	Fin whale	Puget Sound	Washington	Dead
2004	Fin whale	West coast Vancouver Island	British Columbia	Dead
2004	Humpback whale	West coast	Washington	Dead
2005	Killer whale, northern resident	Johnstone Strait	British Columbia	Non-fatal strike
2005	Killer whale, southern resident	Haro Strait	British Columbia	Non-fatal strike
2006	Fin whale	Northwest inland waters	Washington	Dead
2006	Fin whale	Puget Sound	Washington	Dead
2006	Humpback whale	Knight Inlet	British Columbia	Unknown
2006	Humpback whale	Swiftsure Bank, Vancouver Island	British Columbia	Unknown
2006	Humpback whale	Johnstone Strait	British Columbia	Observed injured before it was lost from sight
2006	Humpback whale	Johnstone Strait	British Columbia	Serious injury
2006	Killer whale, northern resident	Campbell River	British Columbia	Injured and died following year
2006	Killer whale, northern resident	Prince Rupert	British Columbia	Dead
2006	Killer whale, northern resident	Campbell River	British Columbia	Non-fatal strike (calf A82 injured)
2006	Killer whale, northern resident	Johnstone Strait	British Columbia	Serious injury
2006	Killer whale, southern resident	Nootka Sound, Vancouver Island	British Columbia	Dead
2007	Killer whale (offshore)	Johnstone Strait	British Columbia	Serious injury (dorsal cut off)

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 2006). The bottom trawl component of the groundfish fishery was expected to capture between 6,000 and 9,000 chinook salmon 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. These bycatch levels compare to a catch of Chinook in the commercial ocean salmon troll fisheries that operate off the coasts of Oregon and Washington that has averaged 321,533 from 2002-2006 (Pacific Fisheries Management Council 2007).

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 Degradaton

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 (Puget Sound Action Team 2007). Between 1991 and 2001, the area of impervious surface in the Puget Sound basin increased 10.4 percent (Puget Sound Action Team 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 (Puget Sound Action Team 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 (Black and Silkey, 1998).

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 (Black and Silkey, 1998). 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 (Staubitz and others, 1997). 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 (Staubitz and others, 1997). 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 (Morgan and Jones, 1999), 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 retardents 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 (Puget Sound Action Team 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 PCB, DDT, and flame –retardents have also been documented in southern resident killer whales (Ross 206, Ross *et al*. 2000, Ylitalo *et al*. 2001, Herman *et al*. 2005). Although the consequences of these pollutants on the fitness of individuals killer whales and the population itself remain unknown, in other species these pollutants have been reported to suppress immune responses (Kakushke 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.

Ambient Noise

Ambient noise is background noise in the environment. When one considers the distance from its source that a signal can be detected, the intensity and frequency characteristics of ambient noise are important factors to consider in combination with the rate at which sound is lost as it is transmitted from its source to a receiver (Richardson et al. 1995). Generally, a signal would be detectable or salient only if it is stronger than the ambient noise at similar frequencies. The lower the intensity of ambient noise, the farther signals would travel and remain salient.

There are many sources of ambient noise in the ocean, including wind and waves, rain and hail, human activities such as shipping, fishing boats, and seismic surveys; sounds produced by living organisms, seismic noise from volcanic and tectonic activity, and thermal noise that results from molecular agitation (which is important at frequencies greater than 30 kHz). We discuss two general categories of ambient noise: deep water ambient noise and shallow water ambient noise.

DEEP WATER AMBIENT NOISE. Urick (1983) discussed 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 frequency spectrum and level of ambient noise 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.

SHALLOW WATER AMBIENT NOISE. In contrast to deep water, ambient noise levels in shallow waters (i.e., coastal areas, bays, harbors, etc.) are subject to wide variations in level and frequency depending on time and location. The primary sources of noise include distant shipping and industrial activities, wind and waves, 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 (1969) 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.

PATTERNS OF CHANGE IN AMBIENT NOISE IN THE ACTION AREA. Several authors have reported that ambient noise levels in the northeast Pacific Ocean increased between the mid-1960s, the mid-1990s, and the early 2000s. Andrew *et al*. (2002) reported that ambient sound levels increased by about 10 dB in the frequency ranges between 20 and 80 Hz and 200 and 300 Hz between the period from 1963 to 1965 and 1994 to 2001. In the frequency range between 200 and 300 Hz, ambient sound levels increased by about 3 dB. Since the 1960s, ambient noise in the 30–50 Hz band has increased by 10–12 dB, with most of this increase resulting from changes in commercial shipping (McDonald *et al*. 2006) and increases in whale song (Andrew *et al*. 2002). In this time interval, the number of commercial vessels increased (Mazzuca, 2001) along increases in the average gross tonnage and horsepower per vessel.

Measurements taken at San Nicholas Island, which were considered representative of patterns that would occur across the Pacific Coast of California, Oregon, and 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).

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 1994, 1996, 2000, 2003, 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.

COMMERCIAL SHIPPING. Commercial shipping traffic is a major source of low frequency (5 to 500 Hz) human generated sound in the world’s oceans (National Research Council 2003, Simmonds and Hutchinson 1996). The U.S. Navy estimated that the 60,000 vessels of the world’s merchant fleet annually emit low frequency sound into the world’s oceans for the equivalent of 21.9 million days, assuming that 80 percent of the merchant ships at sea at any one time (U.S. Navy 2001). 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. NRC (1997) 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; Mintz and Filadelfo 2004a, 2004b). Andrew *et al*. (2010) estimated that the background ocean noise level at 100 Hz has been increasing by about 1.5 dB per decade since the advent of propeller-driven ships.

Michel *et al.* (2001) suggested an association between long-term exposure to low frequency sounds from shipping and an increased incidence of marine mammal mortalities caused by collisions with shipping. At lower frequencies, the dominant source of this noise is the cumulative effect of ships that are too far away to be heard individually, but because of their great number, contribute substantially to the average noise background.

U.S. NAVY TRAINING ACTIVITIES. The U.S Navy has conducted research, development, test, and evaluation activities on the Keyport Range Complex since the mid-1950s. Historically, the number of days each range site has been used have averaged about 60 days for the Keyport Range Site, 130 days for the Dabob Bay Site, and 20 days for the Quinault Underwater Tracking Range Site. Currently, the U.S. Navy uses the Keyport Range Site for an average annual of 55 days, the Dabob Bay Site for an annual average of 200 days, and the Quinault Underwater Tracking Range Site for an annual average of 14 days. At the Quinault Underwater Tracking Range, the U.S. Navy proposes to increase the average annual use from 14 days to 16 days.

As discussed in the *Description of the Proposed Action*, the U.S. Navy has conducted training activities in the Northwest Training Range Complex for decades and has conducted training at current intensities and frequencies for about 10 years. These activities have typically occurred in the W-237 areas that are about 12 kilometers off the coast of northern Washington (according to the U.S. Navy, training rarely occurs off the coasts of Oregon and California). Those training activities have included tracking exercises with maritime patrol aircraft (200 events), tracking exercises with extended echo ranging (10 events), tracking exercises with surface ships (24 events per year employing AN/SQS-53c sonar for a total of 36 hours of active sonar and 36 events per year employing AN/SQS-56 sonar for a total of 54 hours of active sonar), tracking exercises with submarines (96 events with passive sonar), electronic combat exercises, mine warfare exercises (which occurred at higher frequencies than with the proposed action), naval special warfare, strike warfare, and support activities.

Thus far, the impacts of these training activities on endangered or threatened species in the action area have not been apparent. Nevertheless, on May 5, 2003, the U.S. Navy guided missile destroyer *USS Shoup* passed through the strait while operating its mid-frequency sonar during a training exercise. Members of the J pod of southern resident killer whales were in the strait at the same time and exhibited unusual behavior in response to being exposed to sonar at received levels of about 169 dB (Fromm 2004, NMFS 2004, U.S. Navy, Pacific Fleet 2004). Based on the duration and received levels, and the levels known to cause behavioral reactions in other cetaceans, NMFS concluded that J pod had been exposed to the sonar at received levels that were likely to cause behavioral disturbance, but not temporary or permanent hearing loss (NMFS 2004). These findings were consistent with the reports generated from the eyewitness accounts of the event.

RECREATIONAL VESSELS. Recreational fishing boats are also common in the area and represent 11 percent of the vessels operating in the vicinity of Southern Residents from June-September 2003 (Koski 2004). When operating at slow speeds or in idle, these boats usually do not appear to disrupt the whales' behavior (Krahn *et al*. 2004).

WHALE WATCH VESSELS. Erbé (2002) 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 meters 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 an 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 Jr. (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% during the last of the three time periods (2001 to 2003). At the same time, Holt *et al*. (2007) 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 (Swingle *et al.* 1993; Wiley *et al.* 1995). 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 Green 2004; Lusseau 2006). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jackson 1994, Evans *et al.* 1992, 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels is 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, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al.* 2002, Richter *et al.* 2003, Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams *et al.* 2002). 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.

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 Keyport Range Complex and most of the training associated with the Northwest Training Range Complex occurs 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 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.

As discussed in the *Status of the Species* section of this Opinion, 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 degration 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).

5.0 Effects of the Proposed Action

In *Effects of the Action* sections of Opinions, NMFS presents the results of its assessment of the probable direct and indirect effects of federal actions that the subject of a consultation as well as the direct and indirect effects of interrelated, and interdependent actions on threatened and endangered species and designated critical habitat. As we described in the *Approach to the Assessment* section of this Opinion, we organize our effects' analyses using an stressor identification - exposure – response – risk assessment framework; we conclude this section with an *Integration and Synthesis of Effects* that integrates information we presented in the *Status of the Species* and *Environmental Base* sections of this Opinion with the results of our exposure and response analyses to estimate the probable risks the proposed action poses to endangered and threatened species.

Before we begin, we need to address a few definitions. The Endangered Species Act does not define "harassment" nor has NMFS defined this term, pursuant to the ESA, through regulation. However, for military readiness activities, the Marine Mammal Protection Act of 1972, as amended, defines "harassment" as "any act that injures or has the potential to injure a marine mammal or marine mammal stock in the wild" or "any act that disrupts or is likely to disturb a marine mammal or marine mammal stock by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered" (Public Law 106-136, 2004). The latter portion of these definitions (that is, "...causing disruption of behavioral patterns including…migration, breathing, nursing, breeding, feeding, or sheltering") is almost identical to the U.S. Fish and Wildlife Service's definition of harass[3] for the purposes of the Endangered Species Act of 1973, as amended.

For this Opinion, we define "harassment" similarly: "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." We are particularly concerned about changes in animal behavioral 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.

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[3] An intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.4)

5.1 Potential Stressors

The U.S. Navy has conducted military readiness activities in waters on and adjacent to the Keyport Range Complex and the Northwest Training Range Complex (the Action Area) for decades and the potential stressors listed in the following paragraphs have been associated with those earlier activities. As a result, it is more accurate to say that the U.S. Navy's proposes to continue conducting military readiness activities in the Action Area and the Permits Division proposes to authorize the "take" of marine mammals associated with those reseach, development, test and evaluation activities. By extension, the potential stressors associated with the Navy's proposal are stressors that have occurred previously in the Action Area as well.

We discuss the potential stressors associated with the activities the U.S. Navy proposes to conduct on the Keyport Range Complex and on the Northwest Training Range Complex in greater detail in the narratives that follow this introduction. We follow those descriptions with a presentation of the results of our exposure analyses, which are designed to determine whether endangered or threatened individuals are likely to be exposed to one or more of these potential stressors (we do not address critical habitat in this section of our analyses because we had previously concluded that the proposed activities were not likely to adversely to affect critical habitat). We follow those analyses with the results of our response analyses.

As discussed in the *Approach to the Assessment* section of this Opinion, because direct or indirect exposure to a stressor is a necessary condition for an effect, if endangered or threatened individuals are not likely to be exposed to a potential stressor, that "potential stressor" is not likely to be an actual stressor so we would drop it from further discussion. As outlined in the introductory paragraph of this section, we conclude our effects analyses with an Integration and Synthesis which contains the results of our risk analyses.

5.1.1 Stressors Associated with the Keyport Range Complex

The potential stressors we expect to result from the research, development, test, and evaluation activities the U.S. Navy plans to conduct at the Keyport Range Complex are:

1. the risk of collisions between surface vessels, unmanned underwater vehicles, torpedoes, and targets the U.S. Navy plans to employ as part of the proposed research, development, test, and evaluation activities.
2. sound fields produced by the acoustic devices the U.S. Navy would employ during the research, development, test, and evaluation activities;
3. expendable materials; and
5. disturbance produced by the research, development, test, and evaluation activities.

Several elements of the research, development, test, and evaluation activities the U.S. Navy plans to conduct at the Keyport Range Complex are not likely to produce stressors for endangered and threatened species under the jurisdiction of the National Marine Fisheries Service, although they might represent stressors for species under the jurisdiction of the U.S. Fish and Wildlife Service.

1. LIDAR, or **Li**ght **D**etection **a**nd **R**anging, is used to measure distance, speed, rotation, and chemical composition and concentration of remote solid objects such as a ship, or diffuse objects such as a smoke

plume or cloud. LIDAR uses the same principle as radar. The LIDAR instrument transmits short pulses of laser light towards the target. The transmitted light interacts with and is changed by the target. Some of this light is reflected back to the instrument where it is analyzed. The change in the properties of the light enables some property of the target to be determined. The time it takes the light to travel to the target and back to the LIDAR can be used to determine the distance to the target. Since light attenuates rapidly in water, LIDAR that is designed to penetrate water uses light in the blue-green part of the spectrum as it attenuates the least. LIDAR is used commercially to map the ocean floor and detect fish during migration. The best information available leads us to conclude that endangered and threatened species are not likely to be exposed to this technology and, if exposed, they are not likely to respond to that exposure.

2. Inert mine-shapes. Associated with testing, a series of target inertmine shapes are set out in a uniform or random pattern to test the detection, classification and localization capability of the system under test. They are made from plastic, metal, and concrete and vary in shape. For example, an inert-mine shape can measure about 10 by 1.75 ft (3.0 by 0.5 m) and weigh about 800 lbs (362.0 kg). Inert-mine shapes either sit on the bottom or are tethered by an anchor to the bottom at various depths. Inert-mine shapes can be placed approximately 200 – 300 yards (183 – 274 m) apart using a support craft and remain on the bottom until they need to be removed. For example a concrete clump can be put on the bottom. It may be initially identified as a possible inert mine, but as the sensor becomes more sophisticated it will mark the clump as a false target and move on to locate other more probable inert-mine shapes. All major components of all inert-mine systems used as ‘targets’ for inertmine hunting systems are removed within 2 years after use.

   The potential for direct physical contact between a marine mammal and an inert-mine shape is extremely low given the low probability of occurrence of a marine mammal in the area and the negligible probability that a marine mammal would collide with an inert mine shape. It is expected that any marine mammal encountering an inert-mine shape would simply avoid it much as it would avoid a rocky outcrop along the sea floor. The best information available leads us to conclude that endangered and threatened species are not likely to be exposed to this technology and, if exposed, they are not likely to respond to that exposure.

Risk of Collisions

The U.S. Navy proposes to employ two types of unmanned underwater vehicles within the Dabob Bay: “swimmers” and “crawlers.” “Swimmer” unmanned underwater vehicles are self-powered, submersible vehicles 2 – 32 ft (0.6-9.8 m) long, controlled by an onboard navigation system. “Swimmers” are typically placed into and retrieved from the water with a crane located at the Keyport pier.

“Crawler” unmanned underwater vehicles are self-powered underwater vehicles designed to operate on land, in the surf zone, or in very shallow water. They can measure about 2.5 ft (0.8 m) long and weigh about 90 pounds (40.8 kg). They move along the bottom on tracks. “Crawlers” have many of the same capabilities as “swimmers,” but operate along the bottom or in waters too shallow for “swimmers.”

Due to the ability to conduct shore-to-shore and ship-to-shore surveillance and daily boat traffic in the area, it is highly unlikely that a cetacean could enter the Dabob Bay Site without being detected. In addition to the 100-yd (91.4-m) exclusion zone for pinnipeds, pinnipeds are smaller and more maneuverable than cetaceans and are not expected to be susceptible to a collision with unmanned underwater vehicles.

Some unmanned underwater vehicles communicate with a surface vessel, shore-based, or pier-based facility with a 0.01 inch (254-micron) diameter fiber-optic cable. The cable is made of very fine glass and is very brittle. Due to the extremely small diameter of the fiber-optic cable, if a marine mammal or leatherback sea turtles encountered the cable it would probably break immediately which would eliminate a whale's probability of becoming entangled in the cable. As a result, these cables are not likely to adversely affect marine mammals or leatherback sea turtles; this cable would not represent a potential stressors for endangered or threatened species of fish.

VESSELS, TORPEDOES, AND TARGETS. Keyport has policies and procedures within the Range Operating Procedures to reduce the potential for collisions with marine mammals at the surface or underwater. Observations for marine mammals are conducted prior to each test, and tests 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 (U.S. Navy 2008).

In addition, NMFS' Permits Division asked the U.S. Navy to adopt measures that would prevent vessels intentionally approaching within 91 meters (100 yards) of marine mammals. In response to that request, the U.S. Navy will require all naval vessels and aircraft, including all helicopters, under the control of Keyport to comply with this recommendation. Vessels are expected to implement actions, where feasible, to avoid interactions with marine mammals, including maneuvering away from the marine mammal or slowing the vessel. Due to the ability to conduct shore-to-shore and ship-to-shore surveillance and daily boat traffic in the area, it is unlikely that a whale could enter the within the vicinity of the Dabob Bay Range Complex without being detected. However, during reduced visibility conditions (i.e., fog, high sea state, darkness) detecting marine mammals requires more diligence. Historically there has not been a reported vessel strike of a marine mammal within the vicinity of the Dabob Bay Range Complex, including periods of reduced visibility. A collision between a vessel and a marine mammal is considered extremely unlikely.

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., minke, humpback) which generally do not occur within the vicinity of the Dabob Bay Range Complex.

Targets are used to simulate potential threat platforms (i.e., something that simulates a real-world threat) or to stimulate the system under test. They are often equipped with one or a combination of the following devices: shapes that reflect acoustic energy, acoustic projectors, and magnetic sources to trigger magnetic detectors.

There is a negligible risk of a collision between an unmanned underwater vehicle, torpedo, or a target and a marine mammal. Large and/or slow-moving species would be more at risk of being struck than smaller, faster swimmers. Upon review of the Navy's use of torpedoes in training and testing exercises over the past 30 years, there have been no recorded or reported cases of a marine mammal being struck (Navy 2002b). Historically there has not been a reported torpedo strike of a marine mammal within the within the vicinity of the Dabob Bay Range Complex. The implementation of Keyport ROP when cetaceans are present make the possibility of a collision between a marine mammal and a torpedo even more unlikely.

During an air drop of a torpedo, a variety of accessories are also released, all of which consist of materials that are considered to be non-hazardous. Depending on the type of launch craft used, MK 46 Torpedo air launch accessories may consist of a nose cap, suspension bands, air stabilizer (parachute), release wire, and propeller baffle. These accessories could be ingested by or entangle marine mammals. Most pieces vary in size and sink rapidly, but are too small to recover individually. The air stabilizer canopy could billow, potentially posing an entanglement threat to marine mammals that feed on the bottom. With the exception of a highly unlikely encounter of a marine mammal or sea turtle with the air launch accessories as they sink, these accessories are not likely to adversely affect the endangered or threatened species we consider in this Opinion.

Acoustic Devices

As discussed in the *Description of the Proposed Action* section of this Opinion, the U.S. Navy employs a wide variety of acoustic and non-acoustic systems on the Keyport Range Complex (see Table 5, which is a repeat of Table 2). These include general range tracking on the instrumented ranges and portable range sites have active output in narrow frequency bands. Operating frequencies are 10 to 100 kHz. At the Keyport Range Site, the sound pressure level (SPL) of the source (source level) is a maximum of 195 decibels reference 1 micro Pascal at 1 meter (dB re 1 μPa @ 1 m). At the Dabob Bay and Quinault Underwater Tracking Range sites, the source level for general range tracking is a maximum of 203 dB re 1 μPa @ 1 m.

Table 5. Primary Acoustic Sources Routinely Used within the NAVSEA NUWC Keyport Range Complex

Active Acoustic Source	Frequency (kHz)	Maximum Source Level (dB re 1 μPa @ 1 m)
Sonars		
General range tracking (at Keyport Range Site)	10 – 100	195
General range tracking (at DBRC and QUTR Sites)	10 - 100	203
unmanned undersea vehicle tracking	10 – 100	195
Torpedoes	10 - 100	233
Range targets and special tests (at Keyport Range Site)	5 – 100	195
Range targets and special tests (at DBRC and QUTR Sites)	5 – 100	238
Special sonars (e.g., unmanned undersea vehicle payload)	100 – 2,500	235
Fleet aircraft—active sonobuoys and helo-dipping sonars	2 – 20	225
Side-scan	100 – 700	235
Other Acoustic Sources		
Acoustic modems	10 – 300	210
Target simulator	0.1 - 10	170
Aid to navigation (range equipment)	70 - 80	210
Sub-bottom profiler	2 - 7	210
	35 - 45	220
Engine noise (surface vessels, submarines, torpedoes, unmanned undersea vehicles)	0.05 – 10	170

Unmanned undersea vehicle tracking systems operate at frequencies of 10 to 100 kHz with maximum source levels of 195 dB re 1 μPa @ 1 m at all range sites. Torpedo sonars are used for several purposes including detection, classification, and location and vary in frequency from 10 to 100 kHz. The maximum source level of a torpedo sonar is 233 dB re 1 μPa @ 1 m. Range targets and special test systems are within the 5 to 100 kHz frequency range at the Keyport Range Site with a maximum source level of 195 dB re 1 μPa @ 1 m. At the Dabob Bay and Quinault Underwater Tracking Range sites, the maximum source level is 238 dB re 1 μPa @ 1 m. Special sonars can be carried as a payload on a unmanned undersea vehicle, suspended from a range craft, or set on or above the sea floor. These can vary widely from 100 kHz to a very high frequency of 2,500 kHz. The maximum source level of these acoustic sources is 235 dB re 1 μPa @ 1 m. Sonobuoys and helicopter dipping sonars are deployed from Fleet aircraft and operate at frequencies of 2 to 20 kHz with maximum source levels of 225 dB re 1 μPa @ 1 m. Dipping sonars are active or passive devices that are lowered on cable by helicopters or surface vessels to detect or maintain contact with underwater targets. Side-scan sonar is used for mapping, detection, classification, and localization of items on the sea floor such as cabling, shipwrecks, and mine shapes. It is high frequency typically 100 to 700 kHz using multiple frequencies at one time with a very directional focus. The maximum source level is 235 dB re 1 μPa @ 1 m. Side-scan and multibeam sonar systems are towed or mounted on a test vehicle or ship.

Most of the active sonar the U.S. Navy proposes to employ during the research, development, test, and evaluation activities the Navy plans to conduct in waters on and adjacent to the Keyport Range Complex and the Northwest Training Range Complex would consist of mid-frequency active sonar that are represented by the sources identified in Table 6. Center frequencies for these acoustic systems range from 4.5 to 150 kHz with sound pressure levels ranging from below 186 dB to 233 dB.

In the future, the U.S. Navy would employ a variety of other acoustic sources including unmanned underwater vehicle payload and side-scan sonars that produce transmissions with frequencies higher than 100 kHz; range tracking, torpedoes, and range targets in the 5 to 100 kHz range; and target simulators and sub-bottom profilers at approximately 5 kHz.

