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

Agencies: United States Navy

National Marine Fisheries Service

Activities Considered: The U.S. Navy's proposed military readiness activities on the Southern California Range Complex from January 2011 to January 2012

NMFS' 2011 Letter of Authorization to authorize the U.S. Navy to "take" marine mammals incidental to military readiness activities on the Southern California Range Complex January 2011 to January 2012

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

Approved by: Helen Golde for J.H. Lecky

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Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1539(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 (1) the United States Navy, which proposes to undertake military readiness activities on the Southern California Range Complex, and (2) NMFS' Office of Protected Resources – Permits, Conservation, and Education Division, which proposes to issue a Letter of Authorization for the U.S. Navy to "take" marine mammals incidental to those military readiness activities. The consulting agency for these proposals is NMFS' Office of Protected Resources - Endangered Species Division.

This document represents NMFS' final biological opinion (Opinion) on the effects of these two proposals on endangered and threatened species and critical habitat that has been designated for those species. This Opinion has been prepared in accordance with the requirements of section 7 of the ESA, implementing regulations (50 CFR 402), agency policy, and guidance and considers and is based on information contained in NMFS' January 2009 programmatic biological opinion on the U. S. Navy's draft and final Environmental Impact Statement for the Southern California Range Complex; after-action reports and monitoring reports associated with the several Composite Training Unit Exercises (COMPTUEX) and Joint Task Force Exercises (JTFEX) that have been conducted on the Southern California Range Complex between February 2007 through December 2008; and the 2009 and 2010 monitoring reports associated with the U.S. Navy's training activities on the Southern California Range Complex.

This Opinion has been prepared in accordance with section 7 of the ESA and is based on information provided in the applications for the proposed permits, published and unpublished scientific information on the biology and ecology of threatened and endangered whales, sea lions, fur seals, sea turtles, salmon, steelhead, and abalone in the action area, and other sources of information that are discussed in greater detail in the *Approach to the Assessment* section of this Opinion.

Consultation History

On 1 April 2008, the U.S. Navy submitted an application to the Permits Division that requested authorization for the "take" of 37 species of marine mammals incidental to Navy training activities that would be conducted within the Southern California Range Complex over the course of five years. The U.S. Navy requested authorization to "take" individuals of 37 species of marine mammals by Level B Harassment (as the term "take" is defined by the Marine Mammal Protection Act); the U.S. Navy also requested authorization to take, by injury or mortality, up to 10 individuals each of 10 species of beaked whale over the course of the 5-year period, although it did not expect this form of "take" to occur.

In December 2008, the U.S. Navy issued its Final Environmental Impact Statement and Overseas Environmental Impact Statement on activities it planned to conduct on the Southern California Range Complex. In this supplement to the DEIS, the U.S. Navy developed and selected a new preferred alternative.

On 21 January 2009, NMFS published a final rule in the Federal Register on the U.S. Navy's request for a letter of authorization to "take" marine mammals incidental to training activities the U.S. Navy planned to conduct on the Southern California Range Complex (73 Federal Register 60836).

On 14 January 2009, NMFS signed its final programmatic biological opinion on the U.S. Navy's proposal to conduct training activities on the Southern California Range Complex. On 21 January 2009, NMFS' Permits Division provided NMFS' Endangered Species Division with copies of the Letter of Authorization it planned to issue for training activities the U.S. Navy planned to conduct on the Southern California Range Complex from January 2009 through January 2010.

In January 2010, NMFS determined that the military readiness activities the U.S. Navy proposed to conduct on the Southern California Range Complex from 22 January 2010 to 21 January 2011, and the Permits Division's proposal to issue a Letter of Authorization were within the scope of activities analyzed in NMFS' January 2009 programmatic biological opinion and issued an Incidental Take Statement that exempted the "take" of endangered and threatened species incidental to those activities.

On 2 December 2010, NMFS' Permits Division provided the Endangered Species Division with a copy of its final draft 2011 Letter of Authorization for the Southern California Range Complex, which would be operational from January 2011 through January 2012.

On 14 January 2011, NMFS' Endangered Species Division provided the U.S. Navy and the Permits Division with copies of its draft biological opinion on the proposed 2011 Letter of Authorization for the Southern California Range Complex.

On 18 January 2011, NMFS' Endangered Species Division received comments on its draft biological opinion from the U.S. Navy.

BIOLOGICAL OPINION

1.0 Description of the Proposed Action

The proposed action consists of two separate but related activities: (1) the U.S. Navy proposal to conduct a suite of training activities on the Southern California Range Complex during the twelve-month period beginning in January 2011 and (2) the National Marine Fisheries Service's Permits, Conservation, and Education Division's (Permits Division) proposal to issue a Letter of Authorization (LOA) that would allow the U.S. Navy to take marine mammals incidental to the U.S. Navy's training activities on the Southern California Range Complex.

The purpose of the activities the U.S. Navy proposes to conduct on the Southern California Range Complex is to meet the requirements of the U.S. Navy's Fleet Response Training Plan and allow Navy personnel to remain proficient in anti-submarine warfare and mine warfare skills. The purpose of the Permits Division's LOA is to authorize the U.S. Navy to "take" marine mammals incidental to military readiness activities on the Southern California Range Complex.

The following narratives summarize information on the various military readiness activities it plans to conduct from January 2011 through January 2012 (the twelve-month duration of the proposed LOA).

1.1 Military Readiness Activities on the Southern California Range Complex

On 14 January 2009, NMFS issued a programmatic biological opinion that assessed the probable direct and indirect effects of the U.S. Navy's military readiness activities on the Southern California Range Complex. That Opinion concluded that several of the activities the U.S. Navy plans to conduct on the Southern California Range Complex are not likely to adversely affect listed species or designated critical habitat because (1) the activities are not likely to produce stimuli that would represent potential stressors for endangered or threatened species or designated critical habitat under NMFS' jurisdiction; (2) the activities are likely to produce stimuli that would represent potential stressors for endangered or threatened species or designated critical habitat under NMFS' jurisdiction, but those species or critical habitat are not likely to be exposed to stressors; or (3) endangered or threatened species or designated critical habitat under NMFS' jurisdiction are likely to be exposed to potential stressors associated with the activities, but they are not likely to respond given that exposure.

1.1.1 Activities That Are Not Likely to Adversely Affect Listed Resources

Our 14 January 2009 programmatic biological opinion on military readiness activities on the Southern California Range Complex concluded that the following activities are not likely to produce stressors that are relevant for endangered or threatened species and designated critical habitat under NMFS' jurisdiction or those species and designated critical habitat are not likely to be exposed to physical, chemical, or biotic stressors that might be associated with them (see our 2009 programmatic biological opinion for detailed descriptions of these activities). The new information we gathered for the current consultation continues to support that earlier conclusion.

1. ELECTRONIC OPERATIONS. As part of electronic combat operations training, Navy personnel are trained to prevent or reduce the effectiveness of enemy electronic equipment. Typical Electronic Combat activities include signals analysis and use of airborne and surface electronic jamming devices to defeat tracking radar systems. During these activities, aircraft, surface ships, and submarines attempt to control critical portions of the electromagnetic spectrum used by threat radars, communications equipment, and electronic detection equipment. Electronic combat training activities typically last one to two hours. The best information available leads us to conclude that endangered and threatened species are not likely to be exposed to the technologies associated with these training activities and, if exposed, they are not likely to respond to that exposure.

2. NAVAL AUXILIARY LANDING FIELD AIRFIELD ACTIVITIES. The Naval Auxiliary Landing Field (NALF) on San Clemente Island supports aviation events, including training and logistics activities. The primary training activity conducted at the NALF is Field Carrier Landing Practice, which is characterized by touch-and-go practice in day and night conditions on a simulated aircraft carrier outline marked on the landing field. The NALF also supports regular resupply and personnel transport aircraft runs between San Clemente Island and mainland bases. 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. COMMERCIAL AIR SERVICES. Commercial Air Services are services provided by nonmilitary aircraft in contracted support of military training activities; examples of support include air refueling, target towing, and simulation of threat aircraft. 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.

4. SMALL ARMS TRAINING. Navy personnel training in the use of small arms and small unit tactics to defend unit positions or attack simulated enemy positions. Small arms training exercises may include use of 9 mm pistols, 12-gauge shotguns, 5.56 mm automatic rifles, .50 caliber, 7.62 mm, 5.56 mm machine guns, and 40 mm grenades.

5. LAND NAVIGATION. Training in land navigation is conducted on San Clemente Island by individuals and small units on foot utilizing maps, compasses, and other navigation aids on established courses.

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

1.1.2 Activities That Are Likely to Adversely Affect Listed Resources

The following narratives summarize the remaining military readiness activities the U.S. Navy plans to conduct on the Southern California Range Complex; these activities contain. Our 14 January 2009 Programmatic Biological Opinion describes these training operations, including ordnance that might be involved in those operations, in detail.

1. MAJOR TRAINING EXERCISES. Major training events on the Southern California Operating Area (or major range events) are composed of several unit level range training activities conducted by several units operating together while commanded and controlled by a single commander. These exercises typically employ exercise scenarios that are developed to train and evaluate Strike Groups and Strike Forces in requisite naval tactical tasks. In major range events, most of the activities are identical in nature to activities conducted in individual, crew, and smaller-unit training events; however, in major range events, these disparate training tasks are conducted in concert, rather than in isolation. The U.S. Navy conducts two categories of major training exercises on the Southern California Range Complex: Composite Training Unit Exercises (or COMPTUEX) and Joint Task Force Exercises (or JTFEX).

    1.1 Composite Training Unit Exercise. Composite Training Unit Exercises (or COMPTUEX) are Integration Phase, at-sea, major range events. When they involve carrier strike groups, these exercises integrate an aircraft carrier and carrier air wing with surface and submarine units. When they involve expeditionary strike groups, these exercises integrate amphibious ships with their associated air wing, surface ships, submarines, and Marine Expeditionary Unit.

    Live-fire activities that may take place during a COMPTUEX include long-range air strikes, Naval Surface Fire Support (which are discussed in greater detail in narratives that follow), and surface-to-air, surface-to-surface, and air-to-surface missile exercises. A Marine Expeditionary Unit also conducts realistic training based on anticipated operational requirements and to further develop the required coordination between Navy and Marine Corps forces. Special Operations training may also be integrated with the exercise scenario. These exercises typically last for 21 days and may include two 1-day, scenario-driven, "mini" battle problems, culminating with a scenario-driven 3-day final battle problem. Composite Training Unit Exercises have generally occurred three to four times per year.

    1.2 Joint Task Force Exercise. Joint Task Force Exercises are also major range events that are the culminating exercises in Integrated Phase training for Carrier and Expeditionary Strike Groups. For Expeditionary Strike Groups, Joint Task Force Exercises incorporate

Amphibious Ready Group Certification Exercises for amphibious ships and Special Operations Capable Certification for Marine Expeditionary Units. When schedules allow, these exercises may be conducted concurrently for a Carrier Strike Group and an Expeditionary Strike Group. These exercises normally last for 10 days (not including a 3-day force protection exercise that occurs in-port) and are the final at-sea exercise for the Carrier or Expeditionary Strike Groups before they are deployed. These exercises have generally occurred three to four times per year.

1.3 Coordinated Unit-Level Training. Coordinated unit-level training events, which pursue training tailored for components of a Strike Group, are complex exercises of lesser scope than Major Range Events. This type of training includes:

- Ship ASW Readiness and Evaluation Measuring (SHAREM), which allow the Navy to collect and analyze data that can be used to quantitatively "assess" the readiness of surface ships for effectiveness. The program typically involves multiple ships, submarines, and aircraft in several coordinated events over a period of a week or less. A SHAREM may take place once per year on the Southern California Training Range.
- Sustainment Exercise. The U.S. Navy requires post-deployment training and maintenance to ensure that components of Strike Groups maintain an acceptable level of readiness when they return from deployments. Sustainment exercises are designed to challenge strike groups in all warfare areas and are similar to a COMPTUEX but they are shorter in duration. One to two sustainment exercises may occur each year on the Southern California Training Range.
- Integrated ASW Course (IAC) Phase II. These exercises are combined aircraft and surface ship events and consist of two 12-hour events conducted primarily on Southern California ASW Range over a 2-day period. Typical participants include four helicopters, two maritime patrol aircraft (previously P-3 aircraft), two adversary submarines, and two Mk 30 or Mk 39 targets. Four of these exercises may occur per year on the Southern California Training Range.

2. AIR COMBAT MANEUVERS. Air combat maneuvers typically involve supersonic flight and use of chaff and flares. Air Combat Maneuver operations within the Southern California Range Complex are primarily conducted within W-291. These operations typically involve from two to eight aircraft, but may involve over a dozen aircraft. Sorties can be as short as 30 minutes or as long as 2 hours, but the typical Air Combat Maneuver mission has an average duration of 1 to 2 hours. No weapons are fired during these exercises. The U.S. Navy plans to conduct about 3,970 of these maneuvers each year on the Southern California Range Complex.

3. AIR DEFENSE EXERCISE. Air Defense Exercises consist of air-to-air and surface-to-air missile training events. These operations are coordinated between surface ships and aircraft. Tasks include radar detection, positioning, maneuver to a simulated airborne or surface firing position, and recovery of aircraft aboard an aircraft carrier. Air-to-air refueling may be included. These operations vary widely in the numbers of ships and aircraft involved and consist of a full array of tactics and procedures that are practiced between air and surface units for defense of the force. No

weapons are fired during these exercises. The U.S. Navy plans to conduct about 550 of these exercises each year on the Southern California Range Complex.

4. SURFACE-TO-AIR MISSILE EXERCISE. A surface-to-air missile exercise involves surface combatants firing live missiles (RIM-7 Sea Sparrows, SM-1 or SM-2 Standard Missiles) at targets towed behind a commercial air services Lear jet, or by a specialized BQM-74 target (a remote controlled target drone, with a parachute to enable recovery at sea). Recoverable target drones are refurbished and reused. The surface-to-air missiles are launched from ships located within Warning Area W-291. The U.S. Navy plans to conduct about 6 of these exercises each year on the Southern California Range Complex.

5. SURFACE-TO-AIR GUNNERY EXERCISE. A Surface-to-Air gunnery exercise requires an aircraft or missile that will fly high or low altitude threat profiles. Commercial aircraft also tow a target drone unit that ships track, target, and engage with their surface-to-air weapon systems. The exercise lasts about two hours, and typically includes several non-firing tracking runs followed by one or more (up to five) firing runs. The target must maintain an altitude above 500 ft for safety reasons and is not destroyed during the exercise. Gunnery exercise activities are conducted within Warning Areas W-291. The U.S. Navy plans to conduct about 350 of these exercises each year on the Southern California Range Complex.

6. AIR-TO-AIR MISSILE EXERCISE. In an air-to-air missile exercise, missiles are fired from aircraft against unmanned aerial target drones such as BQM-34s and BQM-74s. Additionally, weapons may be fired against flares 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. The U.S. Navy plans to conduct about 13 of these exercises each year on the Southern California Range Complex.

7. ANTI-SUBMARINE WARFARE TRACKING EXERCISE (HELICOPTER). Antisubmarine Warfare Tracking Exercise Helicopter involves helicopters using sonobuoys and dipping sonar to search for, detect, classify, localize, and track a simulated threat submarine. Sonobuoys are typically employed by a helicopter operating at altitudes below 3,000 ft. and are deployed in specific patterns over many different size areas, depending on submarine threat and water conditions. Both passive and active sonobuoys are employed. These exercises usually take one to two hours and may involve a single aircraft, or be undertaken in the context of a coordinated larger exercise involving multiple aircraft or ships, including a major range event. No ordnance is expended. The U.S. Navy plans to conduct about 1,690 of these exercises each year on the Southern California Range Complex.