Table 6. Acoustic sources that are representative of sources the U.S. Navy proposes to use at the Keyport Range Complex

Acoustic Source	Frequency (kHz)	Source Level (dB re 1 μPa @ 1 m)	Typical Duration of Transmissions
Sub-bottom Profiler	4.5	207	4 hours
UUV 1	15.0	205	2 hours
UUV Acoustic Modem	10.0	186	2 hours
UUV 2	150.0	220	2 hours
Range Target	5.0	233	20 minutes
Test Vehicle 1	20.0	233	10 minutes
Test Vehicle 2	25.0	230	10 minutes
Test Vehicle 3	30.0	233	10 minutes

During transmissions, these acoustic sources would be detectable at various distances, with the lower-frequency sources generally being detectable at greater distances and the higher-frequency sources being detectable at shorter distances. For example, the U.S. Navy estimated that signals produced by Test Vehicle 1 would be detectable at received levels greater than 200 dB within 45 meters of the source; at received levels between 190 and 200 dB between 45 and 140 meters of the source; at received levels between 180 and 190 dB between 140 and 400 meters of the source; and at received levels between 170 and 180 dB between 400 and 1 kilometer of the source. Received levels would drop below 150 dB atdistances between 4 and 12 kilometers of the source.

Expendable Materials

Activities within the Dabob Bay Site would produce few expendable materials. There may be some parts of targets, torpedo launching accessories, sonobuoys, markers, target parts and components that are not recovered and may be encountered by marine mammals. The primary hazards to marine mammals from expendable materials are entanglement and injury due to ingestion. Major components are recovered to the maximum extent practicable.

Keyport is known for being able to recover test and other components, providing assistance to the Federal Aviation Administration to locate and recover downed planes, etc. Most marine mammal species feed at the surface or in the water column. Consequently, it is unlikely that marine mammals would ingest expendable materials because most large materials are recovered and other materials would sink to the bottom. Species that feed on or near the bottom may encounter expended materials; however, it is unlikely they would ingest the materials as they are dissimilar from natural prey items. Activities within the vicinity of the Dabob Bay Range Complex would produce few expendable materials and the likelihood of a marine mammal encountering, much less ingesting, expended material is negligible. All packaging, food wastes, and trash that are generated by the range craft during the course of an exercise are required to be retained on board until return to port where they are properly disposed of in a landfill or recycled.

5.1.2 Stressors Associated with the Northwest Training Range Complex

The potential stressors we expect to result from the research, development, test, and evaluation activities the U.S. Navy plans to conduct at the Northwest Training Range Complex are:

1. the risk of collisions between surface vessels, unmanned underwater vehicles, torpedoes, and targets;
2. sound fields produced by active sonar;
3. shock waves and sound fields produced by bombing operations and underwater detonations;
4. ordnance and projectiles associated with bombing exercises, missile exercises, and firing operations;
5. disturbance produced by the vessels involved in those the research, development, test, and evaluation activities.
6. expendable materials; and
7. disturbance produced by surface and sub-surface activities during training missions.

Several elements of the research, development, test, and evaluation activities the U.S. Navy plans to conduct at the Keyport Range Complex are not likely to produce stressors for endangered and threatened species under the jurisdiction of the National Marine Fisheries Service, although they might represent stressors for species under the jurisdiction of the U.S. Fish and Wildlife Service (we do not address critical habitat in this section of our analyses because we had previously concluded that the proposed activities were not likely to adversely to affect critical habitat).

INERT MINE-SHAPES. As discussed previously, the potential for direct physical contact between a marine mammal and an inert-mine shape is extremely low given the low probability of occurrence of a marine mammal in the area and the negligible probability that a marine mammal would collide with an inert mine shape. The best information available leads us to conclude that endangered and threatened species are not likely to be exposed to this technology and, if exposed, they are not likely to respond to that exposure.

1. ELECTRONIC OPERATIONS. As part of electronic combat operations training, Navy personnel are trained to prevent or reduce the effectiveness of enemy electronic equipment and ensures the continued use of friendly equipment as well as the command and control of said 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. INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE: he U.S. Navy conducts intelligence, surveillance, and reconnaissance training with maritime patrol aircraft in W-237 and the Pacific Northwest Operatings Area. Activities typically last six hours and involve a crew of 11 personnel. P-3 aircrews use a variety of intelligence gathering and surveillance methods, including visual, infrared, electronic, radar, and acoustic. EP-3 and EA-6B crews 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.
3. UNMANNED AERIAL SYSTEM TRAINING AND RESEARCH, DEVELOPMENT, TEST, AND EVALUATION: 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.

5.1.2.1 Surface Vessel Traffic

As discussed in the *Description of the Proposed Action* section of this Opinion, the U.S. Navy plans to conduct anti-submarine warfare training events in 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, localizating, and tracking submarines.

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, which is a slight increase over the 200 events the U.S. Navy conducts with current schedules. 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) each year on the Northwest Training Range Complex.

Vessel traffic associated with these training exercises represents a suite of stressors or stress regimes that pose several potential hazards to endangered and threatened species in Puget Sound and off the coasts of Washington, Oregon, and the northern coast of California. First, the size and speed of these surface vessels pose some probability of collisions between marine mammals and sea turtles. Second, vessel traffic represents a source of disturbance for marine animals.

Given the speeds at which these vessels are likely to move, they pose potential hazards to marine mammals. The Navy’s operational orders for ships that are underway are designed to prevent collisions between surface vessels participating in naval exercises and endangered whales that might occur in the action area. These measures, which include marine observers on the bridge of ships, requirements for course and speed adjustments to maintain safe distances from whales, and having any ship that observes whales to alert other ships in the area, have historically been effective measures for avoiding collisions between surface vessels and whales

Although the probability of a collision seem fairly small given the measures that are in place, about 7,220 hours of operations by boats and landing craft air cushion vehicles poses some risk of disturbing sperm whales that might occur in the Action Area. Particularly when that traffic is placed in the context of animals that are likely to have had extensive prior experience with existing levels of vessel traffic associated with inter-island transportation, commercial ship traffic, whale-watching vessels, leisure cruises, and research vessels that were discussed in the *Environmental Baseline* of this Opinion.

5.1.2.2 Active sonar

As discussed in the *Description of the Proposed Action* section of this Opinion, the U.S. 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.

MID-FREQUENCY ACTIVE SONAR. the U.S. Navy proposes to conduct about 26 training events involving guide-missile destroyers and 39 training events involving guided-missile frigates (59 hours of active sonar) each year on the

Northwest Training Range Complex. As proposed, the 26 training events involving guided missile destroyers would produce up to 39 hours of mid-frequency active sonar (from the AN/SQS-53C hull-mounted sonar sonar system) while the 39 training events involving guided-missile frigates would produce up to 59 hours of mid-frequency ative sonar (from the AN/SQS-56 hull-mounted sonar system). This level of training is an increase from the 24 training events (36 hours of active sonar associated with guided-missile destroyers) and 36 training events (54 hours of active sonar associated with guided-missile frigates) the U.S. Navy has conducted each year under current schedules.

The duration, rise times, and wave form of sonar transmissions the U.S. Navy would employ during research, development, test, and evaluation are classified; however, the AN/SQS-53 system has a center frequency of 3.5 kHz, source levels of 235 dB, and pulse lengths between 1 and 2 seconds, with about 24-second intervals between pulses.. This sonar system creates 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).

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. The AN/SQS-53 sonar is installed on Arleigh Burke Class guided missile destroyers and Ticonderoga Class guided missile cruisers.

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, D`Spain *et al.* 2006). 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 MK-48 torpedo is one of 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.

The AN/SSQ-62C Directional Command Activated Sonobuoy System (DICASS) sonar system is part of a sonobuoy that operates under direct command of fixed-wing aircraft or 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. After it enters the water, 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.

The AN/SSQ-110A Explosive Source Sonobuoy is 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 maritime patrol aircraft.

HIGH-FREQUENCY ACTIVE SONAR. The mine detection sonar (the AN/BQS-15 sonar system), uplink transducers on the Portable Undersea Tracking Range, and Range Tracking Pingers the U.S. Navy proposes to use produce high-frequency sounds (source levels are classified).

5.1.2.3 Shock Waves and Sound Waves Produced by 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 Floral Point. 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 each year, with four detonations per training event..

In addition, the U.S. Navy proposes to conduct two sinking exercises each year in the Northwest Training Range Complex..Each SINKEX uses an excess vessel hulk as a target that 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. Examples of missiles that could be fired at the targets include AGM-142 from a B-52 bomber, Walleye AGM-62 from FA-18 aircraft, and a Harpoon from maritime patrol aircraft. Surface ships and submarines may use either torpedoes or Harpoons, surface-to-air missiles in the surface-to-surface mode, and guns. Other weapons and ordnance could include, but are not limited to, bombs, Mavericks, Penguins, and Hellfire. 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.

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 animal's 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.

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.

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5.1.2.4 Ordnance and Projectiles

Many of the activities the U.S. Navy plans to conduct on the Northwest Training Range Complex involve bombs, missiles, targets, and ammunition that introduce expended ordnance and other fragments into the marine environment.

BOMBS. The majority of the bombs, the U.S. Navy would employ during training activities it conducts on the Northwest Training Range Complex would be practice bombs that are not equipped with explosive warheads. About 76 percent of the bombs the U.S. Navy proposes to employ on the Range Complex would be inert practice bombs without 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 (U.S. Navy 2006b).

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 (U.S. Navy 2005b).

MISSILES. Missiles would be fired at a variety of airborne and surface targets on 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 highexplosive 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 missile 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 (U.S. Navy 2006a). For example, missiles employed during a HARMEX would detonate 30 - 60 feet (9.1 – 18.3 m) above the ocean surface.

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 (DoN, 1996).

TARGETS. At-sea targets are usually remotely operated airborne, surface, or subsurface traveling units, most of which are designed to be recovered for reuse. Aerial and surface targets would be deployed annually in the Northwest Training Range Complex. 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 on 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 vehicle).

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.

GUN 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 rounds training rounds and all of the rockets would be non-explosive and contain an iron shell and 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 fuzed 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, nonexplosive 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 (U.S. Navy 2001). Over time, the rapid-detonating explosive residue would be covered by ocean sediments or diluted by ocean water.

CHAFF. Chaff would be used during the 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 (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% silica and 40% 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 (Spargo, 2007). 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; however, some may remain at or near the surface if it were to fall directly on a dense *Sargassum* mat. 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.* (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.

5.1.2.5 Chemicals in Explosive Charges and Ordnance

The chemical products of deep underwater explosions are initially confined to a thin, circular area called a "surface pool." Young (1995) 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.

The concentrations of chemicals associated with the explosive materials are not hazardous to marine mammals, sea turtles, their prey, competitors, or predators. Those chemicals are not likely to adversely affect these species.

5.1.2.6 Parachutes Released During Deployment of Sonobuoys

Each year, 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 3). In total, the U.S. Navy plans to deploy about 9,650 sonobuoys each year during the training it proposes to conduct on the Northwest Training Range Complex.

When these sonobuoys impact the water surface after being deployed from aircraft, their parachute assemblies of sonobuoys are jettisoned and sink away from the sonobuoy, while a float containing an antenna is inflated. 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 squared 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 depend on ocean conditions and the shape of the parachute.

The subsurface assembly descends to a selected depth, and the sonobuoy case falls away and sea anchors deploy to stabilize the hydrophone (underwater microphone). The operating life of the seawater battery is eight hours, after which the sonobuoy scuttles itself and sinks to the ocean bottom. For the sonobouys, concentrations of metals released from batteries were calculated to be 0.0011 mg/L lead, 0.000015mg/L copper, and 0.0000001mg/L silver.

5.1.2.7 Disturbance Associated with Vessel Traffic

Studies of interactions between surface vessels and marine mammals have demonstrated that surface vessels represent a source of acute and chronic disturbance for marine mammals (Au and Green 1990, Au and Perryman 1982, Bain *et al.* 2006, Bauer 1986, Bejder 1999, 2006a, 2006b; Bryant *et al.* 1984, Corkeron 1995, Erbé 2000, Félix 2001, Goodwin and Cotton 2004, Hewitt 1985, Lemon *et al.* 2006, Lusseau 2003, 2006; Lusseau and Bejder 2007, Magalhães *et al.* 2002, Ng and Leung 2003, Nowacek *et al.* 2001, Richter *et al.* 2003, 2006; Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams and Ashe 2007, Williams *et al.* 2002, 2006a, 2006b; Würsig *et al.* 1998). Specifically, in some circumstances, marine mammals respond to vessels with the same behavioral repertoire and tactics they employ when they encounter predators.

These studies establish that free-ranging cetaceans 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 Green 2004; Lusseau 2006). Several, authors, however, suggest that the noise generated by the vessels is probably an important contributing factor to the responses of cetaceans to the vessels (Blane and Jackson 1994, Evans *et al.* 1992, 1994), so we may not be able to treat the effects of vessel traffic as independent of engine and other sounds associated with the vessels.

For surface vessels, the set of variables that help determine whether marine mammals are likely to be disturbed 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 (see Response Analyses for further discussion);

2. *the distance between vessel and marine mammals* when the animal perceives that an approach has started and during the course of the interaction;
3. *the vessel's speed and vector*;
4. *the predictability of the vessel's path*. That is, whether the vessel stays on a single path or makes continuous course changes;
6. *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);
7. *the type of vessel* (displacement versus planing), which marine mammals may be interpret as evidence of a vessel's maneuverability.

Because of the number of vessels hours involved in the proposed research, development, test and evaluation activities, the speed of those vessels, their use of course changes as a tactical measure, and sounds associated with their engines and displacement of water along their bowline, the available evidence leads us to expect marine mammals to treat Navy vessels as potential stressors, although their perception of these activities would differ substantially from their perception of major training exercises (for example, COMPTUEX and JTFEX) the U.S. Navy conducts off the coast of Southern California.

Much of the increase in ambient noise levels in the oceans over the last 50 years has been attributed to increased shipping, primarily due to the increase in the number and tonnage of ships throughout the world, as well as the growth and increasing interconnection of the global economy and trade between distant nations (National Resource Council 2003). Commercial fishing vessels, cruise ships, transport boats, recreational boats, and aircraft, all contribute sound into the ocean (National Resource Council 2003). Military vessels underway or involved in naval operations or exercises, also introduce anthropogenic noise into the marine environment.

5.2 Exposure Analysis

As discussed in the *Approach to the Assessment* section of this opinion, 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 section of this biological opinion, we present the results of 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 one or more of the stressors producted by or associated with an Action and the populations or subpopulations those individuals represent.

As discussed in the *Approach to the Assessment* section of this Opinion, the U.S. Navy, NMFS, and most other entities (for example, oil and gas industries for drilling platforms, geophysics organizations that conduct seismic surveys, etc.) rely on computer models, simulations, or some kind of mathematical algorithm to estimate the number of animals that might be exposed to a sound source. Like all models, these approaches are based on assumptions and are sensitive to those assumptions. Based on our evaluation of assumptions the U.S. Navy incorporates in its models, those models would tend to over-estimate the number of marine mammals that might be exposed to military readiness activities in waters on and adjacent to the Keyport Range Complex and the Northwest Training Range Complex because (1) those models assume that marine mammals would not try to avoid being exposed to the sound field associated with active sonar or would not try to avoid continued exposure to the sound field; (2) those models assume that mean densities of marine mammals within any square kilometer area of the Naval Surface Warfare Center would be constant over time (that is, the models assume that the probability of marine mammals occurring in any square kilometer area over any time interval is 1.0, when, in fact, the probability would be much smaller than 1.0; this difference would tend to overestimate the number of animals in the action area during shorter time intervals).

The following narratives present the results of the exposure analyses we conducted for the military readiness activities the U.S. Navy proposes to conduct on the Keyport Range Complex and the Northwest Training Range Complex.

5.2.1 Exposure on the Keyport Range Complex

As discussed previously, 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 of our analyses, 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 producted by or associated with an Action and the populations or subpopulations those individuals represent. In the case of the Keyport Range Complex, we relied entirely on the exposure analyses the U.S. Navy conducted because, as we discussed in the *Approach to the Assessment* section of this Opinion, the sole or primary stressor is not hull-mounted mid-frequency active sonar.

5.2.1.1 Exposure to Vessel Traffic on the Keyport Range Complex

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 7,220 hours of boat usage the U.S. Navy proposes to conduct are likely to be exposed to visual and acoustic stimuli associated with vessel traffic and related activities. Nevertheless, because RDT&E activities involve fewer vessels, have shorter duration, and are much more localized, fewer endangered and threatened species would be exposed to vessel traffic during these smaller activities.

5.2.1.2 Exposure to Active Sonar on the Keyport Range Complex

The empirical information available does not allow us to independently estimate the number of marine mammals that might be exposed to high- or mid-frequency active sonar during military readiness activities the U.S. Navy plans to conduct in waters on and adjacent to the Keyport Range Complex from June 2010 through June 2015. The narratives that follow present the results of the method the U.S. Navy and NMFS' Permits Division used to estimate the number of marine mammals that might be "taken" (as that term is defined pursuant to the MMPA) in the U.S. Navy's Draft Environmental Impact Statement/Overseas Environmental Impact Statement, on the Keyport Range Complex (U.S. Navy 2008). The "take" the Permits Division proposes to authorize using the Letters of Authorization would reflect these "take" estimates.

MITIGATION MEASURES TO MINIMIZE THE LIKELIHOOD OF EXPOSURE TO ACTIVE SONAR. The Navy proposes to implement a suite of protocols on the Keyport Range Complex that are designed to prevent marine mammals from being exposed to active sonar at any received level or at high received levels. The most important of these protocols would require operators to (1) halt or delay acoustic activities if cetaceans are observed on a range site and (2) terminate transmissions produced by an acoustic source when cetaceans are detected within at least 914 meters (1,000 yards) of the intended track of a test vehicle (sources are either on or off; so the Navy does not have the ability to reduce source levels). If effective, the first of these measures would prevent endangered or threatened cetaceans from being exposed to acoustic stimuli produced by the research, development, test, and evaluation activities the U.S. Navy proposes to conduct on the Keyport Range Complex. If that measure is not effective, the second of these measures is designed to prevent endangered or threatened cetaceans from being exposed to acoustic stimuli at received levels greater than 170 dB.

The U.S. Navy proposes to use visual and passive acoustic monitoring to detect marine mammals that occur on the Keyport Range Complex, including the Quiinault Underwater Tracking Range, and that combination is considered the most effective method of detection currently available. However, the U.S. Navy assumed these protective measures would be completely effective for some marine mammals ─ 100 percent of all detections with no false negatives (that is, animals occur on the range, but the range operating protocols would never fail to detect them) ─ but not other marine mammals. Specifically, the U.S. Navy assumed these protective measures would prevent any endangered or threatened marine mammals (blue, fin, humpback, sei, southern resident killer whales, sperm whales, and Steller sea lions) from being exposed to acoustic stimuli, but would not prevent species such as harbor porpoises, northern fur seal, California sea lions, or elephant seals from being exposed.

Although the protocols the U.S. Navy proposes to employ are the best methods currently available, the evidence available does not allow us to assume that the visual and acoustic detection protocols the U.S. Navy plans to use would always be 100 percent effective, particularly on the Quinault Underwater Tracking Range. Visual monitoring has limited effectiveness because it requires species to occur at the ocean's surface, it is only effective during daylight hours, and because many whales, dolphins, and pinnipeds are difficult to sight at sea in the best conditions and become more difficult to sight when conditions deteriorate. Passive acoustic monitoring avoids many of the problems associated with visual detections, as long as the animals vocalize.

For example, Barlow and Forney (2007) estimated trackline detection probabilities (the probability of detecting a group of animals that is located directly on a transect line) based on shipboard surveys they had conducted off the coasts of Washington, Oregon, and California. For blue, fin, humpback, and killer whales, they reported trackline detection probabilities of 0.921 (coefficient of variation = 0.023); for sperm whales, they reported trackline detection probabilities of 0.870 (coefficient of variation = 0.090). Using those estimates, an observer would have about a 92 percent probability of detecting a group of blue, fin, humpback, or killer whales that occurred directly on a transect line, or about an 8 percent probability of not detecting such a group; an observer would have about an 87 percent probability of detecting a group of sperm whales or a 13 percent probability of failing to detect such a group.

Passive acoustic monitoring would be ineffective for animals that do not vocalize and its effectiveness will vary with the kind of vocalization, sea surface conditions, and distance. Assuming that the target animals are vocalizing, passive acoustic monitoring still does not appear to be 100 percent effective. For example, the U.S. Navy developed and employs a high-frequency active acoustic monitoring system that was specifically designed to detect marine mammals within 1,000 meters of the Navy's SURTASS LFA sonar system to prevent marine mammals from being exposed during sonar transmissions. This high-frequency sonar system, called HF/M3 (for High Frequency/Marine Mammal Monitoring), has detection probabilities that exceed 95 percent for small dolphins at about 750 m [0.4 nm], whale calves at 1,000 m [0.56 nm] and large whales at more than 1,500 m [0.81 nm]. Ward *et al*. (2008) used passive acoustic monitoring, specifically Fast Fourier Transform and matched filter detectors, to detect and localize Blainville's beaked whales. They concluded that the matched filter detectors were more effective than the Fast Fourier Transform detectors (92 percent probability of correct detections versus 49 percent probability) and that the maximum detection range for either method was about 6,500 meters. The passive acoustic system employed by Wang *et al*. (2005) correctly detected the presence of free-ranging finless porpoises (*Neophocaena phocaenoides*) 77.6 percent of the time within an effective distance of 150 m while the passive acoustic system employed by Akamatsu *et al*. (2001) detected finless porpoises 82 percent of the time within 300 m of a hydrophone.

Barlow and Taylor (2005) concluded that the probability of detecting sperm whales using acoustic methods depended on the kind of vocalizations. At distances up to 12 kilometers from the whales, they detected between 70 and 80 percent of slow clicks; at distances between 12 and 18 kilometers, they detected all slow clicks; and beyond 18 kilometers, they detection rate declined to less than 20 percent.

Given the performance of these other passive acoustic systems, the passive acoustic system the U.S. Navy plans to employ at the Keyport Range Complex does not seem likely to detect species like Steller sea lions 100 percent of the time. More importantly, it is not likely to perfectly detect endangered and threatened marine mammals and completely fail to detect other pinnipeds with body sizes similar to or larger than Steller sea lions (such as elephant seals or California sea lions). As a result, we assume that any visual and acoustic monitoring systems the U.S. Navy would employ at the Keyport Range Complex could have a combined effectiveness between 49 and 95 percent, but they would not detect 100 percent of the endangered or threatened marine mammals that occur on the range. Consequently, we cannot assume that the Navy's protocols would completely prevent endangered or threatened marine mammals from being exposed to active sonar produced on the Keyport Range Complex.

U.S. NAVY'S APPROACH TO ESTIMATING EXPOSURES FOR THE KEYPORT RANGE COMPLEX. As discussed in the *Approach to the Assessment* section of this Opinion, our analyses of the effects of the military readiness activities relied on the updated approach the U.S. Navy used to estimate the number of marine mammals that might be "taken" during military readiness activities the U.S. Navy plans to conduct in waters on and adjacent to the Keyport Range Complex from June 2010 through June 2015. Because we relied on the U.S. Navy's estimates to estimate the number of endangered and threatened species that might be exposed to active sonar on the Keyport Range Complex, we briefly summarize the Navy's approach, for more details, refer to Appendix C of the U.S. Navy's Draft Environmental

Impact Statement/ Overseas Environmental Impact Statement for the Keyport Range Complex Extension (U.S. Navy 2008b).

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 metric is either energy flux density (in a limited band or across a full band), peak pressure, or positive impulse. By multiplying impact volumes with 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 specified thresholds. 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 the number of marine mammals that might be "taken" in the form of behavioral harassment, the U.S. Navy used a "risk continuum" (a curve that related 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) that the U.S. Navy and NMFS developed to this area then multiplied that area by a vector that represented the densities of the different species of marine animals that are expected to occur on the Naval Surface Warfare. The risk continuum, which the U.S. Navy adapted from a mathematical equation presented in Feller (1968), was estimated using three data sources: data from controlled experiments conducted at the U.S. Navy's Space and Naval Warfare Systems Center in San Diego, California (Finneran *et al.* 2001, 2003, 2005; Finneran and Schlundt 2004; Schlundt *et al.* 2000), data from a reconstruction of an incident in which killer whales were probably exposed to mid-frequency active sonar (Fromm 2004, Department of the Navy 2003), and a suite of studies of the response of baleen whales to low-frequency sound sources (Nowacek *et al.* 2004).

However, little is known about the effect of short-term disruptions of a marine animal's normal behavior (Richardson *et al.* 1995). Most of the evidence available suggests that most sources of disturbance do not directly kill or injure marine animals. The evidence available also does not lead us to expect endangered or threatened species to strand or suffer resonance effects from the active sonar associated with the research, development, test, and evaluation the U.S. Navy proposes to conduct on the Keyport Range Complex (specifically, at the Dabob Bay Range Complex and Quinault Underwater Tracking Range). As we discussed in our exposure analyses, the Navy concluded that the protective measures it proposed would be 100 percent effective at preventing endangered or threatened species from being exposed to military readiness activities on portions of the Keyport Range Complex. However, we cannot make the same assumption without more empirical evidence of the effectiveness of those measures. As a result, we assume that the U.S. Navy's original estimates represent the best estimate of the number of endangered or threatened marine mammals that might be exposed to acoustic stimuli associated with the proposed research, development, test, and evaluation on the Keyport Range Complex.

Because the protocols the U.S. Navy plans to employ are likely to be very effective, our analyses substantially overestimate the probable number of marine mammals that are likely to be exposed to acoustic stimuli associated with the proposed research, development, test, and evaluation at the Keyport Range Complex (specifically, at the Dabob Bay Range Complex and Quinault Underwater Tracking Range).

FIN WHALE. Fin whales are not known to occur in Puget Sound proper, but one or two fin whales are observed in most years in Georgia Strait (Osborne et al. 1988). However, their frequency and density in Puget Sound is sufficiently low to lead us to conclude that fin whales are not likely to be exposed to research, development, test, and evaluation events on the Keyport Range Site, the Dabob Bay Military Operating Area, or the Hood Canal Military Operating Areas. Fin whales are likely to occur in waters on or proximate to the Quinault Underwater Tracking Range, however, and they might occur during any month of the year (we present more information on the occurrence of fin whales in waters off Washington in the exposure analyses for the Northwest Training Range Complex, which follow this sub-section of our Opinion).

Based on the density estimates for fin whales presented in Columns "F" and "G" of Table 7, the U.S. Navy's models estimated that one fin whale might occur close enough to active acoustic sources on the Quinault Underwater Tracking Range to experience behavioral responses that would constitute "behavioral harassment" (as that term is defined pursuant to the MMPA) each year. However, the U.S. Navy concluded that the monitoring protocols it proposes to employ on the Quinault Underwater Tracking Range would allow the U.S. Navy to detect that fin whale and prevent the whale from being exposed to acoustic sources on the tracking range. Despite this conclusion, and for the reasons we discussed in greater detail in our evaluation of the mitigative measures the U.S. Navy proposes to employ on the Keyport Range Complex, we do not expect the U.S. Navy's monitoring protocols to detect 100 percent of the fin whales that might occur on the Quinault Underwater Tracking Range..

Nevertheless, we conclude that fin whales are not likely to be exposed to active acoustic sources on the Quinault Underwater Tracking Range because of their relatively low density in waters off Washington and the short duration of those events (on the order of three to four hours per event with several events in a single day for about 16 days of the year in the offshore portion of the tracking range). With this combination of factors, the probability of a single fin whale being exposed to the sound field associated with a RDT&E event is less than one tenth of one percent (which we would consider discountable).

HUMPBACK WHALE. Until 2003, only three humpback whales had been identified in Puget Sound and Georgia Strait (Falcone *et al*. 2005). In 2003 and 2004, 13 individual humpback whales were identified in the Sound based on 30 observations. Two of these whales were juveniles observed in the spring of 2004, one in the San Juan Islands and the other in southern Puget Sound between south Vashon Island and Point Defiance. The remaining humpback whales were observed from September through November (Falcone et al. 2005). Despite these recent observations, humpback whales have not been reported from the Hood Canal area and are not likely to be exposed to research, development, test, and evaluation events on the Keyport Range Site, the Dabob Bay Military Operating Area, or the Hood Canal Military Operating Areas. Humpback whales are likely to occur in waters on or proximate to the Quinault Underwater Tracking Range, however, where they might occur during any month of the year with substantially higher densities during the summer months (we present more information on the occurrence of

Table 7. Density estimates presented in the Draft Environmental Impact Statement for the Northwest Training Range Complex, the Draft Environmental Impact Statement for the Quinault Undersea Tracking Range site of the Keyport Range Complex, and the report from the 2005 marine mammal survey on which most of those estimates were based (Barlow and Forney 2007, Forney 2007). "CI" is an acronym for "Confidence Interval"

	Forney (2007)				**Northwest Training Range DEIS**		**Keyport Range Complex DEIS**	
Species	**Estimate**	**(A) Olympic Coast National Marine Sanctuary**	**(B) Olympic Coast Total Warm Season**	**(C) OR-WA Warm Season Total**	**(D) Warm Season Density**	**(E) Cold Season Density**	**(F) Warm Season Density**	**(G) Cold Season Density**
Blue whale	**Estimate**	**-**	**-**	**0.00036**	**0.0005**	**0**	**0.00031**	**0**
	Upper 95% CI	-	-	0.00092	-	-	-	-
	Lower 95% CI	-	-	0.00014	-	-	-	-
Fin whale	**Estimate**	**0.00000**	**-**	**0.00123**	**0.0014**	**0.0014**	**0.00121**	**0.00121**
	Upper 95% CI	-	-	0.00240	-	-	-	-
	Lower 95% CI	-	-	0.00063	-	-	-	-
Humpback whale	**Estimate**	**0.02371**	**0.01602**	**0.00065**	**0.0007**	**0**	**0.02372**	**0**
	Upper 95% CI	0.01253	0.00932	0.00217	-	-	-	-
	Lower 95% CI	0.04460	0.02741	0.00019	-	-	-	-
Sei whale	**Estimate**	**-**	**-**	**0.00018**	**0.0001824**	**0**	**0.00021**	**0.00021**
	Upper 95% CI	-	-	0.00103	-	-	-	-
	Lower 95% CI	-	-	0.00003	0.000115	0	-	-
Killer whale southern resident	**Estimate**	**-**	**-**	**-**	**0.00055**	**0.00055**	**-**	**-**
	Upper 95% CI	-	-	-	-	-	-	-
	Lower 95% CI	-	-	-	-	-	-	-
Killer whale all ecotypes	**Estimate**	**0.00283**	**0.00739**	**0.00135**	**0.00162**	**-**	**0.00282**	**0.00282**
	Upper 95% CI	0.01415	0.02025	0.00418	-	-	-	-
	Lower 95% CI	0.00054	0.00270	0.00043	-	-	-	-
Sperm whale	**Estimate**	**0.00000**	**0.00031**	**0.00260**	**0.002601**	**0.002601**	**0.00113**	**0.00113**
	Upper 95% CI	0.00000	0.00185	0.01345	-	-	-	-
	Lower 95% CI	0.00000	0.00008	0.00050	-	-	-	-
Steller sea lion	**Estimate**	**-**	**-**	**-**	**0.011004**	**0.011004**	**0.0096**	**0.0096**
	Upper 95% CI	-	-	-	-	-	-	-
	Lower 95% CI	-	-	-	0.00011	0.00011	-	-

humpback whales in waters off Washington in the exposure analyses for the Northwest Training Range Complex, which follow this sub-section of our Opinion).

Based on the density estimates for humpback whales presented in Columns "F" and "G" of Table 7, the U.S. Navy's models estimated that there might be three instances in which humpback whales might occur close enough to active acoustic sources on the Quinault Underwater Tracking Range to experience behavioral responses that would constitute "behavioral harassment" (as that term is defined pursuant to the MMPA) each year. However, the U.S. Navy concluded that the monitoring protocols it proposes to employ on the Quinault Underwater Tracking Range would allow the U.S. Navy to detect that humpback whale and prevent the whale from being exposed to acoustic sources on the tracking range. Despite this conclusion, and for the reasons we discussed in greater detail in our evaluation of the mitigative measures the U.S. Navy proposes to employ on the Keyport Range Complex, we do not expect the U.S. Navy's monitoring protocols to detect 100 percent of the humpback whales that might occur on the Quinault Underwater Tracking Range.

Nevertheless, we conclude that humpback whales are not likely to be exposed to active acoustic sources on the Quinault Underwater Tracking Range because of their relatively low density in waters off Washington and the short duration of those events (on the order of three to four hours per event with several events in a single day for about 16 days of the year (in the offshore portion of the tracking range). With this combination of factors, the probability of a single humpback whale being exposed to the sound field associated with a RDT&E event is also less than one tenth of one percent (which we would consider discountable).

SEI WHALE. Because they do not occur in Puget Sound, sei whales are not likely to be exposed to research, development, test, and evaluation events on the Keyport Range Site, the Dabob Bay Military Operating Area, or the Hood Canal Military Operating Areas. Sei whales are likely to occur in waters on or proximate to the Quinault Underwater Tracking Range, however, where they might occur during any month of the year (we present more information on the occurrence of sei whales in waters off Washington in the exposure analyses for the Northwest Training Range Complex, which follow this sub-section of our Opinion).

Based on the density estimates for sei whales presented in Columns "F" and "G" of Table 7, the U.S. Navy's models estimated that there might be one instance in which sei whales might occur close enough to active acoustic sources on the Quinault Underwater Tracking Range to experience behavioral responses that would constitute "behavioral harassment" (as that term is defined pursuant to the MMPA) each year. However, the U.S. Navy concluded that the monitoring protocols it proposes to employ on the Quinault Underwater Tracking Range would allow the U.S. Navy to detect that sei whale and prevent the whale from being exposed to acoustic sources on the tracking range. Despite this conclusion, and for the reasons we discussed in greater detail in our evaluation of the mitigative measures the U.S. Navy proposes to employ on the Keyport Range Complex, we do not expect the U.S. Navy's monitoring protocols to detect 100 percent of the sei whales that might occur on the Quinault Underwater Tracking Range.

Nevertheless, we conclude that sei whales are not likely to be exposed to active acoustic sources on the Quinault Underwater Tracking Range because of their relatively low density in waters off Washington and the short duration of those events (on the order of three to four hours per event with several events in a single day for about 16 days of the year (in the offshore portion of the tracking range). With this combination of factors, the probability of a single sei whale being exposed to the sound field associated with a RDT&E event is also less than one tenth of one percent (which we would consider discountable).

SOUTHERN RESIDENT KILLER WHALE. Southern resident killer whales are the only marine mammals considered in this Opinion that begin and end their lives almost entirely within Puget Sound, Georgia Strait, the Strait of Juan de Fuca, and the outer coasts of Washington and southern Vancouver Island (Ford *et al*. 2000). Although southern resident killer whales occur in Puget Sound, NMFS argued that the Keyport Range Site, the Dabob Bay Military Operating Area, or the Hood Canal Military Operating Areas do not overlap with their current distribution (this issue was addressed in substantial detail in the final rule to designate critical habitat for southern resident killer whales, 71 Federal Register 69054). Therefore, southern resident killer whales are not likely to be exposed to research, development, test, and evaluation events on those components of the Keyport Range Complex.

Based on sighting information and stranding data collected from 1975 through 2007, we know that southern resident killer whales periodically travel to Vancouver Island and the Queen Charlotte Islands, coastal Washington, coastal Oregon, and California (NMFS 2008A). Those movements would bring southern resident killer whales onto or though the Quinault Underwater Tracking Range (we present more information on the occurrence of southern resident killer whales in waters off Washington in the exposure analyses for the Northwest Training Range Complex, which follow this sub-section of our Opinion).

Based on the density estimates for southern resident killer whales presented in Columns “F” and “G” of Table 7, the U.S. Navy’s models estimated that there might be one instance in which southern resident killer whales might occur close enough to active acoustic sources on the Quinault Underwater Tracking Range to experience behavioral responses that would constitute “behavioral harassment” (as that term is defined pursuant to the MMPA) each year. However, the U.S. Navy also concluded that the monitoring protocols it proposes to employ on the Quinault Underwater Tracking Range would allow the U.S. Navy to detect southern resident killer whale and prevent the whale from being exposed to acoustic sources on the tracking range. As we have discussed in the preceding narratives, despite this conclusion, we do not expect the U.S. Navy’s monitoring protocols to detect 100 percent of the southern resident killer whales that might occur on the Quinault Underwater Tracking Range.

Nevertheless, we conclude that southern resident killer whales are not likely to be exposed to active acoustic sources on the Quinault Underwater Tracking Range because they rarely occur in waters along the Olympic Coast of Washington and because of the short duration of those events the U.S. Navy plans to conduct on the tracking range. With this combination of factors, the probability of a southern resident killer whale being exposed to the sound field associated with a RDT&E event is also less than one tenth of one percent (which we would consider discountable).

SPERM WHALE. Because they do not occur in Puget Sound, sperm whales are not likely to be exposed to research, development, test, and evaluation events on the Keyport Range Site, the Dabob Bay Military Operating Area, or the Hood Canal Military Operating Areas. Sperm whales are likely to occur in waters on or proximate to the deeper portions of the Quinault Underwater Tracking Range, however, where they might occur during the summer months (we present more information on the occurrence of sperm whales in waters off Washington in the exposure analyses for the Northwest Training Range Complex, which follow this sub-section of our Opinion).

Based on the density estimates for sperm whales presented in Columns "F" and "G" of Table 7, the U.S. Navy's models estimated that there might be one instance in which sperm whales might occur close enough to active acoustic sources on the Quinault Underwater Tracking Range to experience behavioral responses that would constitute "behavioral harassment" (as that term is defined pursuant to the MMPA) each year. However, the U.S. Navy concluded that the monitoring protocols it proposes to employ on the Quinault Underwater Tracking Range would allow the U.S. Navy to detect that sperm whale and prevent the whale from being exposed to acoustic sources on the tracking range. Despite this conclusion, and for the reasons we discussed in greater detail in our evaluation of the mitigative measures the U.S. Navy proposes to employ on the Keyport Range Complex, we do not expect the U.S. Navy's monitoring protocols to detect 100 percent of the sperm whales that might occur on the Quinault Underwater Tracking Range.

Nevertheless, we conclude that sperm whales are not likely to be exposed to active acoustic sources on the Quinault Underwater Tracking Range because of their relatively low density in waters off Washington, their tendency to occur in waters greater than 2,000 meters in depth, and the short duration of the events the U.S. Navy plans to conduct on the tracking range. With this combination of factors, the probability of a sperm whale being exposed to a sound field associated with a RDT&E event on the tracking range is also less than one tenth of one percent (which we would consider discountable).

STELLER SEA 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 (NMFS 1992, 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.

Because of that rarity, Steller sea lions are not likely to be exposed to research, development, test, and evaluation events on the Keyport Range Site, the Dabob Bay Military Operating Area, or the Hood Canal Military Operating Areas. However, we would expect Steller sea lions to occur on the Quinault Underwater Tracking Range

Based on the density estimates for the eastern population of Steller sea lions presented in Columns "F" and "G" of Table 7, the U.S. Navy's models estimated that there might be three instances in which Steller sea lions might occur close enough to active acoustic sources on the Quinault Underwater Tracking Range to experience behavioral responses that would constitute "behavioral harassment" (as that term is defined pursuant to the MMPA) each year. However, the U.S. Navy also concluded that the monitoring protocols it proposes to employ on the Quinault Underwater Tracking Range would allow the U.S. Navy to detect Steller sea lions and prevent the whale from being exposed to acoustic sources on the tracking range.

As we have discussed in the preceding narratives, although the U.S. Navy concluded that the monitoring protocols it planned to employ would prevent these potential exposure events from occurring, we do not expect the U.S. Navy's monitoring protocols to detect 100 percent of the Steller sea lions that might occur on the Quinault Underwater Tracking Range. More importantly, the U.S. Navy expected these monitoring protocols to completely fail to detect northern fur seals (*Callorhinus ursinus*) , California sea lions (*Zalophus californianus*), and northern elephant seals (*Mirounga angustirostris*) that occur in the Quinault Underwater Tracking Range (see Table 6-25 of U.S. Navy 2008a). Given similarities in their body size and shape or, in the case of elephant seals, their larger body size, it seems unlikely that monitoring protocols that would fail to detect northern fur seals, California sea lions, and northern elephant seals that occur on the tracking range, would detect every Steller sea lion that occurs on the tracking range. Because it seems more likely that the detection probabilities associated with those other pinnipeds would apply to Steller sea lions, we would expect at least three instances in which Steller sea lions might be exposed to active acoustic sources on the Quinault Underwater Tracking Range.

LEATHERBACK SEA TURTLES. During the summer and fall, leatherback sea turtles occupy the California Current where they forage on dense aggregations of brown sea nettle (*Chrysaora fuscescens*) and other scyphomedusae in this area (particularly moon jellyfish *Aurelia labiata*) that occur in waters off the central California coast, north through Washington (Benson *et al*. 2006; 2008; S. Benson, personal communication, cited in NMFS 2009, Eisenberg and Frazier, 1983; Harvey *et al*. 2006, Peterson *et al*. 2006). 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 Quinault Underwater Tracking Range in its current configuration and with the expansion the U.S. Navy proposes. Therefore, we assume that leatherback sea turtles are likely to be exposed to research, development, test, and evaluation activities on the Quinault Underwater Tracking Range portion of the Keyport Range Complex. Nevertheless, the information available did not allow us to estimate the number of times leatherback sea turtles might be exposed to the activities the U.S. Navy plans to conduct on the Keyport Range Complex each year.

SOUTHERN GREEN STURGEON. As discussed in the *Status of the Species* section of this Opinion, green sturgeon are distributed from the Bering Sea, Alaska, to Ensenada, Mexico, although this may or may not encompass the actual distribution of southern green sturgeon. Nevertheless, we assume that southern green sturgeon may occur in those areas that NMFS has designated as critical habitat for the species: coastal bays and estuaries include estuaries from Elkhorn Slough, California, to Puget Sound, Washington. Specifically, they might occur in coastal areas within depths of 60 fathoms where green sturgeon might forage or migrate. Because this distribution overlaps with the action area for this consultation and we do not have evidence that would lead us to conclude that southern green sturgeon are not likely to occur on the Keyport Range Complex (particularly the Quinault Undersea Training Range), we assume that green sturgeon are likely to be exposed to training activities that occur in those areas of the complex.

PACIFIC SALMON, STEELHEAD, AND SOUTHERN EULACHON. As discussed in the *Status of the Species* section of this Opinion, endangered and threatened species of Pacific salmon, steelhead, and southern eulachon distribute in coastal waters from northern California, Oregon, Washington, and in waters further north. As a result, we assume that endangered and threatened species of Pacific salmon, steelhead, and southern eulachon occur in those areas that

NMFS has designated as critical habitat for the species. Because this distribution overlaps with the action area for this consultation and we do not have evidence that would lead us to conclude that endangered and threatened species of Pacific salmon and steelhead are not likely to occur on the Keyport Range Complex, we assume that endangered and threatened species of Pacific salmon, steelhead, and southern eulachon are likely to be exposed to training activities that occur in those areas of the Keyport Range Complex.

5.2.2 Northwest Training Range Complex

Our exposure analyses focused on three potential stressors associated with U.S. Navy training on the Northwest Training Range Complex ─ vessel traffic and the risks of collisions, mid-frequency active sonar, and underwater detonations ─ and we used different approaches to estimate the number of times endangered or threatened species might be exposed to those different stressors. We first summarize the approaches we used to produce these different estimates, then present the results of our exposure analyses by species.

VESSEL TRAFFIC. To estimate the number of times individual whales (because of the rarity of ship strikes involving pinnipeds, sea turtles, and fish, we confined these analyses to the endangered cetceans we consider in this Opinion) might have some risk of struck by a Navy vessel involved in training activities, we estimated the number of times endangered or threatened species might occur within 560 meters of a ship moving at speeds greater than 14 knots. Like our estimates of the number of times endangered or threatened species might be exposed to mid-frequency active sonar (discussed in greater detail in the following paragraph), these estimates required estimates of species' densities in the action area; those estimates were also very sensitive to those density estimates.

The primary problem associated with this approach is that it assumes that sound fields produced by active sonar pings are the only acoustic cues produced by U.S. Navy vessels that are underway and that would be available to endangered or threatened whales. This is not the case: even with quieting technology, 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 whale). 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 smaller than our exposure models suggest.

We present the results of our exposure analyses in the narratives that follow. However, 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.

ACTIVE SONAR. 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. The estimates produced by both of these approaches required estimates of species' densities in the action area and, as discussed in the preceding paragraph, is sensitive to those density estimates. During our 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 Draft EIS/OEIS for the Keyport Range Complex Extension (U.S. Navy 2008b), Draft EIS/OEIS for the Northwest Training Range Complex (U.S. Navy 2009c), and the reports of the surveys that produced those density estimates (Barlow and Forney 2007, Forney 2007).

Table 7 presents the different density estimates that formed the basis the "take" estimates the U.S. Navy developed for the Northwest Training Range Complex (columns a and b) and for the Keyport Range Complex (columns c and d). Some of the values in these columns (marked with a "1") represent density estimates that were developed from large-scale surveys conducted off Oregon and Washington in June-July 2005 and which were presented in Table 5 of Forney (2007). Other values in these columns (marked with a "2") represent density estimates that were developed from fine-scale surveys conducted on the Olympic Coast National Marine Sanctuary over the same time interval and which were also presented in Table 5 of Forney (2007). The values for sperm whales (marked with a "3") represent density estimates that were developed from large-scale (columns a and b) or fine-scale (columns c an d) surveys conducted by Forney and her co-workers over the same time interval and which were also presented in Table 5 of Forney (2007).

As discussed in the opening paragraph of this sub-section, we considered the number of marine mammals that the U.S. Navy estimated might be "taken" (as that term is defined pursuant to the MMPA) that were based on the density estimates identified in Column D of Table 7 and that were used by the U.S. Navy and NMFS' Permits Division for their NEPA analyses and MMPA permitting for the Northwest Training Range Complex (refer to Appendix D of the U.S. Navy's Draft EIS/OEIS for the Northwest Training Range Complex; U.S. Navy 2008d). Although these estimates are not exposure estimates, per se, the estimates provide some insight into the number of times different species might be exposed to active sonar because exposure is a pre-requisite for "take" — that is, an marine mammal that is not exposed, directly or indirectly, to active sonar, could not be "taken" by the active sonar — although the actual number of exposures usually exceeds the number of "takes."

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 and the extended Quinault Underwater Tracking Range (see discussion under Keyport Range Complex extension) will be highly variable as animals enter and leave specific areas while foraging, 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 (Table 7), where those confidence intervals were available. After considering the appropriate interpretation of our exposure analyses, however, we concluded that a mean density estimate would best represent the probable experience of endangered and threatened species in the Northwest Training Range Complex; the exposure narrative that follow this introductory material are based on that conclusion.