8. ANTI-SUBMARINE WARFARE TORPEDO EXERCISE (HELICOPTER). The Antisubmarine Warfare Torpedo Exercise involves helicopters using sonobuoys and dipping sonar to search for, detect, classify, localize, and track a simulated threat submarine, as in the ASW Tracking Exercise (Helicopter). Torpedo exercises proceed to the release of an exercise torpedo against the target, which is typically an MK-39 Expendable Mobile ASW Training Target (EMATT) or MK-30 target system. The U.S. Navy plans to conduct about 245 of these exercises each year on the Southern California Range Complex.

9. ANTI-SUBMARINE WARFARE TRACKING EXERCISE (MARITIME PATROL AIRCRAFT). The Antisubmarine Warfare Tracking Exercise-Maritime Patrol Aircraft involves fixed-wing maritime patrol aircraft (P-3s or P-8s) employing sonobuoys. Sonobuoys are typically employed by maritime patrol aircraft operating at altitudes below 3,000 ft. Both passive and active sonobuoys are employed. For certain sonobuoys, tactical parameters of use may be classified. The target for these exercises are either an MK-39 Expendable Mobile ASW Training Target (EMATT) or live submarine and may be either non-evading and assigned to a specified track, or fully evasive depending on the state of training of the helicopter. These exercises usually last for two to four hours and no ordnance is expended. The U.S. Navy plans to conduct about 29 of these exercises each year on the Southern California Range Complex.

10. ANTI-SUBMARINE WARFARE TORPEDO EXERCISE (MARITIME PATROL AIRCRAFT). The Antisubmarine Warfare Torpedo Exercise Maritime Patrol Aircraft involves patrol aircraft using sonobuoys to search for, detect, classify, localize, and track a simulated threat submarine, as in the tracking exercise involving helicopters. In addition, the TORPEX proceeds to the release of an exercise torpedo against the target (typically an MK-39 Expendable Mobile ASW Training Target or MK-30 target system). The U.S. Navy plans to conduct about 17 of these exercises each year on the Southern California Range Complex.

11. ANTI-SUBMARINE WARFARE EER/IEER/AEER SONOBUOY DEPLOYMENT. This training event is an at-sea flying exercise designed to train maritime patrol aircraft crews in the deployment and use of the Extended Echo Ranging (EER) and Improved Extended Echo Ranging (IEER) sonobuoy systems. EER and IEER sonobuoy systems are airborne anti-submarine warfare systems used in conducting "large area" searches for submarines. The IEER System's active sonobuoy component, the AN/SSQ-110A Sonobuoy, would generate a sonar "ping" and the passive AN/SSQ-101 Air Deployable Active Receiver Sonobuoy would "listen" for the return echo of the sonar ping that has been bounced off the surface of a submarine. These sonobuoys are designed to provide underwater acoustic data necessary for naval aircrews to quickly and accurately detect submerged submarines. After visually searching an area for marine mammals, sonobuoy pairs are dropped from a fixed-wing aircraft into the ocean in a predetermined pattern with a few buoys covering a very large area.

The AN/SSQ-110A Sonobuoy Series is an expendable and commandable sonobuoy. Upon command from the 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. Extended Echo Ranging training events and IEER events differ only in the number and type of sonobuoys used. An EER event uses an SSQ-77 as the receiver buoy, while an SSQ-101 is the receiver buoy during IEER events. Both training events use SSQ-110A sonobuoys as the signal source.

The AN/SSQ-125 Advanced Extended Echo Ranging (AEER) Sonobuoy is a third generation of multi-static active acoustic search systems to be developed under the Extended Echo Ranging family of the systems and is being developed as the replacement for the AN/SSQ-110A. The AN/SSQ-125 sonobuoy is composed of two sections, the control section and the active source section. The control section contains the electronics package while the lower section consists of the active sonar source. The echoes from pings of the sonar are then analyzed on the aircraft to determine a submarine's position.

The U.S. Navy plans to conduct 30 of these exercises each year on the Southern California Range Complex.

12. ANTI-SUBMARINE WARFARE TRACKING EXERCISE (SURFACE). The Antisubmarine Warfare Tracking Exercise involves a surface ship employing hull mounted or towed array sonar against a target which may be an MK-39 Expendable Mobile ASW Training Target or live submarine. The target may be either non-evading and assigned to a specified track or fully evasive depending on the state of training of the ship and crew. Passive and active sonar may be employed in these training events. Active sonar transmits at varying power levels, pulse types, and intervals, while passive sonar listens for noise emitted by the threat submarine. Passive sonar is typically employed first, followed by active sonar to determine an exact target location; however, active sonar may be employed during the initial search phase against an extremely quiet submarine or in situations where the water conditions do not support acceptable passive reception. There is no ordnance expended in this exercise. These exercises usually last two to four hours and may involve a single ship, or be undertaken in the context of a coordinated larger exercise involving multiple aircraft or ships, including a major range event. The U.S. Navy plans to conduct about 900 of these exercises each year on the Southern California Range Complex.

13. ANTI-SUBMARINE WARFARE TORPEDO EXERCISE (SURFACE). The Antisubmarine Warfare Torpedo Exercise-Surface involves a surface ship using hull-mounted and towed sonar arrays to search for, detect, classify, localize, and track a simulated threat submarine, as in the tracking exercise (surface) discussed in the preceding narrative. In addition, these torpedo exercises proceed to the release of an exercise torpedo against the target, which is typically an MK-39 Expendable Mobile ASW Training Target or MK-30 target system. The U.S. Navy plans to conduct about 25 of these exercises each year on the Southern California Range Complex.

14. ANTI-SUBMARINE WARFARE TRACKING EXERCISE (SUBMARINE). The Antisubmarine Warfare Tracking Exercise-Submarine involves a submarine employing hull mounted or towed array sonar against a target which may be an MK-39 Expendable Mobile ASW Training Target or a live submarine. During this event, passive sonar is used almost exclusively; active sonar use is tactically proscribed because it would reveal the tracking submarine's presence to the target submarine. No ordnance is expended during these exercises, which usually lasts two to four hours. The U.S. Navy plans to conduct about 40 of these exercises each year on the Southern California Range Complex.

15. ANTI-SUBMARINE WARFARE TORPEDO EXERCISE (SUBMARINE). The Antisubmarine Warfare Torpedo Exercise-Submarine involves a submarine employing hull mounted and/or towed array sonar against a target which may be an MK-39 Expendable Mobile ASW Training Target or MK-30 Mobile ASW Target, followed by launch of a MK-48 exercise torpedo. Exercise torpedoes are recovered by helicopter or small craft. The U.S. Navy plans to conduct about 22 of these exercises each year on the Southern California Range Complex.

16. ANTI-SURFACE WARFARE TRAINING. 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.

16.1 *Visit, Board, Search, and Seizure*. Visit, Board, Search, and Seizure is conducted to train helicopter crews to insert personnel onto a vessel to inspect the ship's personnel and cargo for compliance with applicable laws and sanctions. These exercises require a cooperative surface ship. The typical duration of these operations is approximately between 2 and 3 hours. The U.S. Navy plans to conduct about 90 visit, board, search, and seizure training events each year on the Southern California Range Complex.

16.2 *Anti-Surface Missile Exercise*. These exercises train fixed winged aircraft and helicopter crews to launch missiles at surface maritime targets, day and night, with the goal of destroying or disabling enemy ships or boats. Specially prepared targets with expendable target area on a stationary floating or remote controlled platform are employed. The missile passes through the expendable target without damaging the platform and explodes near the surface of the water. Live Hellfire missiles are expended during these exercises. These exercises occur in Southern California ASW Range (denoted SOAR), Missile Impact Range, and Shore Bombardment Area (denoted SHOBA).

The U.S. Navy plans to conduct about 50 anti-surface missile exercises each year on the Southern California Range Complex.

16.3 *Air-to-Surface Bombing Exercise*. These exercises involve training of strike fighter aircraft and patrol aircraft in delivery of bombs against surface maritime targets in day or night conditions. The following munitions may be employed by strike fighter in the course of the Bombing Exercise: Unguided munitions: MK-76 and BDU-45 (inert training bombs); MK-80 series (inert or live); MK-20 Cluster Bomb (inert or live). Precision-guided munitions: Laser-guided bombs (inert or live); Laser-guided Training Rounds (inert); Joint Direct Attack Munition (inert or live). Maritime patrol aircraft use bombs to attack surfaced submarines and surface craft that would not present a major threat to the maritime patrol aircraft themselves. These exercises may involve single maritime patrol aircraft, a flight of two strike fighters, or be undertaken in the context of a coordinated larger exercise involving multiple aircraft and/ or ships, including a major range event or Sinking Exercise. On the Southern California Training Range, these exercises occur on the Southern California ASW Range, the Missile Impact Range, and the Shore Bombardment Area.