PROBABLE EFFECTS OF MEASURES TO MINIMIZE THE LIKELIHOOD OF EXPOSURE TO MID-FREQUENCY ACTIVE SONAR. The U.S. Navy proposes to implement a suite of mitigation measures to prevent marine mammals from being exposed to mid frequency active sonar at high received levels. The U.S. Navy has chosen to exclude mid-frequency active sonar training in Puget Sound from the scope of their proposed action, which does not preclude the U.S. Navy from employing mid-frequency active sonar during training in Puget Sound. Instead, the U.S. Navy will require any request to use mid-frequency active sonar in Puget Sound to be approved by the Commander of the Pacific Fleet. We assume that this requirement would reduce the probability of endangered or threatened marine mammals being exposed to mid-frequency active sonar in Puget Sound, but the requirement does not preclude the U.S. Navy from using mid-frequency active sonar in the Sound. Further, we do not know if the U.S. Navy plans to engage in section 7 consultations on any future proposals to employ mid-frequency active sonar in Puget Sound before they are approved. However, for the purposes of this consultation, 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 *et al.* 1993). For harbor porpoises the effective strip width is about 250 m (273 yd), 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, 2001, 2003). 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.

A multi-year study conducted on behalf of the United Kingdom's Ministry of Defense (Aicken *et al.* 2005) concluded that Big Eye binoculars were not helpful. Based on these studies, we would conclude that requiring surface vessels equipped with mid-frequency active sonar to have Big Eye binoculars in good working order is not likely to increase the number of marine mammals detected at distances sufficient to avoid exposing them to received levels that might result in adverse consequences.

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.

UNDERWATER DETONATIONS. To estimate the number of individuals that might be exposed to pressure waves associated with underwater detonations, we assumed that the U.S. Navy's decision to relocate EOD Mobile Unit Eleven forces to a new homebase in Imperial Beach, California, would reduce the number of underwater detonations from a maximum of 60 per year underwater detonations to no more than four detonations per year (U.S. Navy 2008d). Then, we relied on the U.S. Navy's estimates of the number of endangered or threatened marine mammals that might be exposed to those detonations and experience either adverse behavioral responses, temporary threshold shifts, or be exposed to received levels of 205 dB or 13 psi-ms, which would be expected to result in 50 percent tympanic membrane rupture or slight lung injury.

Results of Exposure Analyses

Our analyses of the evidence available led us to conclude that the following species are likely to co-occur, in space and time, with U.S. Navy training activities on the Northwest Training Range Complex as follows:

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*. 1999, Mate *et al*. 1999, Gregr *et al*. 2000; Stafford *et al*. 1999, 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.

Exposure to Vessel Traffic. We did not estimate the number of blue whales or other endangered or threatened whales that might be exposed to vessel traffic independent of the number of individuals that might be exposed to active sonar associated with those exercises because the data we would have needed to support those analyses were not available. Nevertheless, we assumed that any individuals of the endangered or threatened species that were likely to be exposed to active sonar at received levels sufficiently high to bring them close to the bow of Navy vessels moving at speeds would have some risk of being struck by the ship. For the purposes of these analyses, we assumed that a whale that occurred within 560 meters (1,968 feet) of a Navy vessel moving at speeds greater than 14 knots would have some risk of being struck.

If we assume that blue whales would occur at the mean densities reported for Oregon and Washington when they would be exposed to U.S. Navy training activities (0.00036 blue whales per square kilometer), one blue whale might occur close enough to a Navy vessel that is underway to have some risk of being struck by the vessel. In the introduction to this subsection of our Opinion, we discussed the errors associated with this statement and argued that, 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 a blue whale on the Northwest Training Range Complex is sufficiently small to be considered discountable.

Exposure to Mid-frequency Active Sonar. Assuming that blue whales would occur at the mean densities reported for Oregon and Washington when they would be exposed to mid-frequency active sonar during U.S. Navy training activities (0.00036 blue whales per square kilometer), we would expect about 228 exposures involving blue whales to result from the 43 hours of training the U.S. Navy plans to conduct with AN/SQS-53C and the 65 hours of training with AN/SQS-56 at the Northwest Training Range Complex each year. About 143 of these exposure events (about 66 percent) would occur at received levels of lower than 140 dB, when blue whales would be between 51 and 130 kilometers (between about 32 and 81 miles) from the source of a sonar ping. Another 47 of these exposure events (about 20 percent) would occur at received levels between 140 and 150 dB or distances between 25 and 51 kilometers (between about 15.5 and 32 miles) from the source of a sonar ping. In total, we would expect about 86 percent of these 228 exposure events to occur at received levels less than 150 dB and distances greater than 25 kilometers (about 15.5 miles) from a sonar source. About 14 of the 228 exposure events (about 5.4 percent) would occur at received levels between 160 and 180 dB, when blue whales would occur between 0.56 and 10 kilometers (between 0.35 and about 6.2 miles) of the source of a sonar ping (see Figure 3).

Based on the densities presented in Columns “D” and “E” of Table 7, the U.S. Navy estimated that 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.

Exposure to Underwater Detonations. Based on the results of the U.S. Navy’s models, we would expect 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 “behavioral harassment.” We would expect 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 would 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.

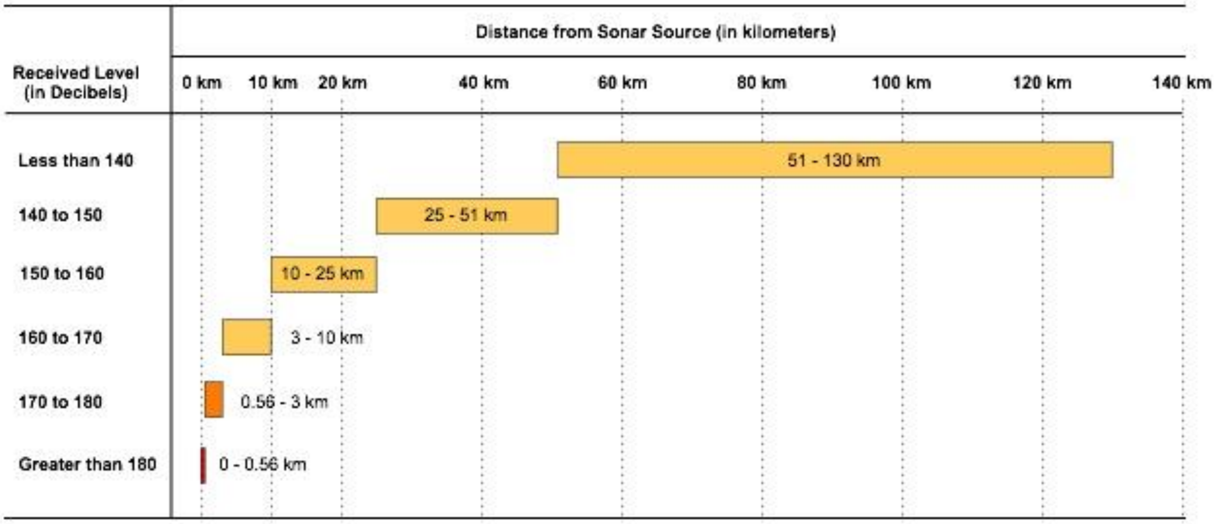

Figure 3. Estimated distances between the source of active sonar and received level in the Northwest Training Range Complex (drawn from data contained in Appendix D of the U.S. Navy's Draft EIS/OEIS for the Northwest Training Range Complex (U.S. Navy 2008d)

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.

Exposure to Vessel Traffic. We did not estimate the number of fin whales or other endangered or threatened whales that might be exposed to vessel traffic independent of the number of individuals that might be exposed to active sonar associated with those exercises because the data we would have needed to support those analyses were not available. Nevertheless, we assumed that any individuals of the endangered or threatened species that were likely to be exposed to active sonar at received levels sufficiently high to bring them close to the bow of Navy vessels moving at speeds would have some risk of being struck by the ship. For the purposes of these analyses, we assumed that a whale that occurred within 560 meters (1,968 feet) of a Navy vessel moving at speeds greater than 14 knots would have some risk of being struck.

If we assume that fin whales would occur at the mean densities reported for Oregon and Washington when they would be exposed to U.S. Navy training activities (0.00123 fin whales per square kilometer), three fin whale might occur close enough to a Navy vessel that is underway to have some risk of being struck by the vessel. In the introduction to this subsection of our Opinion, we discussed the errors associated with this statement and argued that, 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 a fin whale on the Northwest Training Range Complex is sufficiently small to be considered discountable.

As with blue whales, the primary error with this statement is that it assumes that sound fields produced by active sonar pings are the only acoustic cues produced by U.S. Navy vessels that are underway and that would be available to fin whales. This is not the case: even with quieting technology, 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 fin whales 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 whale). 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 smaller than our exposure models suggest.

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 a fin whale on the Northwest Training Range Complex is sufficiently small to be considered discountable.

Exposure to Mid-frequency Active Sonar. Assuming that fin whales would occur at the mean densities reported for Oregon and Washington when they would be exposed to mid-frequency active sonar during U.S. Navy training activities (0.00123 fin whales per square kilometer), we would expect about 790 exposure events involving fin whales to result from the 43 hours of training the U.S. Navy plans to conduct with AN/SQS-53C and the 65 hours of training with AN/SQS-56 at the Northwest Training Range Complex each year. About 495 of these exposure events (about 66 percent) would occur at received levels of lower than 140 dB, when fin whales would be between 51 and 130 kilometers (between about 32 and 81 miles) from the source of a sonar ping. Another 162 of these exposure events (about 20 percent) would occur at received levels between 140 and 150 dB or distances between 25 and 51 kilometers (between about 15.5 and 32 miles) from the source of a sonar ping. In total, we would expect about 86 percent of these 790 exposure events to occur at received levels less than 150 dB and distances greater than 25 kilometers (about 15.5 miles) from a sonar source. About 50 of the 790 exposure events (about 5.4 percent) 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 (see Figure 3).

Based on the densities presented in Columns "D" and "E" of Table 7, the U.S. Navy estimated that 17 fin 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.

Exposure to Underwater Detonations. Based on the results of the U.S. Navy's models, we would expect 12 instances 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 would expect another 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 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.

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 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 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 and declines substantially from September onward (Calambokidis 1997, Calambokidis *et al*. 1997, 2000, 2001; 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 (Green *et al*. 1992, Forney 2007).

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.

Exposure to Vessel Traffic. We did not estimate the number of humpback whales or other endangered or threatened whales that might be exposed to vessel traffic independent of the number of individuals that might be exposed to active sonar associated with those exercises because the data we would have needed to support those analyses were not available.

If we assume that humpback whales would occur at the mean densities reported for Oregon and Washington when they would be exposed to U.S. Navy training activities (0.00065 humpback whales per square kilometer), one humpback whale might occur close enough to a Navy vessel that is underway to have some risk of being struck by the vessel. In the introduction to this subsection of our Opinion, we discussed the errors associated with this statement and argued that, 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 a humpback whale on the Northwest Training Range Complex is sufficiently small to be considered discountable.

Exposure to Mid-frequency Active Sonar. Assuming that humpback whales would occur at the mean densities reported for Oregon and Washington when they would be exposed to mid-frequency active sonar during U.S. Navy training activities (0.00065 humpback whales per square kilometer), we would expect about 416 exposure events involving humpback whales to result from the 43 hours of training the U.S. Navy plans to conduct with AN/SQS-53C and the 65 hours of training with AN/SQS-56 at the Northwest Training Range Complex each year. About 260 of these exposure events (about 66 percent) would occur at received levels of lower than 140 dB, when humpback whales would be between 51 and 130 kilometers (between about 32 and 81 miles) from the source of a sonar ping. Another 85 of these exposure events (about 20 percent) would occur at received levels between 140 and 150 dB or distances between 25 and 51 kilometers (between about 15.5 and 32 miles) from the source of a sonar ping. In total, we would expect about 86 percent of these 416 exposure events to occur at received levels less than 150 dB and distances greater than 25 kilometers (about 15.5 miles) from a sonar source. About 26 of the 416 exposure events (about 5.4 percent) would occur at received levels between 160 and 180 dB, when humpback whales would occur between 0.56 and 10 kilometers (between 0.35 and about 6.2 miles) of the source of a sonar ping (see Figure 3).

Based on the densities presented in Columns “D” and “E” of Table 7, the U.S. Navy estimated that 15 humpback 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.

Exposure to Underwater Detonations. Based on the results of the U.S. Navy’s models, we would not expect any instances in which humpback 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 as a result of that exposure.

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, Gregr and Trites 2001, Best and Lockyer 2002), 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*. 1999).

In the early to mid-1900s, sei whales were hunted off the coast of British Columbia (Pike and MacAskie 1969; Gregr et al. 2000). 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 (Preston 2003) 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.

Exposure to Vessel Traffic. Like the three whales we have discussed thus far, we did not estimate the number of sei whales that might be exposed to vessel traffic independent of the number of individuals that might be exposed to active sonar associated with those exercises because the data we would have needed to support those analyses were not available. Nevertheless, using the approach we described for blue whales (see the preceding narrative) and assuming that sei whales would occur at the mean densities reported for Oregon and Washington when they would be exposed to U.S. Navy training activities (0.00018 sei whales per square kilometer), no sei whale are likely to occur close enough to a Navy vessel that is underway to have some risk of being struck by the vessel.

In the introduction to this subsection of our Opinion, we discussed the errors associated with this statement and argued that, 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 a sei whale on the Northwest Training Range Complex is sufficiently small to be considered discountable.

Exposure to Mid-frequency Active Sonar. Assuming that sei whales would occur at the mean densities reported for Oregon and Washington when they would be exposed to mid-frequency active sonar during U.S. Navy training activities (0.00018 sei whales per square kilometer), we would expect about 113 exposure events involving sei whales to result from the 43 hours of training the U.S. Navy plans to conduct with AN/SQS-53C and the 65 hours of training with AN/SQS-56 at the Northwest Training Range Complex each year. About 71 of these exposure events (about 66 percent) would occur at received levels of lower than 140 dB, when sei whales would be between 51 and 130 kilometers (between about 32 and 81 miles) from the source of a sonar ping. Another 23 of these exposure events (about 20 percent) would occur at received levels between 140 and 150 dB or distances between 25 and 51 kilometers (between about 15.5 and 32 miles) from the source of a sonar ping. In total, we would expect about 86 percent of these 113 exposure events to occur at received levels less than 150 dB and distances greater than 25 kilometers (about 15.5 miles) from a sonar source. About 7 of the 113 exposure events (about 5.4 percent) would occur at received levels between 160 and 180 dB, when sei whales would occur between 0.56 and 10 kilometers (between 0.35 and about 6.2 miles) of the source of a sonar ping (see Figure 3).

Based on the densities presented in Columns “D” and “E” of Table 7, the U.S. Navy estimated that one sei whale 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.

Exposure to Underwater Detonations. Based on the results of the U.S. Navy’s models, we would 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 as a result of that exposure.

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).

Exposure to Vessel Traffic. Like the whales we have discussed thus far, we did not estimate the number of southern resident killer whales that might be exposed to vessel traffic independent of the number of individuals that might be exposed to active sonar associated with those exercises because the data we would have needed to support those analyses were not available. Nevertheless, using the approach we described for blue whales (see the preceding narrative) and assuming that southern resident killer whales occur on the Northwest Training Range Complex at densities estimated for coastal waters of Washington when they would be exposed to U.S. Navy training activities (0.00055 southern resident killer whales per square kilometer), no southern resident killer whales are likely to occur close enough to a Navy vessel that is underway to have some risk of being struck by the vessel.

Exposure to Mid-frequency Active Sonar. Assuming that southern resident killer whales would occur at densities estimated for coastal waters of Washington when they would be exposed to mid-frequency active sonar during U.S. Navy training activities (0.00055 southern resident killer whales per square kilometer), we would not expect southern resident killer whales to be exposed to mid-frequency active sonar the 43 hours of training the U.S. Navy plans to conduct with AN/SQS-53C and the 65 hours of training with AN/SQS-56 at the Northwest Training Range Complex each year.

Based on the densities presented in Columns “D” and “E” of Table 7, the U.S. Navy estimated that 102 southern resident 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. The Navy estimated that there might be two instances in which southern resident killer whales would accumulate sufficient energy to experience temporary threshold shift as a result of their exposure to active sonar associated with the training activities it proposes to conduct on the Northwest

Training Range Complex. Because our exposure analyses did not consider focused on mid-frequency active sonar and, as a result, did not consider every sound source the U.S. Navy proposes to employ on the Northwest Training Range Complex, we will conduct the rest of our analyses using the U.S. Navy's estimates.

Exposure to Underwater Detonations. Based on the results of the U.S. Navy's models, we would not expect any instances in which southern resident killer 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 as a result of that exposure.

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.

Exposure to Vessel Traffic. Like the whales we have discussed thus far, we did not estimate the number of sperm whales that might be exposed to vessel traffic independent of the number of individuals that might be exposed to active sonar associated with those exercises because the data we would have needed to support those analyses were not available. Using the approach we described for blue whales (see the preceding narrative) and assuming that sperm whales occur on the Northwest Training Range Complex at the mean densities reported for Oregon and Washington when they would be exposed to U.S. Navy training activities (0.00260 sperm whales per square kilometer), six sperm whales might occur close enough to a Navy vessel that is underway to have some risk of being struck by the vessel.

In the introduction to this subsection of our Opinion, we discussed the errors associated with this statement and argued that, 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 a blue whale on the Northwest Training Range Complex is sufficiently small to be considered discountable.

Exposure to Mid-frequency Active Sonar. Assuming that sperm whales would occur at the mean densities reported for Oregon and Washington when they would be exposed to mid-frequency active sonar during U.S. Navy training activities (0.00260 sperm whales per square kilometer), we would expect about 1,664 exposure events involving sperm whales to result from the 43 hours of training the U.S. Navy plans to conduct with AN/SQS-53C and the 65 hours of training with AN/SQS-56 at the Northwest Training Range Complex each year. About 1,043 of these exposure events (about 66 percent) would occur at received levels of lower than 140 dB, when sperm whales would be between 51 and 130 kilometers (between about 32 and 81 miles) from the source of a sonar ping. Another 341 of these exposure events (about 20 percent) would occur at received levels between 140 and 150 dB or distances between 25 and 51 kilometers (between about 15.5 and 32 miles) from the source of a sonar ping. In total, we would expect about 86 percent of these 1,664 exposure events to occur at received levels less than 150 dB and distances greater than 25 kilometers (about 15.5 miles) from a sonar source. About 105 of the 1,664 exposure events (about 5.4 percent) would occur at received levels between 160 and 180 dB, when sperm whales would occur between 0.56 and 10 kilometers (between 0.35 and about 6.2 miles) of the source of a sonar ping (see Figure 3).

Based on the densities presented in Columns "D" and "E" of Table 7, the U.S. Navy estimated that 102 sperm 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. The Navy concluded that two sperm whales would accumulate sufficient energy to experience temporary threshold shift as a result of their exposure to active sonar associated with the training activities it proposes to conduct on the Northwest Training Range Complex.

Exposure to Underwater Detonations. Based on the results of the U.S. Navy's models, we would expect 13 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." We would expect another 10 instances in which sperm whales would be exposed to underwater detonations and experience temporary threshold shifts as a result and one 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 as a result of that exposure.

STELLER SEA 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 (NMFS 1992, 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.

Exposure to Mid-frequency Active Sonar. If we assume that Steller sea lions occur at a mean density of 0.011 sea lions per square kilometer per year (see Table 7), we would expect a total of about 7,043 instances in which Steller sea lions might be exposed to mid-frequency active sonar during the military readiness activities the U.S. Navy proposes to conduct at the Northwest Training Range Complex. As with the other marine mammals we have discussed thus far, about 66 percent of these exposure events, or 4,414 exposures events, would occur at received levels of less than 140 dB, when Steller sea lions would be between 51 and 130 kilometers (between about 32 and 81 miles) from the source of a sonar ping. We would expect another 1,442 exposure events (about 20 percent) to occur at received levels between 140 and 150 dB or distances between 25 and 51 kilometers (between about 15.5 and 32 miles) from the source of a sonar ping. In total, we would expect about 86 percent of these 7,043 exposure events to occur at received levels less than 150 dB and distances greater than 25 kilometers (about 15.5 miles) from a sonar source. About 445 of the 7,043 exposure events would occur at received levels between 160 and 180 dB, when

Steller sea lions would occur between 0.56 and 10 kilometers (between 0.35 and about 6.2 miles) of the source of a sonar ping (see Figure 3).

Based on the densities presented in Columns “D” and “E” of Table 7, the U.S. Navy estimated that 114 Steller sea lions 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.

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 Steller sea lions that night 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 rather than in Puget Sound

Exposure to Underwater Detonations. The U.S. Navy estimated that 114 Steller sea lions 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” as a result of that exposure.

LEATHERBACK SEA TURTLES. 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 highest number of observations were made 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 each year other than to recognize that they are likely to be exposed to those activities.

As discussed in greater detail earlier in this Opinion, leatherback sea turtles forage in nearshore waters from the Umpqua River (Winchester Bay), Oregon, north to Cape Flattery, Washington, and offshore to the 2000 meter isobath. This area overlaps with the Quinault Underwater Tracking Range in its current configuration and with the expansion the U.S. Navy proposes. Therefore, we assume that leatherback sea turtles are likely to be exposed to military readiness activities on the Quinault Underwater Tracking Range portion of the Keyport Range Complex. However, their foraging distribution does not appear to bring them into Crescent Harbor Underwater EOD range, Floral Point 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.

SOUTHERN GREEN STURGEON. As discussed in the *Status of the Species* section of this Opinion, green sturgeon are distributed from the Bering Sea, Alaska, to Ensenada, Mexico, although this may or may not encompass the actual distribution of southern green sturgeon. We do not have information on the density of southern green sturgeon in the action area (or a surrogate for that area) that have allowed us to estimate the probability of these sturgeon being exposed to the activities the U.S. Navy plans to conduct in the Northwest Training Range Complex each year other than to recognize that they are likely to be exposed to those activities. Nevertheless, we assume that southern green sturgeon may occur in those areas that NMFS has designated as critical habitat for the species: coastal bays and estuaries include estuaries from Elkhorn Slough, California, to Puget Sound, Washington. Specifically, they might occur in coastal areas within depths of 60 fathoms where green sturgeon might forage or migrate. Because this distribution overlaps with the action area for this consultation and we do not have evidence that would lead us to conclude that southern green sturgeon are not likely to occur on the Northwest Training Range Complex (particularly areas W-237A, W-237B, and W-237E), we assume that green sturgeon are likely to be exposed to training activities that occur in those areas of the Northwest Training Range Complex.

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). 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 green sturgeon would not be exposed to mid-frequency active sonar in Puget Sound.

PACIFIC SALMON AND STEELHEAD. As discussed in the *Status of the Species* section of this Opinion, endangered and threatened species of Pacific salmon and steelhead distribute in coastal waters from northern California, Oregon, Washington, and in waters further north. As a result, we assume that endangered and threatened species of Pacific salmon and steelhead occur in those areas that NMFS has designated as critical habitat for the species. Because this distribution overlaps with the action area for this consultation and we do not have evidence that would lead us to conclude that endangered and threatened species of Pacific salmon and steelhead are not likely to occur on the Northwest Training Range Complex (particularly areas W-237A, W-237B, and W-237E), we assume that endangered and threatened species of Pacific salmon and steelhead are likely to be exposed to training activities that occur in those areas of the Northwest Training Range Complex. 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 endangered and threatened species of Pacific salmon and steelhead would not be exposed to mid-frequency active sonar in Puget Sound.

As we did in our 30 June 2008 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 EOD Range is outside the major migration corridor for river systems in the area while the Indian Island Underwater EOD Range is within a migratory corridor for Chinook, chum, and other salmon species.

Therefore, we expect endangered or threatened salmon to occur in higher densities at the Indian Island Underwater EOD Range area than Crescent Harbor Underwater EOD Range area. At any time of the year, we would expect small numbers of adult salmon to occur within the injury distances of the detonation sites at the time of detonation. Therefore, juvenile and adult salmon are likely to be injured or killed by detonations associated with U.S. Navy training activities on the Northwest Training Range Complex.

SOUTHERN EULACHON. 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 (74 FR 10857). This includes distribution includes areas like Grays Harbor and Willapa Bay on the Washington coast where eulachon have been described as “common” areas like Oregon’s Umpqua River where eulachon are considered “abundant,” areas like the Klamath River in northern California where eulachon are considered abundant, and areas like Puget Sound and Skagit Bay in Washington; Siuslaw River, Coos Bay, and Rogue River in Oregon; and Humboldt Bay in California where eulachon are described as “rare” (Emmett *et al*. 1991, Monaco *et al*. 1990).

We do not have information on the density of southern eulachon in the action area (or a surrogate for that area) that have allowed us to estimate the probability of these sturgeon being exposed to the activities the U.S. Navy plans to conduct in the Northwest Training Range Complex each year other than to recognize that they are likely to be exposed to those activities. Nevertheless, we assume that eulachon are likely to be exposed to training activities that occur in those areas of the Northwest Training Range Complex. (particularly areas W-237A, W-237B, and W-237E).

5.3 Response Analyses

As discussed in the *Approach to the Assessment* section of this biological opinion, response analyses determine how listed resources are likely to respond after being exposed to an Action’s effects on the environment or directly on listed species themselves. For the purposes of consultations on activities involving active sonar, our assessments try to detect the probability of lethal responses, sensory impairment (permanent and temporary threshold shifts and acoustic masking), physiological responses (particular stress responses), behavioral responses, and social responses that might result in reducing the fitness of listed individuals. Ideally, our response analyses consider and weigh evidence of adverse consequences, beneficial consequences, or the absence of such consequences.

It is important to begin these analyses by stating that, to the best of our knowledge, no data or other information are available from actual exposures of endangered or threatened marine mammals to mid-frequency active sonar in either captive or natural settings were available for this consultation. We are aware of the studies of the behavioral responses of small cetaceans given exposed to mid-frequency active sonar that are being conducted at the U.S. Navy’s instrumented training range in the Bahamas (the AUTEC range), the Hawai'i Range Complex, and Southern California Range Complex. Preliminary and qualitative results have been presented for several years; however, the actual data from those studies were not available for us to consider during this consultation. We are also aware of and have cited initial data available from controlled exposure experiments that are being conducted on killer whales by the Norwegian Defense Ministry; we will incorporate additional information from those studies when the information becomes available.

Without more specific empirical information on the actual responses of the endangered and threatened species that we consider in this Opinion upon being exposed to the mid-frequency active sonar the U.S Navy proposes to employ on the Northwest Training Range Complex, we had to rely on the best scientific and commercial data available to assess the probable responses of endangered and threatened species to mid-frequency active sonar. In the narratives that follow this introduction, we summarize the best scientific and commercial data on the responses of marine animals to mid-frequency active sonar. Then we use that information to make inferences about the probable responses of the endangered and threatened species we are considering in this Opinion.

5.3.1 Potential Responses of Listed Species to 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 Green 2004; Lusseau 2006). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jackson 1994, Evans *et al.* 1992, 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels is similar to their behavioral responses to predators.

As we discussed previously, 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 1986, Bejder 1999, 2006a, 2006b; Bryant *et al.* 1984, Corkeron 1995, David 2002, Erbé 2000, Félix 2001, Magalhães *et al.* 2002, Goodwin and Cotton 2004, Hewitt 1985, Lusseau 2003, 2006; Lusseau and Bejder 2007, Ng and Leung 2003, Nowacek *et al.* 2001, Richter *et al.* 2003, 2006; Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams and Ashe 2007, Williams *et al.* 2002, 2006a, 2006b; Würsig *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[4]. 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, Cope *et*

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[4] As discussed in the *Approach to the Assessment* section of this Opinion, we distinguish between “avoidance,” “evasion,” and “escape” using the distinctions proposed by Weihs and Webb (1984): “avoidance” is a shift in position by prey before a potential predator begins an attack; “evasion” is a response by potential prey to a perceived attack from a potential predator; and “escape” is the most acute form of evasive behavior.

al. 2000, David 2002, Lusseau 2003, Kruse 1991, 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);
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, 2006; Williams *et al.* 2002, 2006a, 2006b) than when it engages in frequent course changes (Evans *et al. 1*994, Lusseau 2006, Williams *et al.* 2002)
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, 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, 2006; Würsig *et al.* 1998). For example, Würsig *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, 2005*a*; Notarbartolo di Sciara *et al.* 1996, Nowacek *et al.* 2001, Van Parijs and Corkeron 2001, Williams *et al.* 2002). 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 (Edds and Macfarlane 1987, Baker and Herman 1989, Kruse 1991, Polacheck and Thorpe 1990, Evans *et al. 1*992, Lütkebohle 1996, Nowacek *et al. 1*999). 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 (Stewart *et al.* 1982, 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, Notarbartolo di Sciara *et al.* 1996, 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 distances 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 allows 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.

Because of the number of vessels involved in U.S. Navy training exercises, their speed, their use of course changes as a tactical measure, and sounds associated with their engines and displacement of water along their bowline, the available evidence leads us to expect marine mammals to treat Navy vessels as potential stressors. Animals that perceive an approaching potential predator, predatory stimulus, or disturbance stimulus have four behavioral options (see Blumstein 2003 and Nonacs and Dill 1990):

a. ignore the disturbance stimulus entirely and continue behaving as if a risk of predation did not exist;

b. alter their behavior in ways that minimize their perceived risk of predation, which generally involves fleeing immediately;

c. change their behavior proportional to increases in their perceived risk of predation which requires them to monitor the behavior of the predator or predatory stimulus while they continue their current activity, or

d. take proportionally greater risks of predation in situations in which they perceive a high gain and proportionally lower risks where gain is lower, which also requires them to monitor the behavior of the predator or disturbance stimulus while they continue their current activity.

The latter two options are energetically costly and reduce benefits associated with the animal's current behavioral state. As a result, animals that detect a predator or predatory stimulus at a greater distance are more likely to flee at a greater distance (see Holmes *et al.* 1993, Lord *et al.* 2001). Some investigators have argued that short-term avoidance reactions can lead to longer term impacts such as causing marine mammals to avoid an area (Salden 1988, Lusseau 2005) or alter a population's behavioral budget (Lusseau 2004) which could have biologically significant consequences on the energetic budget and reproductive output of individuals and their populations.

Of the endangered and threatened species that occur in the Action Area for this consultation, the endangered and threatened sea turtles are most likely to ignore U.S. Navy vessels entirely and continue behaving as if the vessels and any risks associated with those vessels did not exist.

5.3.2 Review of Literature on the Potential Responses of Listed Species to Active Sonar

As discussed in the *Approach to the Assessment* section of this Opinion, we conduct response analyses to determine whether and how listed species and designated critical habitat are likely to respond after being exposed to an Action's effects. For the purposes of consultations on activities that involve active sonar or underwater detonations, our assessments try to detect the probability of lethal responses, sensory impairment (permanent and temporary threshold shifts and acoustic masking), physiological responses (particular stress responses), behavioral responses, and social responses that are likely to directly or indirectly reduce the fitness of listed individuals.

Our response analyses consider and weigh all of the evidence available on the response of marine animals upon being exposed to active sonar and probable fitness consequences for the animals that exhibit particular responses or sequence of responses. It is important to acknowledge, however, that the empirical evidence on how endangered or threatened marine animals respond upon being exposed to active sonar and sound pressure waves associated with underwater detonations in natural settings is very limited. Therefore, the narratives that follow this introduction summarize the best scientific and commercial data available on the responses of other species to active sonar, sound pressure waves associated with underwater detonations, or other acoustic stimuli. Based on those data, we identify the probable responses of endangered and threatened marine animals to mid-frequency active sonar transmissions.

Figure 2 illustrates the conceptual model we use to assess the potential responses of marine animals when they are exposed to active sonar or sound pressure waves associated with underwater detonations. The narratives that follow are generally organized around the items listed in the column titled "Proximate Responses by Category" in that Figure. These analyses examine the evidence available to determine if exposing endangered and threatened species to mid-frequency active sonar is likely to cause responses that might reduce the fitness of individuals that might be exposed.

The information that follows is presented as if endangered or threatened marine animals that occur on the Keyport or 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.

5.3.2.1 Physical Damage

For the purposes of this assessment, "injuries" represents physical trauma or damage that is a direct result of an acoustic exposure, regardless of the potential consequences of those injuries 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 is discussed later in this section of the Opinion). Based on the literature available, active sonar might injure marine animals through two mechanisms (see "Box P" in Figure 2): 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 (Box P1 of Figure 2 illustrates the potential consequences of acoustic resonance; see 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 (Ketten 2004, Cudahy and Ellison 2001) and tissue damage resulting from "gas and fat embolic syndrome" (Fernandez *et al*. 2005, Jepson *et al*. 2003, 2005). 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 (2001) 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 (1996) 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.

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[5] 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 (Miller 1974, Ward 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 cells damage does not accompany TTS and loss 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.

Compound threshold shift or CTS, occurs when some loss in hearing sensitivity is permanent and some is temporary (for example, there might be a permanent loss of hearing sensitivity at some frequencies and a temporary loss at other frequencies or a loss of hearing sensitivity followed by partial recovery).

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[5] Animals can experience losses in hearing sensitivity through other mechanisms. The processes of aging and several diseases cause some humans to experience permanent losses in their hearing sensitivity. Body burdens of toxic chemicals can also cause animals, including humans, to experience permanent and temporary losses in their hearing sensitivity (for example, see Mills and Going 1982 and Fechter and Pouyanos 2005).

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.* 2001, 2003) 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.* (2001, 2003) conducted TTS experiments using 1-second duration tones at 3 kHz. The test method was similar to that of Schlundt *et al.* except the tests were conducted in a pool with a very low ambient noise level (below 50 dB re 1 $\mu Pa^2/Hz$), 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 µPa which might cause TTS. 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). However, 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.

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 (Miller 1974, Ward 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 entirely or reduce the intensity of an exposure would 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 suggests that temporary noise-induced hearing losses do not have direct or indirect effect on the longevity or reproductive success of animals that experience permanent, temporary, or compound threshold shifts (Box P2 of Figure 2 illustrates the potential consequences of noise-induced loss in hearing sensitivity). Like humans, free-ranging animals might experience short-term impairment in their ability to use their sense of hearing to detect environmental cues about their environment while their ears recover from the temporary loss of hearing sensitivity. Although we could not locate information 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.

5.3.2.2 Behavioral Responses

Marine mammals, sea turtles, and anadromous fish 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 2004, Bejder *et al*. 2009, Berger *et al*. 1983, Frid 2003, Frid and Dill 2002, Gill *et al*. 2000, 2001; Gill and Sutherland 2000, 2001; Harrington and Veitch 1992, Lima 1998, Lima & Dill 1990, Madsen 1994, 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 *et al*. 2001, (Houston and McNamara 1986, Lima 1998, Lima and Bednekoff 1999, Ydenberg and Dill 1996). Further, animals appear to detect and adjust their responses to temporal variation in predation risks (Kat and Dill 1998, Lima and Bednekoff 1999, Rodriguez-Prieto *et al*. 2008).

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 (e.g., Frid 2001, 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 combinations of these responses (Frid and Dill 2002, Romero 2004, Sapolsky *et al*. 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 (Bejder *et al*. 2009, Gill *et al*. 2001, 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, Mullner *et al*. 2004, Waunters *et al*. 1997), 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 (Boxes BR1.1 and BR1.2 of Figure 2); (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 (Box BR1.3 of Figure 2); (3) they may remain continuously vigilant of the source of the acoustic stimulus, which would alter their time budget. That is, the during the time they are vigilant, they are not engaged in other behavior (Box BR1.4 of Figure 2); 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 (HORIZONTAL AND VERTICAL AVOIDANCE. 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*. (1995) 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 (1993) conducted sound playback experiments to assess the effects of mid-frequency active sonar on humpback whales in Hawai'ian waters. Specifically, he 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, 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.

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 sightability, 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, 1998, 2000, 2001). 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 2003). The analysis of the combined data from all years indicated that baleen whales stayed farther from airguns during periods of shooting (Stone 2003). 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 2003).

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 *et al.* 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 the normal feeding area is not known; however, 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 white 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 *et al.* 1997, Schlundt *et al.* 2000), and to shorter broadband pulsed signals (Finneran *et al.* 2000, 2002). 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 (Schlundt *et al.* 2000, Finneran *et al.* 2002). 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, 2002). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran *et al.* 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway *et al.* 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*. (1995a) and Richardson (1997, 1998) 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 μPa 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 (*Eschrictius robustus*) 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, semisubmersible, drilling platform, and production platform.

Morton *et al*. (2004) 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 1μPa 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*. (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 (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*. (2006) 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 (Lusseau 2004, Allen and Read 2000). 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 Hawai’i for the same reason.

As Bejder *et al*. (2006 and 2009) 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, 2004b; Gill *et al*. 2001, Frid and Dill 2002, 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 Dill 1996). Ydenberg and Dill (1996) 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 am 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 appeared not to be noticed, 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 or 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. On the Northwest Training Range Complex, we would expect these kind of responses at distances between 0 and 0.56 kilometers where received levels from active sonar would be greater than 180 dB. However, at these distances endangered or threatened marine mammals would be aware of a wide array of visual and acoustic cues associated with Navy vessels (including sound associated with a ship’s engines, the bow wake, etc.) and an animal’s decision to change its behavior might be a response to active sonar, one of these other cues, or the entire suite of cues.

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.

Although causal relationships between beaked whale stranding events and active sonar remain unknown, several authors have hypothesized that stranding events involving these species in the Bahama and Canary Islands may have been triggered when the whales changed their dive behavior to avoid exposure to active sonar (Cox *et al*. 2006, Rommel *et al*. 2006). These authors proposed two mechanisms by which the behavioral responses of beaked whales upon being exposed to active sonar might result in a stranding event. First, beaked whales that occur in deep waters that are in close proximity to shallow waters (for example, the "canyon areas" that are cited in the Bahamas stranding event; see D'Spain and D'Amico 2006), may respond to active sonar by swimming into shallow waters to avoid further exposures and strand if they were not able to swim back to deeper waters.

Second, beaked whales exposed to active sonar might alter their dive behavior (see Boxes BR1.2 and BR1.3 of Figure 2). Changes in their dive behavior might cause them to remain at the surface or at depth for extended periods of time which could lead to hypoxia directly by increasing their oxygen demands or indirectly by increasing their energy expenditures (to remain at depth) and increase their oxygen demands as a result. If beaked whales are at depth when they detect a ping from an active sonar transmission and change their dive profile leading to formation of significant gas bubbles, which damage multiple organs or interfere with normal physiological function (Cox *et al*. 2006, Rommel *et al*. 2006, Zimmer and Tyack 2007).

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.

Based on these data, Cox *et al*. (2006) hypothesized that a critical dive sequence might make beaked whales more prone to stranding in response to acoustic exposures. The sequence began with (1) very deep (to depths as deep as 2 kilometers) and long (as long as 90 minutes) foraging dives with (2) relatively slow, controlled ascents, followed by

(3) a series of "bounce" dives between 100 and 400 meters in depth (also see Zimmer and Tyack 2007). They concluded that acoustic exposures that disrupted any part of this dive sequence (for example, causing beaked whales to spend more time at surface without the bounce dives that are necessary to recover from the deep dive) could produce excessive levels of nitrogen super-saturation in their tissues, leading to gas bubble and emboli formation that produces pathologies similar to decompression sickness.

The evidence available suggests that southern resident killer whales and sperm 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 and 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 sperm 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, 1990, Cooper 1997, 1998). 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 2001*a*, 2001*b*), 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, van Rij 2007). 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 1998, Treves 2000). Despite those benefits, however, vigilance has a cost of time: when animals focus their attention on specific environmental cues, it is 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 (Saino 1994, Beauchamp and Livoreil 1997, Fritz *et al*. 2002).

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 2001, 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 1994, White 1983). For example, Madsen (1994) reported that pink-footed geese (*Anser brachyrhynchus*) in undisturbed habitat gained body mass and had about a 46% 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% 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 10^{3}kJ/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 is informative. 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*. 2008, Gill *et al*. 2001, (Houston and McNamara 1986, Lima 1998, Lima and Bednekoff 1999, Ydenberg and Dill 1996). Further, animals appear to detect and adjust their responses to temporal variation in predation risks (Kat and Dill 1998, Lima and Bednekoff 1999, Rodriguez-Prieto *et al*. 2008). As a result, animals that decide that the ecological costs 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. When animals make risk allocation decisions, they accept they tolerate some exposure to a stressor, which means they accept 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 Dill 1996). 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 *et al*. 2008, Rodriguez-Prieto *et al*. 2008, and the example cited earlier from Watkins 1986). 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 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 predator 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.

5.3.2.3 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, Stokes 1971), acquire mates (Patricelli *et al*. 2002, Ryan 1985, Stokes 1971), assess other members of their species (Owings *et al*. 2002, Parker 1974, Sullivan 1984), evade predators (Greig-Smith 1980, Marler 1955, Vieth *et al*. 1980), and defend resources (Alatalo *et al*. 1990, Falls 1963, Zuberbuehler *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 produce vocalizations or visual or chemical displays 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 (Dunlop *et al*. 2010). 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 (Brenowitz 2004, Brumm *et al*. 2004, Lohr *et al*. 2003). Animals are also aware of environment conditions that affect whether listeners can discriminate and recognize their vocalizations from other sounds, which are more important than detecting a vocalization (Brenowitz 1982, Brumm *et al*. 2004, Dooling 2004, Dunlop *et al*. 2010, Marten and Marler 1977, Patricelli *et al*. 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 *et al*. 2004, Cody and Brown 1969, Dunlop *et al*. 2010, Patricelli *et al*. 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 (Box BR2.1 of Figure 2). 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 the voices while talking or singing in the face of high, background levels of sound (Lombard 1911, Dunlop *et al*. 2010, Tonkinson 1990).

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 (Box BR2.2 of Figure 2). 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 (2003) 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 (Box BR2.3 of Figure 2). 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% 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% 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 needs to increase the duration of their vocalization to avoid masking by the boat noise.

4. Adjust the temporal delivery of vocalizations (Boxes BR2.4 and BR2.5 of Figure 2). Animals responding in this way change when they vocalize or changing 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 behaviours 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 behaviours) 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, number of pulses produced per pulsed-call series and call repetition rate as noise levels increased.

Park et al. (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 (Dunlop *et al*. 2010, Patricelli *et al*. 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, the 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 2003, 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 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.

Based on the evidence available, endangered sperm whales may 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 research, development, test, and evaluation activities at the Naval Surface Warfare Center. . As a result, we assume that some of the sperm whales that are exposed to active sonar transmissions during one or more of the proposed missions might experience impaired communication as a result of that exposure. To preserve the saliency of their vocalizations, these whales may have to make one or more of the vocal adjustments discussed in this subsection. 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, vocal adjustments these whales would have to make would also be temporary.

Because the endangered and threatened sea turtles that are considered in this Opinion do not appear to vocalize, they are not likely to experience impaired communication by active sonar transmissions associated with the proposed research, development, test, and evaluation activities the U.S. Navy proposes to conduct.

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 (Dunlop *et al*. 2010, Erbé and Farmer 2000, Tyack 2000). Masking, or *auditory interference*, generally occurs when sounds in the environment are louder than and of a similar frequency to, auditory signals an animal is trying to receive. 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 (Box BR2 of Figure 2 illustrates the potential responses of animals to acoustic masking).

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 and Schevill 1975; Watkins *et al.* 1985). 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). Sperm whales have moved out of areas after the start of air gun seismic testing (Davis *et al.* 1995). Seismic air guns produce loud, broadband, impulsive noise (source levels are on the order of 250 dB) with "shots" every 15 seconds, 240 shots per hour, 24 hours per day during active tests. 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* 1999). 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*. (1974, 1985, 1993) 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).

5.3.2.4 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 *et al*. 2005, Seyle 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 response.

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 (Box S! of Figure 2). 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 1987, Rivier 1995, Box S2 of Figure 2) and altered metabolism (Elasser *et al*. 2000), reduced immune competence (Blecha 2000) and behavioral disturbance. Increases in the circulation of glucocorticosteroids (cortisol, corticosterone, and aldosterone in marine mammals; see Romano *et al*. 2004) have been equated with stress for many years.

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 impairs 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 diversts 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" (*sensu* 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, Krausman *et* *al*. 2004, Lankford *et al*. 2005, Reneerkens *et al*. 2002, Thompson and Hamer 2000). 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 (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*. (2004a, 2004b) 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.

5.3.2.6 Stranding Events

Despite the small number of instances in which marine mammal stranding events have been associated with mid-frequency active sonar usage and despite the fact that none of these stranding events involved endangered or threatened species, the amount of controversy that surrounds this issue requires us to address it. 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; 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 (Geraci *et al.* 1976, Eaton 1979, Odell *et al.* 1980, Best 1982). 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 the 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, Mignucci-Giannoni *et al.* 2000). These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Chroussos 2000, Creel 2005, DeVries *et al.* 2003, Fair and Becker 2000, Foley *et al.* 2001, Moberg 2000, Relyea 2005a, 2005b, 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 experiment 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 (2005) identified ten mass stranding events of Cuvier’s beaked whales 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 (Franzis 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, *Mesoplodon europaeus*, 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 Scientific Committee 2005).

Between 1960 and 2006, 48 (68%) involved beaked whales, 3 (4%) involved dolphins, and 14 (20%) involved whale species. Cuvier's beaked whales were involved in the greatest number of these events (48 or 68%), followed by sperm whales (7 or 10%), and Blainville and Gervais' beaked whales (4 each or 6%). Naval activities that might have involved active sonar are reported to have coincided with 9 (13%) or 10 (14%) of those stranding events. Between the mid-1980s and 2003 (the period reported by the International Whaling Commission), 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 *et al.* 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) and is noteworthy because it 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 have been reported. Of those 85 mass stranding events, 29 represent stranding events that occurred before 1958; 25 of those 29 (about 34%) 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.

Major Mass Stranding Events

In 1998, the North Atlantic Treaty Organization (NATO) Supreme Allied Commander, Atlantic Center Undersea Research Centre that conducted the sonar tests convened panels to review the data associated with the maneuvers in 1996 and beaked whale stranding events in the Mediterranean Sea. The report of these panels presented more detailed acoustic data than were available for beaked whales stranded in the Canary Islands (SACLANTCEN 1998). The NATO sonar transmitted two simultaneous signals lasting four seconds and repeating once every minute.