The U.S. Navy plans to conduct about 40 air-to-surface bombing exercises each year on the Southern California Range Complex.

16.4 *Air-to-Surface Gunnery Exercise*. These exercises involve training of strike fighter aircraft and helicopters to employ guns to attack surface maritime targets in day or night. Sea targets simulate enemy ships, boats, or floating or near-surface mines. Land targets simulate enemy formations, vehicles or facilities. Exercises involving strike fighter aircraft typically involve a flight of two aircraft firing approximately 250 rounds of inert ammunition against either land (most often) or water targets. These exercises last about 1 hour.

In the Southern California Training Range, these exercises occur in Warning Area W-291. The U.S. Navy plans to conduct about 60 air-to-surface gunnery exercises each year on the Southern California Range Complex.

16.5 *Surface-to-Surface Gunnery Exercise*. These exercises involve training of crews manning small boats to use machine guns to attack and disable or destroy a surface target that simulates another ship, boat, floating mine or near shore land targets. A number of different types of boats are used depending on the unit using the boat and their mission. Boats are mostly used by Naval Special Warfare teams and Navy Expeditionary Combat Command units with a mission to protect ships in harbors and high value units, such as: aircraft carriers, nuclear submarines, liquid natural gas tankers, etc., while entering and leaving ports, as well as to conduct riverine operations, insertion and extractions, and various naval special warfare operations. The boats used by these units include: Small Unit River Craft, Combat Rubber Raiding Craft, Rigid Hull Inflatable Boats, Patrol Craft, and many other versions of these types of boats. These boats use inboard or outboard, diesel or gasoline engines with either propeller or water jet propulsion.

In the Southern California Training Range, these exercises occur in Warning Area W-291 and the Shore Bombardment Area. The U.S. Navy plans to conduct about 350 of these exercises each year on the Southern California Range Complex.

16.6 *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.

In the Southern California Training Range, these exercises occur in Warning Area W-291. The U.S. Navy plans to conduct about 2 sinking exercises each year on the Southern California Range Complex.

17. AMPHIBIOUS WARFARE TRAINING. Amphibious warfare training exercises are designed to provide a realistic environment for amphibious assault training, reconnaissance training, hydrographic

surveying, surf condition observance, and communication. Amphibious vehicles are typically launched approximately 1,829 meters (2,000 yards) from the beach.

17.1 *Naval Surface Fire Support*. Naval Surface Fire Support (NSFS) trains surface ships' crews to employ main battery guns in support of amphibious operations and operations by forces ashore. Naval Surface Fire Support normally consists of the bombardment of a target within an impact area on San Clemente Island's Shore Bombardment Area, by one or more ships. The ship is often supported by Navy or Marine spotters ashore, or by spotters embarked in fixed-wing aircraft or helicopters in the air, to call for the fire support from the ship, and to adjust the fall of shot onto the target. Target shapes simulate vehicles, aircraft or personnel on the ground.

These exercises typically occur over a 2- to 3-day period. The U.S. Navy plans to conduct about 52 naval surface fire support exercises each year on the Southern California Range Complex.

17.2 *Expeditionary Fires Exercise*. Expeditionary Fires Exercise/Supporting Arms Coordination Exercises are major training exercises oriented around Naval Surface Fire Support and Marine artillery fires in support of ground amphibious operations. The mission of the exercises is to achieve effective integration of Naval gunfire, close air support, and artillery fire support. These exercises typically last for eight days, during which an Expeditionary Strike Group commander runs a schedule-of-operations driven exercise.

The U.S. Navy plans to conduct about 8 expeditionary fire exercises each year on the Southern California Range Complex.

17.3 *Expeditionary Assault – Battalion Landing*. Battalion landing operations are proposed for San Clemente Island. The U.S. Navy plans to conduct two battalion landing exercises each year on the Southern California Range Complex.

17.4 *Stinger Firing Exercise*. The Stinger missile is a portable, shoulder fired weapon that also may be mounted on and fired from a vehicle. Proposed Stinger training would be conducted from positions on-shore in the Shore Bombardment Area, toward the ocean, not over land, at target drones, either Ballistic Aerial Targets or Remotely Piloted Vehicles.

The U.S. Navy plans to conduct four stinger firing exercises each year on the Southern California Range Complex.

17.5 *Amphibious Landings and Raids*. San Clemente Island supports training of small units of Marines or Naval Special Warfare personnel in the conduct of amphibious operations using small boats, amphibious craft or assault amphibian vehicles. Training includes both live-fire and non-live-fire events, including reconnaissance missions, raids, tactical recovery of aircraft and personnel exercises, and assault amphibian vehicle landing events. These events typically involve units of from 12 to 40 personnel, and may be conducted across beaches at Wilson Cove, Horse Beach Cove, Northwest Harbor, and Eel Point, and in any of various training areas designated on San Clemente Island.

The U.S. Navy plans to conduct about 66 amphibious landings and raids each year on the Southern California Range Complex.

17.6 *Amphibious Operations*. The ocean area adjacent to Camp Pendleton is designated as the Camp Pendleton Amphibious Assault Area or CPAAA. Training events in this area include: reconnaissance unit training, small boat unit training, assault amphibian vehicle crew and unit training, and Marine Expeditionary Unit (Special Operations Capable) events, and Expeditionary Strike Group training.

The U.S. Navy plans to conduct about 2,276 amphibious operations each year on the Southern California Range Complex.

18. 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. Naval mines can be laid by purpose-built minelayers, other ships, submarines, or airplanes. Mine warfare training includes Mine Countermeasures Exercises and Mine Laying Exercises.

18.1 *Mine Countermeasures Exercise*. Mine Countermeasures (MCM) consists of mine avoidance training and mine neutralization training. Training utilizes simulated minefields constructed of moored or bottom mines, or instrumented mines that can record effectiveness of mine detection efforts. Ship or submarine-mounted mid-frequency active sonar systems employed are: AN/SQS-53, AN/SQS-56, AN/SQQ-32, AN/BQQ-5 or 10. Helicopters engaged in airborne MCM training use equipment that includes: AN/AQS-20 Mine Hunting System (employing side-looking sonar); AN/AES-1 Airborne Laser Mine Detection System; and AN/ALQ-220 Organic Airborne Surface Influence Sweep.

Mine countermeasures exercises typically last one or two hours for surface ships and helicopters, and may last up to 15 hours for specially configured MCM ships. Navy units typically conduct mine countermeasures training in stand-alone events, involving few aircraft, or single ships or submarines, however mine countermeasures training may occur in the context of a coordinated larger exercise involving multiple aircraft, ships, and submarines, including a major range event. The U.S. Navy plans to conduct about 48 mine countermeasures exercises each year on the Southern California Range Complex.

18.2 *Mine Neutralization*. Mine Neutralization operations involve the detection, identification, evaluation, rendering safe, and disposal of mines and unexploded ordnance (which the Navy abbreviates as UXO) that constitutes a threat to ships or personnel. Mine neutralization training is conducted by a variety of air, surface and sub-surface assets.

The total net explosive weight used against each mine ranges from less than 1 pound to 20 pounds. Occasionally, marine mammals are used in mine detection training operations. The U.S. Navy's Very Shallow Water Mine Countermeasures Detachment of Commander Mine Warfare Command deploys trained Atlantic bottlenose dolphins of their marine mammal mine-hunting systems in several missions. Each mission includes up to four motorized small craft, several crew members and a trained dolphin. Exercises using dolphins are coordinated with other U.S. Navy units to avoid conflicts with other U.S. Navy activities, underwater acoustic emissions associated with those activities, or civilian craft.

Mine neutralization operations take place offshore in the shallow water training range offshore near Cortes and Tanner Banks. The U.S. Navy plans to conduct about 732 mine neutralization exercises each year on the Southern California Range Complex.

18.3 *Mine Laying*. Mine laying operations are designed to train forces to conduct offensive (deploy mines to tactical advantage of friendly forces) and defensive (deploy mines for protection of friendly forces and facilities) mining operations. Mines can be laid from the air (FA-18/P-3) or by submarine.

Submarine mine laying exercises are typically “virtual” with no expenditure of any mine shape or any range requirements. The U.S. Navy plans to conduct about 18 mine laying exercises each year on the Southern California Range Complex.

19. NAVY SPECIAL OPERATIONS TRAINING. 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.

19.1 *NSW Land Demolition*. Naval Special Warfare or Explosive Ordnance Disposal personnel train in use of explosive charges to destroy land mines, explosives such as improvised explosive devices, unexploded ordnance, structures, or other items as required. The size of an explosive charge is defined in terms of net explosive weight. Charge sizes typically employed range from 1 to 20 pounds (net explosive weight).

The U.S. Navy plans to conduct 674 of these exercises each year on the Southern California Range Complex.

19.2 *Underwater Demolition*. Naval Special Warfare or Explosive Ordnance Disposal personnel use small explosive charges to destroy obstacles or other structures in an underwater area that could cause interference with friendly or neutral forces and planned operations. There are basically three types of underwater demolition: Single charges, Mat Weave, and Obstacle Loading. Single charge training includes smaller explosives between 5 and 20 lb (2 and 9 kg) of C-4 and detonation cord. The charges are assembled on the beach and placed in 5-20 ft of water.

The U.S. Navy plans to conduct 85 single-charge exercises each year on the Southern California Range Complex. The U.S. Navy plans to conduct 18 multiple charge exercises each year.

19.3 *NSW/UAV/UAS Operations*. Unmanned Aerial Vehicles (UAV) obtain information about the activities of an enemy or potential enemy or tactical area of operations by use of various onboard surveillance systems including: visual, aural, electronic, photographic, or other means. Unmanned Aerial Vehicles are typically flown at altitudes well above 3,000 ft.

The U.S. Navy plans to conduct 1,176 of these exercises each year on the Southern California Range Complex.

19.4 *Insertion/Extraction*. Naval Special Warfare and other personnel train to approach or depart an objective area using various transportation methods and tactics. 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 submarines which deliver personnel into the water, and small inflatable boats.

The U.S. Navy plans to conduct 15 of these exercises each year on the Southern California Range Complex.

19.5 *NSW Boat Operations*. Naval Special Warfare personnel assigned to Special Boat Units train in open ocean and littoral activities, including in the vicinity of San Clemente Island. Training events include firing of crew-served machine guns and hand held weapons into land impact areas of the Shore Bombardment Area.

The U.S. Navy plans to conduct 320 of these exercises each year on the Southern California Range Complex.

19.6 *SEAL Platoon Training Activities*. San Clemente Island is a principal training venue for SEAL platoons and other Naval Special Warfare personnel. Typically, Naval Special Warfare personnel employ a variety of live fire or blank small arms and explosive ordnance in the course of training.

The U.S. Navy plans to conduct 668 of these exercises each year on the Southern California Range Complex.

19.7 *NSW Direct Action*. Direct action training is a specialized Naval Special Warfare event involving a squad or platoon size force of personnel inserted into and later extracted from a hostile area by helicopter, small boat or other means to conduct live-fire offensive actions against simulated hostile forces or targets.

The U.S. Navy plans to conduct 190 of these exercises each year on the Southern California Range Complex.

20. STRIKE WARFARE TRAINING. Strike Warfare operations typically involve simulated strike missions with flights of four or more aircraft.

20.1 *Bombing Exercise* (*Land*). These exercises train crews of strike fighter aircraft or helicopter to deliver ordnance against land targets in day or night conditions.

The following munitions may be employed by strike fighters in the course of the Bombing Exercise: Unguided munitions: MK-76 and BDU-45 (inert training bombs); MK-80 series (inert or live); MK-20 Cluster Bomb (inert or live). Precision-guided munitions: Laser-guided bombs (inert or live); Laser-guided Training Rounds (inert); Joint Direct Attack Munition (inert or live). Rockets: 5-inch Zuni rockets.

The U.S. Navy plans to conduct about 216 of these exercises each year on the Southern California Range Complex.

20.2 *Combat Search and Rescue*. Combat Search and Rescue training involves fixed-winged aircraft, helicopters or submarines using tactical procedures to rescue military personnel within a hostile area of operation.

The U.S. Navy plans to conduct about eight of these exercises each year on the Southern California Range Complex.

21 EXPLOSIVE ORDNANCE DISPOSAL ACTIVITIES. Explosive Ordnance Disposal personnel train to gain and maintain qualification and proficiency in locating, neutralizing or destroying unexploded ordnance and conducting other hazardous range clearance activities. Operations are conducted in impact areas on San Clemente Island.

The U.S. Navy plans to conduct 10 of these exercises each year on the Southern California Range Complex.

22. UNITED STATES COAST GUARD TRAINING. Coast Guard personnel regularly train in maritime rescue and patrol activities on the Southern California Range Complex, using a variety of boats, small ships, and helicopters.

The U.S. Coast Guard plans to continue conducting 1,022 of these training activities each year on the Southern California Range Complex.

23. RESEARCH, DEVELOPMENT, TEST, AND EVALUATION ACTIVITIES. The Space and Naval Warfare Systems Center conducts research, development, test and evaluation; engineering; and Fleet support for command, control, and communications systems and ocean surveillance. Space and Naval Warfare Systems tests on San Clemente Island include ocean engineering, missile firing, torpedo testing, manned and unmanned submersibles. Unmanned aerial vehicles, electronic countermeasures, and other Navy weapons systems that are employed in these activities are:

23.1 *Ship Torpedo Tests*. This is a test event for reliability, maintainability, and performance of Exercise (EXTORP) and Recoverable Exercise Torpedoes (REXTORP). These events include torpedo firing.

The U.S. Navy plans to conduct about 20 of these tests each year on the Southern California Range Complex.

23.2 *Unmanned Underwater Vehicles*. These are in-water events for the development and operational testing of advanced designs of underwater vehicles, conducted in the vicinity of Naval Ordnance Test Station Pier.

The U.S. Navy plans to conduct about 15 of these tests each year on the Southern California Range Complex.

23.3 *Sonobuoy QA/QC Testing*. This testing event evaluates random lots of sonobuoys and determines the quality of the set. The sonobuoys are dropped from an aircraft into the San Clemente Island Underwater Range area east of San Clemente Island. Defective buoys are recovered. All non-defective buoys are scuttled.

The U.S. Navy plans to conduct about 120 of these tests each year on the Southern California Range Complex.

23.4 *Ocean Engineering*. Ocean engineering tests determine the characteristics, reliability, maintainability and endurance of various pieces of marine design. The items to be tested are left in the water off NOTS Pier for an extended period, and are monitored by Navy personnel.

The U.S. Navy plans to conduct about 242 of these tests each year on the Southern California Range Complex.

23.5 *Marine Mammal Mine Shape Location/Research*. In this series of events, trained marine mammals are taught to locate and mark inert mine shapes. The marine mammals, most of which are Atlantic bottlenose dolphins, are penned and cared for at Naval Base Point Loma, and transported to San Clemente Island for mine location and applied research.

The U.S. Navy plans to conduct about 30 of these tests each year on the Southern California Range Complex.

23.6 *Missile Flight Tests*. Missile flight test events confirm performance, reliability, maintainability and suitability for operational use of various missiles in the Navy inventory. Tests involve launches from operational ships and aircraft from within either the Point Mugu Sea Range or the Southern California Range Complex against airborne targets in W-291, or land targets in the Missile Impact Range on San Clemente Island.

The U.S. Navy plans to conduct about 20 of these tests each year on the Southern California Range Complex.

23.7 *NUWC Underwater Acoustics Testing*. These tests are conducted to evaluate the accuracy of several acoustic and non-acoustic ship sensors. Tests occur at San Clemente Island Underwater Range.