The simultaneous signals were broadcast at source levels of just under 230 dB re 1 µPa at 1 m. One of the signals covered a frequency range from 450-700 Hz and the other one covered 2.8-3.3 kHz. The *Ziphius* stranding events in the Kyparissiakos Gulf occurred during the first two sonar runs on each day of 12 and 13 May 1996. The close timing between the onset of sonar transmissions and the first stranding events suggests closer synchrony between the onset of the transmissions and the stranding events than was presented in Frantzis (1998). However, the Bioacoustics Panel convened by NATO concluded that the evidence available did not allow them to accept or reject sonar exposures as a causal agent in these stranding events. Their official finding was "An acoustic link can neither be clearly established nor eliminated as a direct or indirect cause for the May 1996 strandings."

KYPARISSIAKOS GULF, GREECE (1996). Frantzis (1998) reported an 'atypical' mass stranding of 12 Cuvier's beaked whales on the coast of Greece that was associated with acoustic trials by vessels from the North Atlantic Treaty Organisation (NATO). He was the first to hypothesize that these stranding events were related to exposure to low-frequency military sonar. However, the sonar in question produced both low- and mid-frequency signals (600Hz, 228 dB SPL re: 1µPa at 1m rms and 3kHz, 226 dB SPL, D'Amico and Verboom, 1998). Frantzis' hypothesis prompted an in-depth analysis of the acoustic activity during the naval exercises, the nature of the stranding events and the possibility that the acoustic source was related to the stranding events (D'Amico and Verboom, 1998). Since full necropsies had not been conducted and no gross or histological abnormalities were noted, the cause of the stranding events could not be determined unequivocally (D'Amico and Verboom, 1998). The analyses thus provided some support but no clear evidence for the hypothesized cause-and-effect relationship of sonar operations and stranding events.

BAHAMAS (2000). Concern about potential causal relationships between low-frequency sonar and marine mammal stranding resurfaced after a beaked whale stranding in the Bahamas in 2000. Fox *et al.* (2001) ruled out natural sound sources as a possible cause of the stranding, which pointed to an anthropogenic source. In 2001, the *Joint Interim Report, Bahamas Marine Mammal Stranding Event of 14-16 March 2000* (U.S. Department of Commerce and Secretary of the Navy 2001) exonerated the low-frequency sonar but concluded that "tactical mid-range frequency sonar onboard U.S. Navy ships that were in use during the sonar exercise in question were the most plausible source of this acoustic or impulse trauma." The report also went on to conclude, "the cause of this stranding event was the confluence of Navy tactical mid-range frequency sonar and the contributory factors acting together." The contributory factors identified included "a complex acoustic environment that included the presence of a strong surface duct, unusual underwater bathymetry, intensive use of multiple sonar over an extended period of time, a constricted channel with limited access, and the presence of beaked whales that appear to be sensitive to the frequencies produced by these sonars."

MADEIRA, SPAIN (2000). The stranding in the Bahamas was soon followed by another atypical mass stranding of Cuvier's beaked whales in the Madeira Islands. Between 10 and 14 May 2000, three Cuvier's beaked whales stranded on two islands in the Madeira archipelago. NATO naval exercises involving multiple ships occurred concurrently with these stranding events, although NATO has thus far been unwilling to provide information on the sonar activity during their exercises. Only one of the stranded animals was marginally fresh enough for a full necropsy (24 hours post-stranding). The necropsy revealed evidence of haemorrhage and congestion in the right lung and both kidneys (Freitas, 2004), as well as evidence of intracochlear and intracranial haemorrhage similar to that observed in the Bahamas beaked whales (D. Ketten, unpublished data).

CANARY ISLANDS (2002). In September 2002, a beaked whale stranding event occurred in the Canary Islands. On 24 September, 14 beaked whales (7 Cuvier's beaked whales, 3 Blainville's beaked whales, 1 Gervais' beaked whale, *M. europeaus*, and 3 unidentified beaked whales) stranded on the beaches of Fuerteventura and Lanzarote Islands, close to the site of an international naval exercise (called Neo-Tapon 2002) held that same day. The first animals are reported to have stranded about four hours after the onset of the use of mid-frequency sonar activity (3- 10kHz, D'Spain *et al.* 2006; Jepson *et al.* 2003). Seven whales (1 female Blainville's beaked whale, 1 female Gervais' beaked whale and 5 male Cuvier's beaked whales) are known to have died that day (Fernández *et al.* 2005). The remaining seven live whales were returned to deeper waters. Over the next three days, three male and one female Cuvier's beaked whales were found dead and a carcass of an unidentified beaked whale was seen floating offshore.

A total of nine Cuvier's beaked whales, one Blainville's beaked whale and one Gervais' beaked whale were examined post mortem and studied histopathologically (one Cuvier's beaked whale carcass was lost to the tide). No inflammatory or neoplastic processes were noted grossly or histologically and no pathogens (e.g. protozoa, bacteria and viruses, including morbillivirus) were identified. Stomach contents were examined in seven animals and six of them had recently eaten, possibly indicating that the event(s) leading to their deaths had had a relatively sudden onset (Fernández *et al.* 2005). Macroscopic examination revealed that the whales had severe, diffuse congestion and haemorrhages, especially in the fat in the jaw, around the ears, in the brain (e.g. multifocal subarachnoid haemorrhages) and in the kidneys (Fernandez, 2004; Fernandez *et al.* 2004). Gas bubble-associated lesions were observed in the vessels and parenchyma (white matter) of the brain, lungs, subcapsular kidney veins and liver; fat emboli were observed in epidural veins, liver sinusoids, lymph nodes and lungs (Jepson *et al.* 2003; Fernandez, 2004; Fernandez *et al.* 2004; 2005). After the event, researchers from the Canary Islands examined past stranding records and found reports of eight other stranding events of beaked whales in the Canaries since 1985, at least five of which coincided with naval activities offshore (Martín *et al.* 2004).

GULF OF CALIFORNIA (2002). In September 2002, marine mammal researchers vacationing in the Gulf of California, Mexico discovered two recently deceased Cuvier's beaked whales on an uninhabited island. They were not equipped to conduct necropsies and in an attempt to contact local researchers, found that a research vessel had been conducting seismic surveys approximately 22km offshore at the time that the stranding events occurred (Taylor *et al.* 2004). The survey vessel was using three acoustic sources: (1) seismic air guns (5-500Hz, 259dB re: 1mPa Peak to Peak (p-p); Federal Register, 2003); (2) sub-bottom profiler (3.5kHz, 200dB SPL; Federal Register, 2004); and (3) multi-beam sonar (15.5kHz, 237dB SPL; Federal Register, 2003). Whether or not this survey caused the beaked whales to strand has been a matter of debate because of the small number of animals involved and a lack of knowledge regarding the temporal and spatial correlation between the animals and the sound source. This stranding underlines the uncertainty regarding which sound sources or combinations of sound sources may cause beaked whales to strand. Although some of these stranding events have been reviewed in government reports or conference proceedings (e.g. Anonymous 2001, Evans and Miller 2004), many questions remain. Specifically, the mechanisms by which beaked whales are affected by sound remain unknown. A better understanding of these mechanisms will facilitate management and mitigation of sound effects on beaked whales.

As a result, in April 2004, the United States' Marine Mammal Commission convened a workshop of thirty-one scientists from a diverse range of relevant disciplines (e.g. human diving physiology and medicine, marine mammal ecology, marine mammal anatomy and physiology, veterinary medicine and acoustics) to explore issues related to the vulnerability of beaked whales to anthropogenic sound. The purpose of the workshop was to (1) assess the current knowledge of beaked whale biology and ecology and recent beaked whale mass stranding events; (2) identify and characterize factors that may have caused the stranding events; (3) identify ways to more adequately investigate possible cause and effect relationships; and (4) review the efficacy of existing monitoring and mitigation methods. This paper arose out of the discussions at that workshop.

HANALEI BAY, KAUA'I, HAWAI'I (2004). On 3 – 4 July 2004, between 150 and 200 melon-headed whales (*Peponocephala electra*) occupied the shallow waters of Hanalei Bay, Kaua'i, Hawai'i for over 28 hours. These whales, which are usually pelagic, milled in the shallow confined bay and were returned to deeper water with human assistance. The whales are reported to have entered the Bay in a single wave formation on July 3, 2004, and were observed moving back into shore from the mouth of the Bay shortly thereafter. On the next morning, the whales were herded out of the Bay with the help of members of the community, the Hanalei Canoe Club, local and Federal employees, and staff and volunteers with the Hawai'ian Islands Stranding Response Group and were out of visual sight later that morning.

One whale, a calf, had been observed alive and alone in Hanalei Bay on the afternoon of 4 July 2004 and was found dead in the Bay the morning of 5 July 2004. A full necropsy performed on the calf could not determine the cause of its death, although the investigators concluded that maternal separation, poor nutritional condition, and dehydration was probably a contributing factor in the animal's death.

Environmental factors, abiotic and biotic, were analyzed for any anomalous occurrences that would have contributed to the animals entering and remaining in Hanalei Bay. The bathymetry in the bay is similar to many other sites in the Hawai'ian Island chain and dissimilar to that which has been associated with mass stranding events in other parts of the U.S. The weather conditions appeared to be normal for the time of year with no fronts or other significant features noted. There was no evidence for unusual distribution or occurrence of predator or prey species or unusual harmful algal blooms. Weather patterns and bathymetry that have been associated with mass stranding events elsewhere were not found to occur in this instance.

This stranding event was spatially and temporally correlated with 2004 Rim of the Pacific exercises. Official sonar training and tracking exercises in the Pacific Missile Range Facility warning area did not commence until about 0800 hrs (local time) on 3 July and were ruled out as a possible trigger for the initial movement into Hanalei Bay. However, the six naval surface vessels transiting to the operational area on 2 July had been intermittently transmitting active mid-frequency sonar [for ~9 hours total] as they approached from the south. After ruling out other phenomena that might have caused this stranding, NMFS concluded that the active sonar transmissions associated with the 2004 Rim of the Pacific exercise were a plausible contributing causal factor in what may have been a confluence of events. Other factors that may have contributed to the stranding event include the presence of nearby deep water, multiple vessels transiting in a directed manner while transmitting active sonar over a sustained period, the presence of surface sound ducting conditions, or intermittent and random human interactions while the animals were in the Bay.

OTHER MASS STRANDING EVENTS. Several unusual stranding events have also occurred in Chinese waters in 2004 during a period when large-scale naval exercises were taking place in nearby waters south of Taiwan (IWC 2005). Between 24 February and 10 March 2004, 9-10 short-finned pilot whales (*Globicephala macrorhynchus*), one ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*), one striped dolphin (*Stenella coeruleoalba*), seven short-finned pilot whales, and one short-finned pilot whale were reported to have stranded. The stranding events were unusual (with respect to the species involved) compared to previous stranding records since 1994 for the region. Gross examination of the only available carcass, a ginkgo-toothed beaked whale, revealed many unusual injuries to structures that are associated with, or related to acoustics or diving. The injuries, the freshness of the carcass, its discovery location and the coincidence of the event with a military exercise suggest that this beaked whale died from acoustic or blast trauma that may have been caused by exposure to naval activities south of Taiwan. Taiwanese newspapers reported that live ammunition was used during these exercises. At the same time, natural phenomena that might cause whales to strand – such as earthquakes and underwater volcanoes – have not been ruled out in these cases.

Association Between Mass Stranding Events and Exposure to Active Sonar

Several authors have noted similarities between some of these stranding incidents: they occurred in islands or archipelagoes with deep water nearby, several appeared to have been associated with acoustic waveguides like surface ducting, and the sound fields created by ships transmitting mid-frequency sonar (Cox *et al.* 2006, D'Spain *et al.* 2006). Although Cuvier's beaked whales have been the most common species involved in these stranding events (81% of the total number of stranded animals and see Figure 2), other beaked whales (including *Mesoplodon europeaus*, *M. densirostris*, and *Hyperoodon ampullatus*) comprise 14% of the total. Other species (*Stenella coeruleoalba*, *Kogia breviceps* and *Balaenoptera acutorostrata*) have stranded, but in much lower numbers and less consistently than beaked whales.

Based on the evidence available, however, we cannot determine whether (a) *Ziphius cavirostris* is more prone to injury from high-intensity sound than other species, (b) their behavioral responses to sound makes them more likely to strand, or (c) they are more likely to be exposed to mid-frequency active sonar that other cetaceans (for reasons that remain unknown). Because the association between active sonar exposures and marine mammals mass stranding events is not consistent — some marine mammals strand without being exposed to sonar and some sonar transmissions are not associated with marine mammal stranding events despite their co-occurrence — other risk factors or a groupings of risk factors probably contribute to these stranding events.

STRANDING PATTERNS ASSOCIATED WITH RIM OF THE PACIFIC EXERCISES IN HAWAI'I. Nitta (1991) reported that between 1936 and 1988, 8 humpback whales, 1 fin whale, and 5 sperm whales stranded in the Hawai'ian Archipelago. In a partial update of that earlier report, Maldini *et al.* (2005) identified 202 toothed cetaceans that had stranded between 1950 and 2002. Sperm whales represented 10 percent of that total. Until recently, however, there has been no correlation between the number of known stranding events and the Navy's anti-submarine training exercises in Hawai'i. The number of stranding events have increased over time, but the number of stranding events in the main Hawai'ian Islands recorded between 1937 and 2002 is low compared with other geographic areas (although this may be an result of having large areas of coastline where no people or few people can report a stranding). Known stranding events also occurred in all months with no significant temporal trend (Maldini *et al.* 2005).

The Navy has conducted Rim of the Pacific exercises every second year since 1968 and anti-submarine warfare activities have occurred in each of the 19 exercises that have occurred thus far. This observation supports several different inferences. One line of reasoning is: if the mid-frequency sonar employed during those exercises killed or injured whales whenever the whales encountered the sonar, mass stranding events are likely to have occurred at least once or twice over the 38-year period since 1968. With one exception, there is little evidence of a pattern in the record of stranding events reported for the main Hawai'ian Islands.

A second line of reasoning leads to a very different conclusion: the absence of reports of stranding events may result from the small number of people searching for stranded animals relative to the coastline of Hawai'i —although stranding events have been reported in the Hawai'ian Islands since 1937, no toothed whales were reported until 1950 — or it may be because only a fraction of the whales that are killed or injured in Hawai'ian waters strand (as opposed to sinking, being transported to the open ocean by the strong currents that flow across the northern shore of the islands, or being eaten by predators like sharks). Faerber and Baird (2007) presented evidence that supports this inference. They compared patterns of beaked whale stranding events in the Canary Islands and the main Hawai'ian Islands (they compared water depths immediately adjacent to shore, accessibility of shorelines, and population densities relative to land area and amount of shoreline) and concluded that beaked whales were less likely to strand in the main Hawai'ian Islands and were not likely to be detected if they did strand.

Finally, the apparent absence of stranding events coincident with the decades of antisubmarine warfare training exercises in the Northwest and in waters off the main Hawai'ian islands could also suggest that mid-frequency sonar transmissions pose a hazard to cetaceans in some circumstances, but not others (for example, see the discussion under *Behavioral Avoidance*).

5.3.3 Probable Responses to RDT&E Activities on the Keyport Range Complex

Thus far, this Opinion has identified the endangered and threatened species and designated critical habitat that might be exposed to vessel traffic, active sonar, and underwater detonations associated with the training activities the U.S. Navy proposes to conduct on the Keyport Range Complex and the potential responses of those species given that exposure. Based on the evidence available, the research, development, test and evaluation activities the U.S. Navy proposes to conduct on the Keyport Range Complex each year from March 2010 through March 2015 are not likely to kill or injure endangered or threatened species.

5.3.3.1 Responses Given Exposure to Vessel Traffic on the Keyport Range Complex

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 7,220 hours of boat usage the U.S. Navy proposes to conduct are likely to be exposed to visual and acoustic stimuli associated with vessel traffic and related activities. Nevertheless, because RDT&E activities involve fewer vessels, have shorter duration, and are much more localized, fewer endangered and threatened species would be exposed to vessel traffic during these smaller activities.

5.3.3.2 Responses Given Exposure to Active Sonar on the Keyport Range Complex

Our exposure analyses concluded that fin whales, humpback whales, sei whales, southern resident killer whales, and sperm whales were not likely to be exposed to active acoustic sources on the Quinault Underwater Tracking Range because relatively low density of these species in waters off Washington and the short duration of those events reduced their probability of being exposed to sound fields associated with a RDT&E events to levels that we would consider discountable. As we discussed in the *Approach to the Assessment* chapter of this Opinion, endangered or threatened animals (and plants) that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because fin, humpback, sei, southern resident, and sperm whales are not likely to be directly or indirectly exposed to the acoustic stimuli that would occur on the Quinault Underwater Tracking Range, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. We do not consider these species further in this section of our Opinion.

STELLER SEA LION (EASTERN POPULATION). Our exposure analyses concluded that we would expect at least three instances in which Steller sea lions might be exposed to active acoustic sources on the Quinault Underwater Tracking Range.

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 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 and Lowry (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. (1990, 1991), 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*. (2003, 2005) 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.* 1999, Kastak 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.

LEATHERBACK SEA TURTLES. Although the information available did not allow us to estimate the number of times leatherback sea turtles might be exposed to the activities the U.S. Navy plans to conduct on the Quinault Underwater Tracking Range, we assume that some leatherback sea turtles are likely to be exposed to low-, mid- and high-frequency sounds produced by research, development, test and evaluation activities the U.S. Navy proposes to conduct on the Quinault Underwater Tracking Range portion of the Keyport Range Complex.

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) (Ridgway *et al.* 1969; Lenhardt *et al.* 1983; Bartol *et al.* 1999, Lenhardt 1994, O’Hara and Wilcox 1990). 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) the latter has sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Peterson 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 μPa and 175 db re 1 μPa, respectively. The sea turtles responded consistently: above a level of approximately 166 dB re 1 μPa_{rms} the turtles noticeably increased their swimming activity compared to non-airgun operation periods. Above 175 dB re 1 μPa mean squared pressure their behavior became more erratic possibly indicating the turtles were in an agitated state. Because the acoustic sources the U.S. Navy proposes to employ during research, development, test, and evaluation activities at the Keyport Range Complex transmit at frequencies that are substantially higher than 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 “may affect, but is not likely to adversely affect” leatherback sea turtles.

SOUTHERN GREEN STURGEON. Although the information available did not allow us to estimate the number of times southern green sturgeon might be exposed to the activities the U.S. Navy plans to conduct on the Quinault Underwater Tracking Range, we assume that some southern green sturgeon are likely to be exposed to low-, mid- and high-frequency sounds produced by research, development, test and evaluation activities the U.S. Navy proposes to conduct on the Quinault Underwater Tracking Range portion of the Keyport Range Complex.

We would not expect southern green sturgeon to respond to that exposure. We do not have specific information on hearing in southern green sturgeon. However, 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*. (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 a bandwidths between 200 and 300 Hz and higher thresholds at 100 and 500 Hz. Because of their hearing sensitivity, we would not expect southern green sturgeon to respond to high- or mid-frequency active sonar and are not likely to be adversely affected by the activities the U.S. Navy plans to conduct in waters on the Keyport Range Complex..

PACIFIC SALMON, STEELHEAD, AND SOUTHERN EULACHON. Although the information available did not allow us to estimate the number of times endangered and threatened species of Pacific salmon, steelhead, and eulachon might be exposed to the activities the U.S. Navy plans to conduct on the Quinault Underwater Tracking Range, we assume that some endangered and threatened species of Pacific salmon, steelhead, and eulachon are likely to be exposed to low-, mid- and high-frequency sounds produced by research, development, test and evaluation activities the U.S. Navy proposes to conduct on the Quinault Underwater Tracking Range and the Keyport Range Complex.

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 (U.S. Navy 2008f, 2009a) 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*. (2005, 2007) investigated the potential effects of exposing several fish species to the U.S. Navy's SURTASS LFA sonar, focusing on the to hearing and on non-auditory tissues. Their study exposed the fish to LFA sonar pulses for time intervals that would be substantially longer than what would occur in nature, but the fish did not experience mortalities or damage to body tissues at the gross or histological level. Some fish experienced temporary losses in their hearing sensitivity but they recovered within several days of exposure.

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 the 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); however, because these species are anadromous, the juveniles, larvae, and eggs of southern green sturgeon, Pacific salmon, steelhead, and southern eulachon 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 probably protects them from the small, but potentially-significant mortality rates reported by Jørgensen and his co-workers (2005).

If Pacific salmon and steelhead are exposed to mid-frequency active sonar associated with the military readiness activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex, they might experience startle responses or change 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.

5.3.4 Probable Responses to Training Activities on the NWTR Complex

Thus far, this Opinion has identified the endangered and threatened species and designated critical habitat that might be exposed to vessel traffic, active sonar, and underwater detonations associated with the training activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex and the potential responses of those species given that exposure. The narratives that follow discuss the probable responses of those species (we do not address critical habitat in this section of our analyses because we had previously concluded that the proposed activities were not likely to adversely to affect critical habitat).

BLUE WHALE. 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 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 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 47 of these exposure events would occur at received levels between 140 and 150 dB or distances between 25 and 51 kilometers from the source of a sonar ping; and about 14 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. The U.S. Navy estimated that 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. we would expect 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 "behavioral harassment." We would expect 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 would 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.

PROBABLE RESPONSES OF BLUE WHALE TO ACTIVE SONAR. Blue 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 blue whale hearing so we assume that blue 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 (Cummings and Thompson 1971; Edds 1982; Thompson and Friedl 1982; McDonald *et al.* 1995; Clark and Fristrup 1997; Rivers 1997). 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. Blue 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 1971). The whale produced a short, 390 Hz pulse during the moan.

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). Although blue 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 47 blue whales that find themselves between 25 and 51 kilometers (between about 15.5 and 32 miles) from a sonar transmission to change their behavioral state, despite being exposed to received levels ranging from 140 and 150 dB; these whales might engage in low-level avoidance behavior or short-term vigilance behavior. The 14 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. However, as we discussed previously, we do not assume that these blue whales would respond to the active sonar rather than all of the environmental cues produced by a vessel moving through the ocean's surface while transmitting active sonar.

PROBABLE RESPONSES OF BLUE WHALE TO UNDERWATER DETONATIONS. Our summary of the conclusions of our exposure analyses identifies how we would expect blue whales to response to underwater detonations: we would expect 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 "behavioral harassment." We would expect 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 would 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.

FIN WHALE. 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 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

   bout 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 162 of these exposure events would occur at received levels between 140 and 150 dB or distances between 25 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.

2. we would expect 12 instances 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 would expect another 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 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.

PROBABLE RESPONSES OF FIN WHALE TO ACTIVE SONAR. 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 (Cummings and Thompson 1971; Edds 1982; Thompson and Friedl 1982; McDonald *et al.* 1995; Clark and Fristrup 1997; Rivers

1997). 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 1971). 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 162 fin whales that find themselves between 25 and 51 kilometers from a sonar transmission to change their behavioral state, despite being exposed to received levels ranging from 140 and 150 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. However, as we discussed previously, we do not assume that these fin whales would respond to the active sonar rather than all of the environmental cues produced by a vessel moving through the ocean’s surface while transmitting active sonar.

The U.S. Navy estimated that 17 fin 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.

PROBABLE RESPONSES OF FIN WHALE TO UNDERWATER DETONATIONS. Our summary of the conclusions of our exposure analyses identifies how we would expect fin whales to response to underwater detonations: we would expect 12 instances 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 would expect another 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 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.

HUMPBACK WHALE. 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 in which humpback whales would be exposed to sound fields produced by this sonar

bout 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 85 of these exposure events would occur at received levels between 140 and 150 dB or distances between 25 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.

2. we would expect 12 instances in which humpback whales might be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in “behavioral harassment.” We would expect another 7 instances in which humpback 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 humpback 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.