The U.S. Navy plans to conduct about 139 of these tests each year on the Southern California Range Complex.

23.8 *Other Tests*. The Southern California Range Complex supports diverse tests including surface warfare tests against fast-moving, small boats, mine countermeasures, naval gunfire, electronic combat and combat systems verification. Testing is conducted primarily in the waters west of San Clemente Island.

The U.S. Navy plans to conduct about 20 other tests each year on the Southern California Range Complex.

1.1.3 Acoustic Systems Associated with Anti-Submarine Warfare Training

During anti-submarine warfare training exercises, the U.S. Navy uses tactical military sonars that were designed to search for, detect, localize, classify, and track submarines. The U.S. Navy typically employs two types of sonars: passive sonar and active sonar:

1. Passive sonars only listen to incoming sounds and, since they do not emit sound energy in the water, lack the potential to acoustically affect the environment.
2. Active sonars generate and emit acoustic energy specifically for the purpose of obtaining information concerning a distant object from the received and processed reflected sound energy. These sonars may produce high-frequency, mid-frequency, or low-frequency active sonar (although the U.S Navy does not currently employ low-frequency active sonar systems on the Southern California Training Range)

The simplest active sonars emit omnidirectional pulses or “pings” and calculate the length of time the reflected echoes return from the target object to determine the distance between the sonar source and a target. More sophisticated active sonar emits an omnidirectional ping and then scans a steered receiving beam to calculate the direction and distance of a target. More advanced sonars transmit multiple preformed beams, listening to echoes from several directions simultaneously and providing efficient detection of both direction and range. The types of sound sources that would be used in the anti-submarine warfare exercises discussed in the preceding narratives include:

Sonar Systems Associated with Surface Ships. A variety of surface ships participate in Navy training exercises, including guided missile cruisers, destroyers, guided missile destroyers, and frigates. Some ships (e.g., aircraft carriers) do not have any onboard active sonar systems, other than fathometers. Others, like guided missile cruisers, are equipped with active as well as passive sonars for submarine detection and tracking. For purposes of the analyses in this consultation, the primary surface ship sonars considered are AN/SQS-53 and its variants with a nominal source level of 235 decibels (dB_{rms}) re 1 μPa at 1 m[1] and AN/SQS-56 having a nominal source level of 225 dB.

Sonar Systems Associated with Submarines. Submarines are equipped with a variety of active and passive sonar systems (for the purposes of this assessment, these primarily represent the mid-frequency AN/BQQ-10

[1] All decibels cited in this document use the same reference unless noted otherwise

sonar and the high-frequency AN/BQQ-15 sonar) that they use to detect and target enemy submarines and surface ships. However, submarines rarely use active sonars and, when they do, sonar pulses are very short.

Sonar Systems Associated with Aircraft. Aircraft sonar systems that typically operate during Navy training exercises include sonobuoys and dipping sonar. Current dipping sonar systems used by the Navy are either AN/SQS-22 or AN/AQS -13. AN/AQS -13 is an older and less powerful dipping sonar system (maximum source level 216 dB re µPa-s^2 at 1m) than the AN/AQS -22 (maximum source level 217 dB re µPa-s^2 at 1m). In its modeling, the Navy assumed that all dipping sonar were AN/AQS -22. Maritime patrol aircraft (P-3s or P-8s) may deploy sonobuoys while helicopters may deploy sonobuoys or dipping sonars (the latter are used by carrier-based helicopters).

Sonobuoys are expendable devices used by aircraft for the detection of underwater acoustic energy and for conducting vertical water column temperature measurements. Dipping sonar is an active or passive sonar device lowered on cable by helicopters to detect or maintain contact with underwater targets. In addition, the U.S. Navy employs tonal sonobuoys (DICASS, AN/SSQ-62) and the Extended Echo Ranging, Improved Extended Echo Ranging, and Advanced Extended Echo Ranging (EER/IEER/AEER) Systems discussed earlier.

Torpedoes. Torpedoes (primarily MK-46 and MK-48) are the primary anti-submarine warfare weapon used by surface ships, aircraft, and submarines. The guidance systems of these weapons can be autonomous or electronically controlled from the launching platform through an attached wire. The autonomous guidance systems are acoustically based. They operate either passively, exploiting the emitted sound energy by the target, or actively ensonifying the target and using the received echoes for guidance.

Acoustic Device Countermeasures. These countermeasures (which include the AN/SLQ-25 NIXIE) act as decoys by making sounds that simulate submarines to avert localization or torpedo attacks.

Training Targets. Anti-submarine warfare training targets are used to simulate target submarines. They are equipped with one or a combination of the following devices: (1) acoustic projectors emanating sounds to simulate submarine acoustic signatures; (2) echo repeaters to simulate the characteristics of the echo of a particular sonar signal reflected from a specific type of submarine; and (3) magnetic sources to trigger magnetic detectors.

Range Sources. Range pingers are active acoustic devices that allow each of the in-water platforms on the range (e.g., ships, submarines, target simulators, and exercise torpedoes) to be tracked by hydrophones in the range transducer nodes. In addition to passively tracking the pinger signal from each range participant, the range transducer nodes also are capable of transmitting acoustic signals for a limited set of functions. These functions include submarine warning signals, acoustic commands to submarine target simulators (acoustic command link), and occasional voice or data communications (received by participating ships and submarines on range).

1.2 Mitigation Measures Proposed by the U.S. Navy

As required to satisfy the requirements of the Marine Mammal Protection Act of 1972, as amended, the U.S. Navy 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 and the Permits Division's proposed rule (73 Federal Register 60836):

1.0 *Measures Applicable to Hull-Mounted Surface and Submarine Active Sonar*.

1.1 Personnel Training

1.1.1 All lookouts onboard platforms involved in ASW training events will review the NMFS approved MSAT material prior to MFA sonar use.

1.1.2 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 MFA sonar.

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

1.1.4 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 preclude personnel being trained as lookouts from being counted as those listed in previous measures so long as supervisors monitor their progress and performance.

1.1.5 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 protective measures if marine species are spotted.

1.2 Lookout and Watchstander Responsibilities

1.2.1 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.

1.2.2 In addition to the three personnel on watch noted previously, all surface ships participating in ASW exercises will have at all times during the exercise at least two additional personnel on watch as lookouts.

1.2.3 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.

1.2.4 On surface vessels equipped with MFA 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.

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

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

1.2.7 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.

1.3 Operating procedures

1.3.1 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 protective measures.

1.3.2 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.

1.3.3 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.

1.3.4 During MFA sonar training activities, personnel will utilize all available sensor and optical systems (such as night vision devices) to aid in the detection of marine mammals.

1.3.4 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.

1.3.5 Aircraft with deployed sonobuoys will use only the passive capability of sonobuoys when marine mammals are detected within 200 yards of the sonobuoy.

1.3.6 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.

1.3.7 Safety Zones—When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically), the Navy will ensure that MFA transmission levels are limited to at least 6 decibels (dB) below normal operating levels if any detected animals are within 1,000 yards of the sonar dome (the bow)

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

(ii) The Navy will ensure that MFA sonar transmissions will be limited to at least 10 dB below the equipment's normal operating level if any detected animals are within 500 yards of the sonar dome. Ships and submarines will continue to limit maximum ping levels by this 10-dB factor until the marine mammal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yards beyond the location of the last detection.

(iii) The Navy will ensure that MFA sonar transmissions will cease if any detected animals are within 200 yards of the sonar dome. MFA 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 yards beyond the location of the last detection.

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

(v) If the need for MFA sonar power-down should arise as detailed in “Safety Zones” above, the ship or submarine shall follow the requirements as though they were operating MFA sonar 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 the MFA sonar was being operated).

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

1.3.9 MFA sonar levels (generally)—the ship or submarine will operate MFA sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet tactical training objectives.

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

1.3.11 Helicopters shall not dip their sonar within 200 yards of a marine mammal and shall cease pinging if a marine mammal closes within 200 yards after pinging has begun.

1.3.12 Submarine sonar operators will review detection indicators of close-aboard marine mammals prior to the commencement of ASW events involving MFA sonar.

1.3.13 Increased vigilance during major ASW training with tactical MFA sonar when critical conditions are present.

Based on lessons learned from strandings in the Bahamas (2000), Madeira (2000), the Canaries (2002), and Spain (2006), beaked whales are of particular concern since they have been associated with MFA sonar training activities. The Navy should avoid planning major ASW training with MFA sonar in areas where they will encounter conditions that, in their aggregate, may contribute to a marine mammal stranding event.

The conditions to be considered during exercise planning include:

(i) Areas of at least 1,000-meter (m) depth near a shoreline where there is a *rapid change in bathymetry* on the order of 1,000 m to 6,000 m occurring across a relatively short horizontal distance (e.g., 5 nautical miles [nm]).

(ii) Cases for which *multiple ships or submarines* (≥ 3) operating MFA sonar in the same area over extended periods of time (≥ 6 hours) in close proximity (≤ 10 nm apart).

(iii) An area surrounded by *land masses, separated by less than 35 nm and at least 10 nm in length*, or an *embayment*, wherein events involving multiple ships/subs (≥ 3) employing MFA sonar near land may produce sound directed toward the channel or embayment that may cut off the lines of egress for marine mammals.

(iv) Although not as dominant a condition as bathymetric features, the historical presence of a *strong surface duct* (i.e., a mixed layer of constant water temperature extending from the sea surface to 100 or more feet).

If the Major Exercise must 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 protective measure:

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 MFA 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, any stranded animals) shall be reported to the Officer in Tactical Command, who should give consideration to delaying, suspending, or altering the exercise.

All safety zone power-down requirements described in Measure 1.3.7 apply. The post-exercise report must include specific reference to any event conducted in areas where the above conditions exist, with exact location and time/duration of the event, and noting results of surveys conducted.

3.0 *Mitigation Associated with Surface-to-Surface Gunnery (up to 5-in. explosive rounds)*

- Lookouts will visually survey for floating weeds and kelp, and algal mats which may be inhabited by immature sea turtles in the target area. Intended impact shall not be within 600 yd (585 m) of known or observed floating weeds and kelp, and algal mats.
- A 600-yd radius buffer zone will be established around the intended target.
- From the intended firing position, 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.
- When manned, 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.
- 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.

4.0 *Mitigation Associated with Surface-to-Surface Gunnery (non-explosive rounds)*

- Lookouts will visually survey for floating weeds and kelp, and algal mats which may be inhabited by immature sea turtles in the target area. Intended impact will not be within 200 yd (183 m) of known or observed floating weeds and kelp, and algal mats.
- A 200-yd (183-m) radius buffer zone will be established around the intended target.
- From the intended firing position, 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.

- When manned, 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.
- 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.

5.0 *Mitigation Associated with Surface-to-Air Gunnery (explosive and nonexplosive rounds)*

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

6.0 *Mitigiation Associated with Air-to-Surface Gunnery (explosive and non-explosive rounds)*

- If surface vessels are involved, lookouts will visually survey for floating kelp, which may be inhabited by immature sea turtles, in the target area. Impact should not occur within 200 yd (183 m) of known or observed floating weeds and kelp or algal mats.
- A 200-yd (183-m) radius buffer zone will be established around the intended target.
- 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.
- 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 (152-456 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.
- The exercise will be conducted only if marine mammals and sea turtles are not visible within the buffer zone.

7.0 *Mitigation Associated with Small Arms Training (grenades, explosive and nonexplosive rounds)*

- 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.

8.0 *Mitigation Associated with Air-to-Surface At-Sea Bombing Exercises (explosive bombs and cluster munitions, rockets)*

- If surface vessels are involved, lookouts will survey for floating kelp, which may be inhabited by immature sea turtles. Ordnance shall not be targeted to impact within 1,000 yd (914 m) of known or observed floating kelp, sea turtles, or marine mammals.
- A buffer zone of 1,000-yd (914-m) radius will be established around the intended target.
- 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 (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.
- The exercises will be conducted only if marine mammals and sea turtles are not visible within the buffer zone.

9.0 *Mitigation Associated with Air-to-Surface At-Sea Bombing Exercises (nonexplosive bombs and cluster munitions, rockets)*

- If surface vessels are involved, 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.
- A 1,000-yd (914-m) radius buffer zone will be established around the intended target.
- 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 (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 the most effective search tactics and capabilities.
- The exercise will be conducted only if marine mammals and sea turtles are not visible within the buffer zone.

10.0 *Mitigation Associated with Air-to-Surface Missile Exercises (explosive and non-explosive)*

- Ordnance shall not be targeted to impact within 1,800 yd (1646 m) of known or observed floating kelp, which may be inhabited by immature sea turtles.
- 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) or lower, if safe to do so, and at slowest safe speed. Firing or range clearance aircraft must be able to actually see ordnance impact areas. Explosive ordnance shall not be targeted to impact within 1,800 yd (1646 m) of sighted marine mammals and sea turtles.

11.0 *Underwater Detonations (up to 20-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 TTS or PTS during Major Exercises.

11.1 *Exclusion Zones*

All Mine Warfare and Mine Countermeasures Training activities 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 shall extend in a 700-yd arc radius around the detonation site.

12.0 *Measures Applicable to Mine Laying*.

Mine Laying involves aerial drops of inert training shapes on target points. Aircrews are scored for their ability to accurately hit the target points. This training activity does not involve live ordnance. The probability of a marine species being in the exact spot in the ocean where an inert object is dropped is remote. However, as a conservative measure, initial target points will be briefly surveyed prior to inert ordnance release from an aircraft to ensure the intended drop area is clear of marine mammals and sea turtles. To the extent feasible, the Navy shall retrieve inert mine shapes dropped during Mine Laying.

13.0 *Measures Applicable to Sinking Exercise*

The selection of sites suitable for Sinking Exercises involves a balance of operational suitability, requirements established under the Marine Protection, Research, and Sanctuaries Act (MPRSA) permit granted to the Navy (40 C.F.R. § 229.2), and the identification of areas with a low likelihood of encountering marine mammals. 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 nonmilitary air or watercraft. The MPRSA permit requires vessels to be sunk in waters which are at least 1,000 fathoms (6,000 ft) deep and at least 50 nm from land. In general, most marine mammals 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.

13.1 *Sinking Exercise Range Clearance Plan*

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

- All weapons firing would be conducted during the period 1 hour after official sunrise to 30 minutes before official sunset.
- Extensive range clearance training activities would 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.
- An exclusion zone with a radius of 1.0 nm (1.85 km) would be established around each target. This exclusion zone is based on calculations using a 990-lb TNT net explosive weight high explosive source detonated 5 ft (1.5 m) below the surface of the water, which yields a distance of 0.85 nm

(1.57 km) (cold season) and 0.89 nm (1.64 km) (warm season) beyond which the received level is below the 182-dB re: 1 micropascal squared seconds (μPa2-s) threshold established for the WINSTON S CHURCHILL (DDG-81) shock trials (U.S. Navy, 2001). An additional buffer of 0.5 nm (0.93 km) would be added to account for errors, target drift, and animal movements. Additionally, a safety zone, which extends from the exclusion zone at 1.0 nm (1.85 km) out an additional 0.5 nm (0.93 km), would be surveyed. Together, the zones extend out 2 nm (3.7 km) from the target.

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

    - Overflights within the exclusion zone would 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.

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

    - In addition to the overflights, the exclusion zone would 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 would 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.

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

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

    - If a marine mammal is observed within the exclusion zone is diving, firing would 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.

- o During breaks in the exercise of 30 minutes or more, the exclusion zone would again be surveyed for any marine mammal. If marine mammals are sighted within the exclusion zone, the OCE would be notified, and the procedure described above would be followed.
- o Upon sinking of the vessel, a final surveillance of the exclusion zone would be monitored for 2 hours, or until sunset, to verify that no marine mammals were harmed.