PROBABLE RESPONSES OF HUMPBACK WHALE TO ACTIVE SONAR. 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. Those vocalizations include a variety of sounds described as low frequency moans or long pulses in the 10-100 Hz band (Cummings and Thompson 1971; Edds 1982; Thompson and Friedl 1982; McDonald *et al.* 1995; Clark and Fristrup 1997; Rivers 1997). 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. Humpback 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 1971). The whale produced a short, 390 Hz pulse during the moan.

As discussed in the *Status of the Species* narrative for humpback whales, these whales produce a wide variety of sounds. During the breeding season males sing long, complex songs, with frequencies in the 25-5000 Hz range and intensities as high as 181 dB (Payne 1970, Thompson *et al.* 1986, Winn *et al.* 1970). Source levels average 155 dB and range from 144 to 174 dB (Thompson *et al.* 1979). The songs appear to have an effective range of approximately 10 to 20 km. Animals in mating groups produce a variety of sounds (Silber 1986, Tyack 1981; Tyack and Whitehead 1983).

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 1970; Winn *et al.* 1970a; Richardson *et al.* 1995)
2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3kHz (Tyack and Whitehead 1983, Richardson *et al.* 1995); and

3 Feeding area vocalizations that are less frequent, but tend to be 20Hz – 2 kHz with estimated sources levels in excess of 175 dB re 1 uPa-m (Thompson *et al.* 1986, Richardson *et al.* 1995). 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).

More recently, Au *et al.* (2006) conducted field investigations of humpback whale songs 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, 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 μPa. 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 150dB re 1 μPa/Hz at 350Hz (Lien *et al.* 1993, Todd *et al.* 1996). However, at least two individuals were probably killed by the high-intensity, impulsed 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 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 85 instances in which humpback whales find themselves between 25 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 150 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, behavioural disturbance, and physiological stress responses as a result of that exposure.

The U.S. Navy estimated that 15 humpback 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.

PROBABLE RESPONSES OF HUMPBACK WHALE TO UNDERWATER DETONATIONS. Our summary of the conclusions of our exposure analyses identifies how we would expect humpback whales to response to underwater detonations: we would expect 12 instances in which humpback whales might be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in "behavioral harassment." We would expect another 7 instances in which humpback 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 humpback 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

SEI WHALE. 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 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 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 23 these exposure events would occur at received levels between 140 and 150 dB or distances between 25 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.

2. we would 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 as a result of that exposure.

PROBABLE RESPONSES OF SEI WHALE TO ACTIVE SONAR. 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 23 tances in which sei whales might find themselves between 25 and 51 kilometers (between about 15.5 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 instances 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.

Te U.S. Navy estimated that one sei whale 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.

PROBABLE RESPONSES OF SEI WHALE TO UNDERWATER DETONATIONS. Because we would not expect any instances in which sei whales to 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 exposure..

SOUTHERN RESIDENT KILLER WHALE. Our analyses led us to reach the following conclusions about the potential stressors southern resident killer whales might be exposed to on the Northwest Training Range Complex and the number of instances in which southern resident killer whales might be exposed:

1. we would not expect southern resident killer whales to be exposed to mid-frequency active sonar the 43 hours of training the U.S. Navy plans to conduct with AN/SQS-53C and the 65 hours of training with AN/SQS-56 at the Northwest Training Range Complex each year. However, we would expect at least 102 instances in which southern resident killer whales would be exposed to other active sonar sources on the Northwest Training Range Complex.
2. we would also expect two instances in which southern resident killer whales would accumulate sufficient energy to experience temporary threshold shift as a result of their exposure to active sonar associated with the training activities it proposes to conduct on the Northwest Training Range Complex;
2. we would not expect any instances in which southern resident killer 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 as a result of that exposure.

PROBABLE RESPONSES OF SOUTHERN RESIDENT KILLER WHALE TO ACTIVE SONAR. The U.S. Navy estimated that 102 southern resident 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. The Navy estimated that there might be two instances in which southern resident killer whales would accumulate sufficient energy to experience temporary threshold shift as a result of their exposure to active sonar associated with the training activities it proposes to conduct on the Northwest Training Range Complex. Because our exposure analyses did not consider focused on mid-frequency active sonar and, as a result, did not consider every sound source the U.S. Navy proposes to employ on the Northwest Training Range Complex, we will conduct the rest of our analyses using the U.S. Navy's estimates.

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 night 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, southern resident 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 southern resident killer whales experience extreme distress when exposed to mid-frequency active sonar (AN/SQS-53) at received levels of about 169.3 dB (Fromm 2004, Department of the Navy 2003); we do not know if those whales suffered 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.

There are four primary ways in which the activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex might have adverse consequences for southern resident killer whales. First they could result in the death or serious injury of killer whales as a result of ship strikes or acoustic trauma (resonance). Second they could reduce the current or expected future reproductive success of southern resident killer whales resulting from chronic exposure to sound (that is, by causing threshold shifts, stress physiology, and long-term disturbance responses). Third, they could reduce the forage base of southern resident killer whales by affecting the distribution or abundance of Chinook salmon. Finally, they could reduce the southern resident killer whale's ability to forage effectively by excluding them from critical foraging areas.

We would 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 (Box BR2.1 of Figure 2; Holt *et al*. 2007). 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% 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 needs 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 @ 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 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, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al.* 2002, Richter *et al.* 2003, Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams *et al.* 2002). 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.

PROBABLE RESPONSES OF SOUTHERN RESIDENT KILLER WHALE TO UNDERWATER DETONATIONS. Because we would not expect any instances in which southern resident killer whales to 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.

SPERM WHALE. Our analyses led us to reach 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:

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 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 341 these exposure events would occur at received levels between 140 and 150 dB or distances between 25 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.

2. we would expect 13 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." We

would expect another 10 instances in which sperm whales would be exposed to underwater detonations and experience temporary threshold shifts as a result and one 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 as a result of that exposure.

PROBABLE RESPONSES OF SPERM WHALE TO ACTIVE SONAR. 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 (Weilgart and Whitehead 1993, Goold and Jones 1995). 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 under-water 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 and Scheville1975, Watkins *et al.* 1985), pingers (Watkins and Scheville 1975), the Heard Island Feasability 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 Scheville 1975). Goold (1999) reported six sperm whales that were driven through a narrow channel using ship noise, echosounder, and fishfinder emissions from a flotilla of 10 vessels. Watkins and Scheville (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).

As discussed previously, 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 *et al.* 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 *et al.* 1997, Schlundt *et al.* 2000), and to shorter broadband pulsed signals (Finneran *et al.* 2000, 2002). Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure or to avoid the location of the exposure site during subsequent tests (Schlundt *et al.* 2000, Finneran *et al.* 2002). 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 reactions to shorter pulses were higher (Finneran *et al.* 2000, 2002). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran *et al.* 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway *et al.* 1997, Schlundt *et al.* 2000). The relevance of these data to free-ranging odontocetes is uncertain. In the wild, cetaceans some-times 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 μPa 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 μPa at the source), but not to the other sources played to them.

Published reports identify instances in which sperm whales may 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 they examined in the northern Gulf of Mexico, contrary to what Mate *et al.* (1994) reported. In one DTAG deployment in the northern Gulf of Mexico on July 28, 2001, researchers documented that the tagged whale moved away from an operating seismic vessel once the seismic pulses were received at the tag at roughly 137 dB re 1 μPa (Johnson and Miller 2002). 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, 1998, 2000, 2001, 2003). 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 2003). The results from these waters seem to show that some sperm whales tolerate seismic surveys.

Preliminary data from an experimental study of sperm whale reactions to seismic surveys in the Gulf of Mexico and a study of the movements of sperm whales with satellite-linked tags in relation to seismic surveys show that during two controlled exposure experiments in which sperm whales were exposed to seismic pulses at received levels up to 148 dB re 1 μPa over octave band with most energy, the whales did not avoid the vessel or change their feeding efficiency (National Science Foundation 2003). Although the sample size is small (4 whales in 2 experiments), the results are consistent with those off northern Norway.

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.

The U.S. Navy estimated that 102 sperm 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. The Navy concluded that two sperm whales would accumulate sufficient energy to experience temporary threshold shift as a result of their exposure to active sonar associated with the training activities it proposes to conduct on the Northwest Training Range Complex.

PROBABLE RESPONSES OF SPERM WHALE TO UNDERWATER DETONATIONS. Our summary of the conclusions of our exposure analyses identifies how we would expect sperm whales to response to underwater detonations: we would expect 13 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." We would expect another 10 instances in which sperm whales would be exposed to underwater detonations and experience temporary threshold shifts as a result and one 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 as a result of that exposure.

STELLER SEA LION. 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 7.043 instances in which Steller sea lions would be exposed to sound fields produced by this sonar

   About 4,414 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 1,442 these exposure events would occur at received levels between 140 and 150 dB or distances between 25 and 51 kilometers from the source of a sonar ping. About 445 the 7,043 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.

2. we would expect 114 instances in which Steller sea lions 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" as a result of that exposure.

3. we would expect 3 instances 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." We would expect another 3 instances in which Steller sea lions would be exposed to underwater detonations and 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.

PROBABLE RESPONSES OF STELLER SEA LION TO ACTIVE SONAR. 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 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 and Lowry (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. (1990, 1991), 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*. (2003, 2005) 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.* 1999, Kastak 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.

PROBABLE RESPONSES OF STELLER SEA LION TO UNDERWATER DETONATIONS. Our summary of the conclusions of our exposure analyses identifies how we would expect sperm whales to response to underwater detonations: we would expect 3 instances 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" (as that term is defined pursuant to the MMPA). We would expect another 3 instances in which Steller sea lions would be exposed to underwater detonations and 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 TURTLES. We assume that leatherback sea turtles are likely to be exposed to military readiness activities on the Quinault Underwater Tracking Range portion of the Keyport Range Complex. Because their foraging distribution does not appear to bring them into Crescent Harbor Underwater EOD range, Floral Point Underwater EOD Range, or the Indian Island Underwater EOD Range, leatherback sea turtles are not likely to be exposed to underwater detonations that would occur on these underwater EOD Ranges.

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) (Ridgway *et al.* 1969; Lenhardt *et al.* 1983; Bartol *et al.* 1999, Lenhardt 1994, O'Hara and Wilcox 1990). 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) the latter has sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Peterson 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 μPa and 175 db re 1 μPa, respectively. The sea turtles responded consistently: above a level of approximately 166 dB re 1 μPa_{rms} the turtles noticeably increased their swimming activity compared to non-airgun operation periods. Above 175 dB re 1 μPa mean squared pressure their behavior became more erratic possibly indicating the turtles were in an agitated state. 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 "may affect, but is not likely to adversely affect" leatherback sea turtles.

ENDANGERED AND THREATENED FISH IN THE NORTHWEST TRAINING RANGE COMPLEX. As a result of our exposure analyses, we assumed 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, 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 those 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 those areas of the Northwest Training Range Complex (particularly areas W-237A, W-237B, and W-237E);

3. 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, particularly during explosive ordnance disposal operations at Crescent Harbor, Port Townsend Bay, and Bangor in northern Hood Canal; and

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.

PROBABLE RESPONSES OF ENDANGERED AND THREATENED FISH TO ACTIVE SONAR. 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 (U.S. Navy 2008f, 2009a) 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*. (2005, 2007) investigated the potential effects of exposing several fish species to the U.S. Navy’s SURTASS LFA sonar, focusing on the to hearing and on non-auditory tissues. Their study exposed the fish to LFA sonar pulses for time intervals that would be substantially longer than what would occur in nature, but the fish did not experience mortalities or damage to body tissues at the gross or histological level. Some fish experienced temporary losses in their hearing sensitivity but they recovered within several days of exposure.

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 the 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); however, because these species are anadromous, the juveniles, larvae, and eggs of southern green sturgeon, Pacific salmon, steelhead, and southern eulachon 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 probably protects them from the small, but potentially-significant mortality rates reported by Jørgensen and his co-workers (2005).

If Pacific salmon and steelhead are exposed to mid-frequency active sonar associated with the military readiness activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex, they might experience startle responses or change 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.

PROBABLE RESPONSES OF ENDANGERED AND THREATENED FISH TO UNDERWATER DETONATIONS. As we did in our 30 June 2008 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 EOD Range is outside the major migration corridor for river systems in the area while the Indian Island Underwater EOD Range is within a migratory corridor for Chinook, chum, and other salmon species.

Our 2008 Opinion on U.S. Navy explosive ordnance disposal operations at Crescent Harbor, Port Townsend Bay, and Bangor in northern Hood Canal concluded that 50 adult and 5,094 juvenile Puget Sound Chinook salmon, 101 adult and 1,022 juvenile Hood Canal summer run chum salmon, and 20 adult and 182 juvenile Puget Sound steelhead were likely to be killed by the detonations of 2.5- and 20-pound ordnance in those three areas. However, that conclusion was based on an assumption that the U.S. Navy would conduct 32 underwater detonations and 20 surface detonations each year.

The U.S. Navy currently proposes to conduct no more than 4 such detonations each year, proposes to move the single detonation it planned to conduct at Indian Island to Hood Canal, and reduce the net explosive weight of the detonation they would use in the training event from 2.5 pounds to 1.5 pounds. Using the same approach we applied in our 2008 Opinion, we would expect each of the four sirface 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 to die during each underwater detonation at Hood Canal; and 27 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.

6.0 Integration and Synthesis of Effects

In the *Assessment Approach* section of this Opinion, our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. 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; Mills and Beatty 1979; Brandon 1978; Stearns 1977, 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.

As we summarize in the narratives that follow, our analyses led us to conclude that endangered or threatened individuals that are likely to be exposed to the research, development, test, and evaluation activities the U.S. Navy proposes to conduct at the Keyport Range Complex and Northwest Training Range Complex are not likely to experience reductions in the fitness of the individual animals that are likely to be exposed to those activities.

6.1 Keyport Range Complex

FIN WHALE. Our exposure analyses concluded that fin whales were not likely to be exposed to active acoustic sources on the Quinault Underwater Tracking Range because relatively low density of these species in waters off Washington and the short duration of those events reduced their probability of being exposed to sound fields associated with a RDT&E events to levels that we would consider discountable. As we discussed in the *Approach to the Assessment* chapter of this Opinion, endangered or threatened animals (and plants) that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because fin whales are not likely to be directly or indirectly exposed to the acoustic stimuli that would occur on the Quinault Underwater Tracking Range, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. As we also discussed in the *Approach to the Assessment* section of this opinion, 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 Keyport Range Complex each year from June 2010 through June 2015 would not appreciably reduce the fin whales' likelihood of surviving and recovering in the wild.

HUMPBACK WHALE. Our exposure analyses concluded that humpback whales were not likely to be exposed to active acoustic sources on the Quinault Underwater Tracking Range because relatively low density of these species in waters off Washington and the short duration of those events reduced their probability of being exposed to sound fields associated with a RDT&E events to levels that we would consider discountable. As we discussed in the *Approach to the Assessment* chapter of this Opinion, endangered or threatened animals (and plants) that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because humpback whales are not likely to be directly or indirectly exposed to the acoustic stimuli that would occur on the Quinault Underwater Tracking Range, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. As we also discussed in the *Approach to the Assessment* section of this opinion, 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 Keyport Range Complex each year from June 2010 through June 2015 would not appreciably reduce the humpback whales' likelihood of surviving and recovering in the wild.

SEI WHALE. Our exposure analyses concluded that sei whales were not likely to be exposed to active acoustic sources on the Quinault Underwater Tracking Range because relatively low density of these species in waters off Washington and the short duration of those events reduced their probability of being exposed to sound fields associated with a RDT&E events to levels that we would consider discountable. As we discussed in the *Approach to the Assessment* chapter of this Opinion, endangered or threatened animals (and plants) that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because sei whales are not likely to be directly or indirectly exposed to the acoustic stimuli that would occur on the Quinault Underwater Tracking Range, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. As we also discussed in the *Approach to the Assessment* section of this opinion, 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 Keyport Range Complex each year from June 2010 through June 2015 would not appreciably reduce the sei whales' likelihood of surviving and recovering in the wild.

SOUTHERN RESIDENT KILLER WHALE. Our exposure analyses concluded that southern resident killer whales were not likely to be exposed to active acoustic sources on the Quinault Underwater Tracking Range because relatively low density of these species in waters off Washington and the short duration of those events reduced their probability of being exposed to sound fields associated with a RDT&E events to levels that we would consider discountable. As we discussed in the *Approach to the Assessment* chapter of this Opinion, endangered or threatened animals (and plants) that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because southern resident killer whales are not likely to be directly or indirectly exposed to the acoustic stimuli that would occur on the Quinault Underwater Tracking Range, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. As we also discussed in the *Approach to the Assessment* section of this opinion, 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 Keyport Range Complex each year from June 2010 through June 2015 would not appreciably reduce the southern resident killer whales' likelihood of surviving and recovering in the wild.

SPERM WHALE. Our exposure analyses concluded that sperm whales were not likely to be exposed to active acoustic sources on the Quinault Underwater Tracking Range because relatively low density of these species in waters off Washington and the short duration of those events reduced their probability of being exposed to sound fields associated with a RDT&E events to levels that we would consider discountable. As we discussed in the *Approach to the Assessment* chapter of this Opinion, endangered or threatened animals (and plants) that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because sperm whales are not likely to be directly or indirectly exposed to the acoustic stimuli that would occur on the Quinault Underwater Tracking Range, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. As we also discussed in the *Approach to the Assessment* section of this opinion, 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 Keyport Range Complex each year from June 2010 through June 2015 would not appreciably reduce the sperm whales' likelihood of surviving and recovering in the wild.

STELLER SEA LION (EASTERN POPULATION). Our exposure analyses concluded that we would expect at least three instances in which Steller sea lions might be exposed to active acoustic sources on the Quinault Underwater Tracking Range. 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 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 and Lowry (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. (1990, 1991), 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*. (2003, 2005) 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.* 1999, Kastak 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.

LEATHERBACK SEA TURTLES. Although the information available did not allow us to estimate the number of times leatherback sea turtles might be exposed to the activities the U.S. Navy plans to conduct on the Quinault Underwater Tracking Range, we assume that some leatherback sea turtles are likely to be exposed to low-, mid- and high-frequency sounds produced by research, development, test and evaluation activities the U.S. Navy proposes to conduct on the Quinault Underwater Tracking Range portion of the Keyport Range Complex.

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) (Ridgway *et al.* 1969; Lenhardt *et al.* 1983; Bartol *et al.* 1999, Lenhardt 1994, O'Hara and Wilcox 1990). 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) the latter has sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Peterson 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 μPa and 175 db re 1 μPa, respectively. The sea turtles responded consistently: above a level of approximately 166 dB re 1 μPa_{rms} the turtles noticeably increased their swimming activity compared to non-airgun operation periods. Above 175 dB re 1 μPa mean squared pressure their behavior became more erratic possibly indicating the turtles were in an agitated state. Because the acoustic sources the U.S. Navy proposes to employ during research, development, test, and evaluation activities at the Keyport Range Complex transmit at frequencies that are substantially higher than 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 “may affect, but is not likely to adversely affect” leatherback sea turtles..

SOUTHERN GREEN STURGEON. Although the information available did not allow us to estimate the number of times southern green sturgeon might be exposed to the activities the U.S. Navy plans to conduct on the Quinault Underwater Tracking Range, we assume that some southern green sturgeon are likely to be exposed to low-, mid- and high-frequency sounds produced by research, development, test and evaluation activities the U.S. Navy proposes to conduct on the Quinault Underwater Tracking Range portion of the Keyport Range Complex.

We would not expect southern green sturgeon to respond to that exposure. We do not have specific information on hearing in southern green sturgeon. However, 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*. (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 a bandwidths between 200 and 300 Hz and higher thresholds at 100 and 500 Hz. Because of their hearing sensitivity, we would not expect southern green sturgeon to respond to high- or mid-frequency active sonar and are not likely to be adversely affected by the activities the U.S. Navy plans to conduct in waters on the Keyport Range Complex.

PACIFIC SALMON, STEELHEAD, AND SOUTHERN EULACHON. Although the information available did not allow us to estimate the number of times endangered and threatened species of Pacific salmon, steelhead, and eulachon might be exposed to the activities the U.S. Navy plans to conduct on the Quinault Underwater Tracking Range, we assume that some endangered and threatened species of Pacific salmon, steelhead, and eulachon are likely to be exposed to low-, mid- and high-frequency sounds produced by research, development, test and evaluation activities the U.S. Navy proposes to conduct on the Quinault Underwater Tracking Range and the Keyport Range Complex.

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 (U.S. Navy 2008f, 2009a) 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*. (2005, 2007) investigated the potential effects of exposing several fish species to the U.S. Navy's SURTASS LFA sonar, focusing on the to hearing and on non-auditory tissues. Their study exposed the fish to LFA sonar pulses for time intervals that would be substantially longer than what would occur in nature, but the fish did not experience mortalities or damage to body tissues at the gross or histological level. Some fish experienced temporary losses in their hearing sensitivity but they recovered within several days of exposure.

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 the 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); however, because these species are anadromous, the juveniles, larvae, and eggs of southern green sturgeon, Pacific salmon, steelhead, and southern eulachon 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 probably protects them from the small, but potentially-significant mortality rates reported by Jørgensen and his co-workers (2005).

If Pacific salmon and steelhead are exposed to mid-frequency active sonar associated with the military readiness activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex, they might experience startle responses or change 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.

6.2 Northwest Training Range Complex

Thus far, this Opinion has identified the endangered and threatened species and designated critical habitat that might be exposed to vessel traffic, active sonar, and underwater detonations associated with the training activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex and the potential responses of those species given that exposure. The narratives that follow discuss the probable responses of those species (we do not address critical habitat in this section of our analyses because we had previously concluded that the proposed activities were not likely to adversely to affect critical habitat). Based on the evidence available, the training activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex each year from June 2010 through June 2015 are not likely to kill or injure endangered or threatened species.

BLUE WHALE. 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 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 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 47 of these exposure events would occur at received levels between 140 and 150 dB or distances between 25 and 51 kilometers from the source of a sonar ping; and about 14 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. The U.S. Navy estimated that 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. we would expect 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 “behavioral harassment.” We would expect 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 would 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.

PROBABLE RESPONSES OF BLUE WHALE TO ACTIVE SONAR. Blue 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 blue whale hearing so we assume that blue 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 (Cummings and Thompson 1971; Edds 1982; Thompson and Friedl 1982; McDonald *et al.* 1995; Clark and Fristrup

1997; Rivers 1997). 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. Blue 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 1971). The whale produced a short, 390 Hz pulse during the moan.

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). Although blue 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 47 blue whales that find themselves between 25 and 51 kilometers (between about 15.5 and 32 miles) from a sonar transmission to change their behavioral state, despite being exposed to received levels ranging from 140 and 150 dB; these whales might engage in low-level avoidance behavior or short-term vigilance behavior. The 14 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. However, as we discussed previously, we do not assume that these blue whales would respond to the active sonar rather than all of the environmental cues produced by a vessel moving through the ocean's surface while transmitting active sonar.

PROBABLE RESPONSES OF BLUE WHALE TO UNDERWATER DETONATIONS. Our summary of the conclusions of our exposure analyses identifies how we would expect blue whales to response to underwater detonations: we would expect 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 "behavioral harassment." We would expect 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 would 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.As we discussed, we assume that the blue whales the might be exposed to stressors associated with U.S. Navy readiness activities on the Northwest Training Range Complex are members of the population of blue whales that inhabits the northeast Pacific from the Gulf of Alaska to waters off Central America. As a result, these blue whales would not only be exposed to readiness activities on the two range complexes considered in this Opinion, they would also be exposed to readiness activities on the Southern California Range Complex. The biological opinion we completed on U.S. Navy training activities the Southern California Range Complex expected about 5,432 instances in which blue whales might be exposed to mid-frequency active sonar associated with major training exercises conducted on the Southern California Range Complex during the cold season (November to April), about 1,030 exposures associated with major exercises conducted on the range complex during the warm season; about 4,329 exposure events during unit-level training and maintenance activities conducted during the cold season, and about 804 exposure events during unit-level training and maintenance activities conducted in the warm season. Based on our analyses, we expected blue whales to exhibit behavioral responses that would rise to the level of constituting behavioral harassment in about 102 of these exposures to active sonar and other acoustic cues associated with surface vessels; we expected blue whales to be harassed in four of the exposures to underwater detonations on the Southern California Range Complex. Because of their migratory habit, we assume that the same individuals that might be exposed on the Southern California Range Complex would also be exposed on the Northwest Training Range Complex.

The 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 (Amaral and Carlson 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al.* 2002, Richter *et al.* 2003, Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams *et al.* 2002). 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.

Based on the evidence available, we conclude that training exercises and other activities the U.S. Navy plans to conduct in the Northwest Training Range Complex each year from June 2010 through June 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. As we discussed in the *Approach to the Assessment* section of this opinion, 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 each year from June 2010 through June 2015 would not appreciably reduce the blue whales' likelihood of surviving and recovering in the wild.

FIN WHALE. 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 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

   bout 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 162 of these exposure events would occur at received levels between 140 and 150 dB or distances between 25 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.

2. we would expect 12 instances 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 would expect another 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 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.

PROBABLE RESPONSES OF FIN WHALE TO ACTIVE SONAR. 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 (Cummings and Thompson 1971; Edds 1982; Thompson and Friedl 1982; McDonald *et al.* 1995; Clark and Fristrup 1997; Rivers 1997). 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 1971). 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 162 fin whales that find themselves between 25 and 51 kilometers from a sonar transmission to change their behavioral state, despite being exposed to received levels ranging from 140 and 150 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. However, as we discussed previously, we do not assume that these fin whales would respond to the active sonar rather than all of the environmental cues produced by a vessel moving through the ocean's surface while transmitting active sonar.

The U.S. Navy estimated that 17 fin 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.

PROBABLE RESPONSES OF FIN WHALE TO UNDERWATER DETONATIONS. Our summary of the conclusions of our exposure analyses identifies how we would expect fin whales to response to underwater detonations: we would expect 12 instances 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 would expect another 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 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.

The 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 (Amaral and Carlson 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al.* 2002, Richter *et al.* 2003, Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams *et al.* 2002). 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.

Based on the evidence available, we conclude that training exercises and other activities the U.S. Navy plans to conduct in the Northwest Training Range Complex each year from June 2010 through June 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. As we discussed in the *Approach to the Assessment* section of this opinion, 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 each year from June 2010 through June 2015 would not appreciably reduce the fin whales' likelihood of surviving and recovering in the wild.

HUMPBACK WHALE. 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 in which humpback whales would be exposed to sound fields produced by this sonar

   bout 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 85 of these exposure events would occur at received levels between 140 and 150 dB or distances between 25 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.

2. we would expect 12 instances in which humpback whales might be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in "behavioral harassment." We would expect another 7 instances in which humpback 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 humpback 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.

PROBABLE RESPONSES OF HUMPBACK WHALE TO ACTIVE SONAR. 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. Those vocalizations include a variety of sounds described as low frequency moans or long pulses in the 10-100 Hz band (Cummings and Thompson 1971; Edds 1982; Thompson and Friedl 1982; McDonald *et al.* 1995; Clark and Fristrup 1997; Rivers 1997). 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. Humpback 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 1971). The whale produced a short, 390 Hz pulse during the moan.

As discussed in the *Status of the Species* narrative for humpback whales, these whales produce a wide variety of sounds. During the breeding season males sing long, complex songs, with frequencies in the 25-5000 Hz range and intensities as high as 181 dB (Payne 1970, Thompson *et al.* 1986, Winn *et al.* 1970). Source levels average 155 dB and range from 144 to 174 dB (Thompson *et al.* 1979). The songs appear to have an effective range of approximately 10 to 20 km. Animals in mating groups produce a variety of sounds (Silber 1986, Tyack 1981; Tyack and Whitehead 1983).

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 1970; Winn *et al.* 1970a; Richardson *et al.* 1995)
2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3kHz (Tyack and Whitehead 1983, Richardson *et al.* 1995); and

3 Feeding area vocalizations that are less frequent, but tend to be 20Hz – 2 kHz with estimated sources levels in excess of 175 dB re 1 uPa-m (Thompson *et al.* 1986, Richardson *et al.* 1995). 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).

More recently, Au *et al.* (2006) conducted field investigations of humpback whale songs 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, 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 μPa. 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 150dB re 1 μPa/Hz at 350Hz (Lien *et al.* 1993, Todd *et al.* 1996). However, at least two individuals were probably killed by the high-intensity, impulsed 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 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 85 instances in which humpback whales find themselves between 25 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 150 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, behavioural disturbance, and physiological stress responses as a result of that exposure.

The U.S. Navy estimated that 15 humpback 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.

PROBABLE RESPONSES OF HUMPBACK WHALE TO UNDERWATER DETONATIONS. Our summary of the conclusions of our exposure analyses identifies how we would expect humpback whales to response to underwater detonations: we would expect 12 instances in which humpback whales might be exposed to underwater detonations on the Northwest Training Range Complex at received levels that would result in “behavioral harassment.” We would expect another 7 instances in which humpback 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 humpback 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

Like blue and fin whales, the 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, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al.* 2002, Richter *et al.* 2003, Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams *et al.* 2002). 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.

Based on the evidence available, we conclude that training exercises and other activities the U.S. Navy plans to conduct in the Northwest Training Range Complex each year from June 2010 through June 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. As we discussed in the *Approach to the Assessment* section of this opinion, 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 each year from June 2010 through June 2015 would not appreciably reduce the humpback whales' likelihood of surviving and recovering in the wild.

SEI WHALE. 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 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 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 23 these exposure events would occur at received levels between 140 and 150 dB or distances between 25 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.

2. we would 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 as a result of that exposure.

PROBABLE RESPONSES OF SEI WHALE TO ACTIVE SONAR. 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 23 tances in which sei whales might find themselves between 25 and 51 kilometers (between about 15.5 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 instances 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.

Te U.S. Navy estimated that one sei whale 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.

PROBABLE RESPONSES OF SEI WHALE TO UNDERWATER DETONATIONS. Because we would not expect any instances in which sei whales to 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 exposure..

Based on the evidence available and which we have summarized throughout this Opinion, we conclude that training exercises and other activities the U.S. Navy plans to conduct in the Northwest Training Range Complex each year from June 2010 through June 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. As we discussed in the *Approach to the Assessment* section of this opinion, 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 each year from June 2010 through June 2015 would not appreciably reduce the sei whales' likelihood of surviving and recovering in the wild.

SOUTHERN RESIDENT KILLER WHALE. Our analyses led us to reach the following conclusions about the potential stressors southern resident killer whales might be exposed to on the Northwest Training Range Complex and the number of instances in which southern resident killer whales might be exposed:

1. we would not expect southern resident killer whales to be exposed to mid-frequency active sonar the 43 hours of training the U.S. Navy plans to conduct with AN/SQS-53C and the 65 hours of training with AN/SQS-56 at the Northwest Training Range Complex each year. However, we would expect at least 102 instances in which southern resident killer whales would be exposed to other active sonar sources on the Northwest Training Range Complex.
2. we would also expect two instances in which southern resident killer whales would accumulate sufficient energy to experience temporary threshold shift as a result of their exposure to active sonar associated with the training activities it proposes to conduct on the Northwest Training Range Complex;

2. we would not expect any instances in which southern resident killer 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 as a result of that exposure.

PROBABLE RESPONSES OF SOUTHERN RESIDENT KILLER WHALE TO ACTIVE SONAR. The U.S. Navy estimated that 102 southern resident 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. The Navy estimated that there might be two instances in which southern resident killer whales would accumulate sufficient energy to experience temporary threshold shift as a result of their exposure to active sonar associated with the training activities it proposes to conduct on the Northwest Training Range Complex. Because our exposure analyses did not consider focused on mid-frequency active sonar and, as a result, did not consider every sound source the U.S. Navy proposes to employ on the Northwest Training Range Complex, we will conduct the rest of our analyses using the U.S. Navy's estimates.

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 night 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, southern resident 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 southern resident killer whales experience extreme distress when exposed to mid-frequency active sonar (AN/SQS-53) at received levels of about 169.3 dB (Fromm 2004, Department of the Navy 2003); we do not know if those whales suffered 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.

There are four primary ways in which the activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex might have adverse consequences for southern resident killer whales. First they could result in the death or serious injury of killer whales as a result of ship strikes or acoustic trauma (resonance). Second they could reduce the current or expected future reproductive success of southern resident killer whales resulting from chronic exposure to sound (that is, by causing threshold shifts, stress physiology, and long-term disturbance responses). Third, they could reduce the forage base of southern resident killer whales by affecting the distribution or abundance of Chinook salmon. Finally, they could reduce the southern resident killer whale's ability to forage effectively by excluding them from critical foraging areas.

We would 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 (Box BR2.1 of Figure 2; Holt *et al*. 2007). 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% 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 needs 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 @ 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 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, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al.* 2002, Richter *et al.* 2003, Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams *et al.* 2002). 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.

PROBABLE RESPONSES OF SOUTHERN RESIDENT KILLER WHALE TO UNDERWATER DETONATIONS. Because we would not expect any instances in which southern resident killer whales to 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.

As a result, based on the evidence available, we conclude that the training activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex from June 2010 through June 2015 are not likely to adversely affect the behavioral ecology, and social dynamics of individual southern resident killer whales in ways or to a degree that would reduce their longevity or reproductive success. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual southern resident killer whales would not be likely to reduce the viability of the populations those individual whales represent by reducing the population dynamics, behavioral ecology, and social dynamics of those populations (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). Therefore, we would not expect training activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex are likely to appreciably reduce the southern resident killer whales' likelihood of surviving and recovering in the wild by reducing their numbers, reproduction, or distribution.

SPERM WHALE. Our analyses led us to reach 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:

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 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 341 these exposure events would occur at received levels between 140 and 150 dB or distances between 25 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.

2. we would expect 13 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." We would expect another 10 instances in which sperm whales would be exposed to underwater detonations and experience temporary threshold shifts as a result and one 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 as a result of that exposure.

PROBABLE RESPONSES OF SPERM WHALE TO ACTIVE SONAR. 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 (Weilgart and Whitehead 1993, Goold and Jones 1995). 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 and Scheville1975, Watkins *et al.* 1985), pingers (Watkins and Scheville 1975), the Heard Island Feasability 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 Scheville 1975). Goold

(1999) reported six sperm whales that were driven through a narrow channel using ship noise, echosounder, and fishfinder emissions from a flotilla of 10 vessels. Watkins and Scheville (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).

As discussed previously, 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 *et al.* 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 *et al.* 1997, Schlundt *et al.* 2000), and to shorter broadband pulsed signals (Finneran *et al.* 2000, 2002). Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure or to avoid the location of the exposure site during subsequent tests (Schlundt *et al.* 2000, Finneran *et al.* 2002). 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 reactions to shorter pulses were higher (Finneran *et al.* 2000, 2002). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran *et al.* 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway *et al.* 1997, Schlundt *et al.* 2000). The relevance of these data to free-ranging odontocetes is uncertain. In the wild, cetaceans some-times 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 μPa 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 μPa at the source), but not to the other sources played to them.

Published reports identify instances in which sperm whales may 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 they examined in the northern Gulf of Mexico, contrary to what Mate *et al.* (1994) reported. In one DTAG deployment in the northern Gulf of Mexico on July 28, 2001, researchers documented that the tagged whale moved away from an operating seismic vessel once the seismic pulses were received at the tag at roughly 137 dB re 1 μPa (Johnson and Miller 2002). 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, 1998, 2000, 2001, 2003). 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 2003). The results from these waters seem to show that some sperm whales tolerate seismic surveys.

Preliminary data from an experimental study of sperm whale reactions to seismic surveys in the Gulf of Mexico and a study of the movements of sperm whales with satellite-linked tags in relation to seismic surveys show that during two controlled exposure experiments in which sperm whales were exposed to seismic pulses at received levels up to 148 dB re 1 μPa over octave band with most energy, the whales did not avoid the vessel or change their feeding efficiency (National Science Foundation 2003). Although the sample size is small (4 whales in 2 experiments), the results are consistent with those off northern Norway.

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.

The U.S. Navy estimated that 102 sperm 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. The Navy concluded that two sperm whales would accumulate sufficient energy to experience temporary threshold shift as a result of their exposure to active sonar associated with the training activities it proposes to conduct on the Northwest Training Range Complex.

PROBABLE RESPONSES OF SPERM WHALE TO UNDERWATER DETONATIONS. Our summary of the conclusions of our exposure analyses identifies how we would expect sperm whales to response to underwater detonations: we would expect 13 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.” We would expect another 10 instances in which sperm whales would be exposed to underwater detonations and experience temporary threshold shifts as a result and one 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 as a result of that exposure.

As a result, based on the evidence available, we conclude that the training activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex from June 2010 through June 2015 are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual sperm whales in ways or to a degree that would reduce their fitness. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual sperm whales would not be likely to reduce the viability of the populations those individual whales represent by reducing the population dynamics, behavioral ecology, and social dynamics of those populations (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). Therefore, we would not expect those research, development, test, and evaluation activities would appreciably reduce the sperm whales' likelihood of surviving and recovering in the wild by reducing their numbers, reproduction, or distribution.

STELLER SEA LION (EASTERN POPULATION). 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 7.043 instances in which Steller sea lions would be exposed to sound fields produced by this sonar

   About 4,414 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 1,442 these exposure events would occur at received levels between 140 and 150 dB or distances between 25 and 51 kilometers from the source of a sonar ping. About 445 the 7,043 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.

2. we would expect 114 instances in which Steller sea lions 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" as a result of that exposure.

3. we would expect 3 instances 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." We would expect another 3 instances in which Steller sea lions would be exposed to underwater detonations and 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.

PROBABLE RESPONSES OF STELLER SEA LION TO ACTIVE SONAR. 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 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 and Lowry (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. (1990, 1991), 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*. (2003, 2005) 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.* 1999, Kastak 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.

PROBABLE RESPONSES OF STELLER SEA LION TO UNDERWATER DETONATIONS. Our summary of the conclusions of our exposure analyses identifies how we would expect sperm whales to response to underwater detonations: we would expect 3 instances 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" (as that term is defined pursuant to the MMPA). We would expect another 3 instances in which Steller sea lions would be exposed to underwater detonations and 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.

Based on the evidence available, we conclude that training exercises and other activities the U.S. Navy plans to conduct in the Northwest Training Range Complex each year from June 2010 through June 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. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual sea lions would not be likely to reduce the viability of the populations those individual 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 each year from June 2010 through June 2015 would not appreciably reduce the Steller sea lions' likelihood of surviving and recovering in the wild.

LEATHERBACK SEA TURTLES. We assume that leatherback sea turtles are likely to be exposed to military readiness activities on the Quinault Underwater Tracking Range portion of the Keyport Range Complex. Because their foraging distribution does not appear to bring them into Crescent Harbor Underwater EOD range, Floral Point Underwater EOD Range, or the Indian Island Underwater EOD Range, leatherback sea turtles are not likely to be exposed to underwater detonations that would occur on these underwater EOD Ranges.

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) (Ridgway *et al.* 1969; Lenhardt *et al.* 1983; Bartol *et al.* 1999, Lenhardt 1994, O'Hara and Wilcox 1990). 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) the latter has sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Peterson 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 μPa and 175 db re 1 μPa, respectively. The sea turtles responded consistently: above a level of approximately 166 dB re 1 μPa_{rms} the turtles noticeably increased their swimming activity compared to non-airgun operation periods. Above 175 dB re 1 μPa mean squared pressure their behavior became more erratic possibly indicating the turtles were in an agitated state. 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 "may affect, but is not likely to adversely affect" leatherback sea turtles.

ENDANGERED AND THREATENED FISH IN THE NORTHWEST TRAINING RANGE COMPLEX. As a result of our exposure analyses, we assumed 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, 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 those 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 those areas of the Northwest Training Range Complex (particularly areas W-237A, W-237B, and W-237E);

3. 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, particularly during explosive ordnance disposal operations at Crescent Harbor, Port Townsend Bay, and Bangor in northern Hood Canal; and

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.

PROBABLE RESPONSES OF ENDANGERED AND THREATENED FISH TO ACTIVE SONAR. 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 (U.S. Navy 2008f, 2009a) 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*. (2005, 2007) investigated the potential effects of exposing several fish species to the U.S. Navy's SURTASS LFA sonar, focusing on the to hearing and on non-auditory tissues. Their study exposed the fish to LFA sonar pulses for time intervals that would be substantially longer than what would occur in nature, but the fish did not experience mortalities or damage to body tissues at the gross or histological level. Some fish experienced temporary losses in their hearing sensitivity but they recovered within several days of exposure.

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 the 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); however, because these species are anadromous, the juveniles, larvae, and eggs of southern green sturgeon, Pacific salmon, steelhead, and southern eulachon 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 probably protects them from the small, but potentially-significant mortality rates reported by Jørgensen and his co-workers (2005).

If Pacific salmon and steelhead are exposed to mid-frequency active sonar associated with the military readiness activities the U.S. Navy proposes to conduct on the Northwest Training Range Complex, they might experience startle responses or change 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.

PROBABLE RESPONSES OF ENDANGERED AND THREATENED FISH TO UNDERWATER DETONATIONS. As we did in our 30 June 2008 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 EOD Range is outside the major migration corridor for river systems in the area while the Indian Island Underwater EOD Range is within a migratory corridor for Chinook, chum, and other salmon species.

Our 2008 Opinion on U.S. Navy explosive ordnance disposal operations at Crescent Harbor, Port Townsend Bay, and Bangor in northern Hood Canal concluded that 50 adult and 5,094 juvenile Puget Sound Chinook salmon, 101 adult and 1,022 juvenile Hood Canal summer run chum salmon, and 20 adult and 182 juvenile Puget Sound steelhead were likely to be killed by the detonations of 2.5- and 20-pound ordnance in those three areas. However, that conclusion was based on an assumption that the U.S. Navy would conduct 32 underwater detonations and 20 surface detonations each year. The U.S. Navy currently proposes to conduct no more than 4 such detonations each year, proposes to move the single detonation it planned to conduct at Indian Island to Hood Canal, and reduce the net explosive weight of the detonation they would use in the training event from 2.5 pounds to 1.5 pounds. Using the same assumptions as those used in our 2008 Opinion, as a result of the underwater detonations the U.S. Navy proposes to conduct over the next five years, we would 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 underwater detonation 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.

Based on the evidence available, we conclude that training exercises and other activities the U.S. Navy plans to conduct in the Northwest Training Range Complex each year from June 2010 through June 2015 is likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual Pacific salmon, steelhead or southern eulachon in ways or to a degree that would reduce their fitness. However, the number of individuals that are likely to be affected relative to the size of the populations they represent are not likely to reduce 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 each year from June 2010 through June 2015 would not appreciably reduce the likelihood of Pacific salmon, steelhead or southern eulachon surviving and recovering in the wild.

7.0 CONCLUSION

After reviewing the current status of fin whales, humpback whales, sei whales, southern resident killer whales, sperm whales, Steller sea lion (eastern population), leatherback sea turtles, southern green sturgeon. southern 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, coho Southern Oregon – Northern Coastal California salmon, lower Columbia River coho, 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 research, development, test, and evaluation activities the U.S. Navy plans to conduct on the Keyport Range Complex and the cumulative effects, it is NMFS' biological opinion that the Navy's proposal to conduct research, development, test and evaluation activities on the Keyport Range Complex, each year for a five-year period beginning in 2010 are likely to adversely affect but are not likely to jeopardize the continued existence of these threatened and endangered species under NMFS jurisdiction.

The opinion also concluded that research, development, test, and evaluation activities the U.S. Navy plans to conduct on the Keyport 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.

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, green sturgeon. 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, coho Southern Oregon – Northern Coastal California salmon, lower Columbia River coho, 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 research, development, test, and evaluation 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 Navy's proposal to conduct research, development, test and evaluation activities on the Northwest Training Range Complex, each year for a five-year period beginning in June 2010 are likely to adversely affect but are not likely to jeopardize the continued existence of these threatened and endangered species under NMFS jurisdiction.

The opinion also concluded that research, development, test, and evaluation 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.

8.0 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.

The National Marine Fisheries Service is not including a statement that would exempt the take of endangered or threatened species incidental to the military readiness activities the U.S. Navy proposes to conduct on the Keyport Range Complex or Northwest Training Range Complex from the prohibitions of section 9 of the ESA in this Opinion. There are two reasons for this. First, the incidental take of marine mammals has not been authorized pursuant to section 101(a)(5) of the Marine Mammal Protection Act of 1972, as amended; the National Marine Fisheries Service's Permits, Conservation, and Education Division plans to issue annual Letters of Authorization that would authorize the U.S. Navy to "take" marine mammals pursuant to the MMPA. The National Marine Fisheries Service generally treats those Letters of Authorization as actions for the purposes of section 7(a)(2) of the ESA; therefore, we complete section 7 consultations on the issuance of those Letters of Authorization, may issue biological opinions at the conclusion of those consultations that would include incidental take statements for the endangered and threatened marine mammals, as appropriate.

Second, the military readiness activities and MMPA regulations described in this Opinion and that we concluded are not likely to jeopardize the continued existence of endangered or threatened species and are not likely to result in the destruction or adverse modification of critical habitat that has been designated for those species represent the maximum number, frequency, duration, and intensity that would occur in any of the five years between June 2010 and June 2015. In any particular year, however, the U.S. Navy might alter the number, timing, frequency, duration, location, and intensity of the activities they plan to conduct on the Keyport Range Complex or Northwest Training Range Complex or the measures they plan to employ to mitigate the effects of their training on living marine resources. For example, in the past, such changes have reduced the number of endangered or threatened species that we would expect to be "taken" as a result. To insure that our incidental take statements reflect the amount or extent of take that we actually expect to occur in any particular year and to insure that any terms and conditions we include in incidental take statements address the needs of all endangered or threatened species that might be “taken” as a result of U.S. Navy military readiness activities and MMPA authorizations.

9.0 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:

1. *Cumulative Impact Analysis.* The U.S. Navy should work with NMFS Endangered Species 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 Division informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Permits, Conservation and Education Division of the Office of Protected Resources should notify the Endangered Species Division of any conservation recommendations they implement in their final action.

10.0 REINITIATION NOTICE

This concludes formal consultation on research, development, test, and evaluation activities the U.S. Navy plans to conduct on (1) the 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 and the National Marine Fisheries Service’s Permits, Conservation, and Education Division’s proposal to promulgate regulations that would allow them to authorize the U.S. Navy to “take” marine mammals incidental to this training.

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. However, because this Biological Opinion did not exempt any “take” of endangered or threatened species, any “take” of endangered or threatened species that might result from the proposed training activities will be considered in subsequent biological opinions that accompany any Letters of Authorization the National Marine Fisheries Service issues on the proposed military readiness activities on the Keyport Range Complex or the Northwest Training Range Complex.

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