- Aerial surveillance would 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 would be used. These aircraft would 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.
- Every attempt would 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 would be increased within the zones. This would be accomplished through the use of an additional aircraft, if available, and conducting tight search patterns.
- The exercise would not be conducted unless the exclusion zone could be adequately monitored visually.
- In the event that any marine mammals are observed to be harmed in the area, a detailed description of the animal would be taken, the location noted, and if possible, photos taken. This information would be provided to National Oceanographic and Atmospheric Administration (NOAA) Fisheries via the Navy's regional environmental coordinator for purposes of identification.
- 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 would be submitted to NOAA Fisheries.

14.0 *San Clemente Island Very Shallow Water Underwater Detonations Mitigation Measures*

- For each exercise, a safety-boat with an observer is launched 30 or more minutes prior to detonation and moves through the area around the detonation site. The task of the safety observer is to augment a shore observer's visual search of the mitigation zone for marine mammals and turtles. The safety-boat observer is in constant radio communication with the exercise coordinator and shore observer.
- At least 10 minutes prior to the planned initiation of the detonation event-sequence, the shore observer, on an elevated on-shore position, begins a continuous visual search with binoculars of the mitigation zone. At this time, the safety-boat observer informs the shore observer if any marine mammal or turtle has been seen in the zone and, together, both search the surface within and beyond the mitigation zone for marine mammals and turtles.

- The shore observer will indicate that the area is clear of animals after 10 or more minutes of continuous observation with no marine mammals or turtles having been seen in the mitigation zone or moving toward it.
- The observer will indicate that the area is not clear of animals any time a marine mammal or turtle is sighted in the mitigation zone or moving toward it and, subsequently, indicate that the area is clear of animals when the animal is out and moving away and no others have been sited.
- Initiation of the detonation sequence will only begin on receipt of an indication from the shore observer that the area is clear of animals and will be postponed on receipt of an indication from that observer that the area is not clear of animals.
- Following the detonation, visual monitoring of the mitigation zone continues for 30 minutes for the appearance of any marine mammal or turtle in the zone. Any marine mammal or sea turtle appearing in the area will be observed for signs of possible injury. Possibly injured marine mammals or turtles are reported to the Commander, Naval Region Southwest Environmental Director and the San Diego Detachment office of Commander, Pacific Fleet.

15.0 *Mitigation measures associated with events using EER/IEER/AEER Sonobuoys*

a. AN/SSQ-110A Pattern Deployment:

- Crews will conduct visual reconnaissance of the drop area prior to laying their intended sonobuoy pattern. This search should be conducted below 1500 feet (ft) at a slow speed when operationally feasible and weather conditions permit. In dual aircraft training activities, crews may conduct coordinated area clearances.
- 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.
- For any part of the briefed pattern where a post will be deployed within 1000 yards (yds) of observed marine mammal activity, crews will deploy the receiver ONLY and monitor while conducting a visual search. When marine mammals are no longer detected within 1000 yds of the intended post position, crews will collocate the AN/SSQ-110A sonobuoy (source) with the receiver.
- When operationally feasible, crews 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.

b. AN/SSQ-110A Pattern Employment:

(i) Aural Detection:

- Aural detection of marine mammals cues the aircrew to increase the diligence of their visual surveillance.

- If, following aural detection, no marine mammals are visually detected, then the crew may continue multi-static active search.

(ii) Visual Detection:

- If marine mammals are visually detected within 1000 yds (914 m) 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 1,000 yds (914 m) safety buffer. Aircrews may shift their multi-static active search to another post, where marine mammals are outside the 1,000 yds (914 m) safety buffer.
- Aircrews may shift their multi-static active search to another post, where marine mammals are outside the 1000 yd safety zone.

c. AN/SSQ-110A Scuttling Sonobuoys:

(i) Aircrews shall make every attempt to manually detonate the unexploded charges at each post in the pattern prior to departing the training activities 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 a 1000 yd safety zone, visually clear of marine mammals, is maintained around each post as is done during active search training activities.

(ii) 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 method or tertiary method.

- Aircrews ensure all payloads are accounted for. Sonobuoys that cannot be scuttled shall be reported as unexploded ordnance via voice communications while airborne and, upon landing, via Naval message.

Mammal monitoring shall continue until out of their aircraft sensor range.

1.3 Scope of the MMPA Regulations and Proposed Letter of Authorization

On 10 November 2010, NMFS’ Permits Division finalized regulations (50 CFR 216.270 *et seq.*) that authorize the U.S. Navy to “take” marine mammals (a) within the U.S. Navy’s Southern California Range Complex, which extends southwest from southern California in an approximately 700 by 200 nautical mile rectangle with the seaward corners at 27^{o}30’00” North latitude; 127^{o}10’04” West longitude and 24^{o}00’01” North latitude; 125^{o}00’03” West longitude and (b) incidental to the following activities within the following designated amounts of use over the 12-month duration of the proposed Letter of Authorization:

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

i. AN/SQS-53 (hull-mounted sonar) – 1977 hours

ii. AN/SQS-56 (hull-mounted sonar) – 494 hours

iii. AN/BQQ-10 (submarine mounted sonar) – 815 hours

iv. AN/BQS-15 (submarine navigational sonar) – 122 hours

v. AN/AQS-22 (helicopter dipping sonar) – 2719 dips

vi. SSQ-62 (sonobuoys) – 4256 sonobuoys

vii. SSQ-125 (AEER sonobuoy) – 1150 sonobuoys

viii. MK-48 (heavyweight torpedoes) – 87 torpedo events

ix. MK-46 (lightweight torpedoes) – 84 torpedo events

x. AN/SLQ-25A (NIXIE) – 1600 hours.

2 The detonation of the following underwater explosives as part of the training events indicated in item (2)(ii):

i Underwater Explosives:

(A) 5” Naval Gunfire (9.5 lbs)

(B) 76 mm rounds (1.6 lbs)

(C) Maverick (78.5 lbs)

(D) Harpoon (448 lbs)

(E) MK-82 (238 lbs)

(F) MK-83 (574 lbs)

(G) MK-84 (945 lbs)

(H) MK-48 (851 lbs)

(I) Demolition Charges (20 lbs.)

(I) AN/SSQ-110A (EER/IEER explosive sonobuoy – 5 lbs)

ii Training Events:

(A) Surface-to-surface Gunnery Exercises – 402 exercises

(B) Air-to-surface Missile Exercises – 50 exercises

(C) Bombing Exercises – 40 exercises

(D) Sinking Exercises – 2 exercises

(E) Extended Echo Ranging and Improved Extended Echo Ranging Systems – 462 IEER sonobuoy deployments (30 exercises, total, of EER/IEER and AEER combined).

No person in connection with the activities described in the proposed regulations may:

1. “Take” any marine mammals that are not specifically identified in the regulations;
2. “Take” any of the marine mammals identified in the regulations other than by incidental take;
3. “Take” a marine mammal identified in the regulations if such taking results in more than a negligible impact on the species or stocks of such marine mammal; or
4. Violate, or fail to comply with, the terms, conditions, and requirements of the regulations or future Letters of Authorization issued under the regulations.

1.4 Mitigation Requirements Proposed by NMFS’ Permits Division

When the U.S. Navy conducts the training activities on the Southern California Range Complex, as described in the relevant regulations, the LOA NMFS’ Permits Division proposes to issue 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 mid-frequency 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) Floating weeds and kelp, algal mats, clusters of seabirds, and jellyfish are good indicators of marine mammal presence. Therefore, where these circumstances exist, the Navy shall exercise increased vigilance in watching for marine mammals.

(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 1,000 yards (914 m) of the sonar dome (the bow).

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

(2) When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) the Navy shall ensure that sonar transmission levels are limited to at least 10 dB below normal operating levels if any detected marine mammals are within 500 yards (457 m) of the sonar dome (the bow). Ships and submarines shall continue to limit maximum ping levels by this 10-dB factor until the animal has been seen to leave the 500-yd safety zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yds (1,829 m) beyond the location of the last detection.

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

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

(5) If the need for power-down should arise as detailed in “Safety Zones” above, the Navy shall follow the requirements as though they were operating at 235 dB – the normal operating level (i.e., the first power-

down will be to 229 dB, regardless of what level above 235 dB active sonar was being operated).

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

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

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

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

(A) Lookouts shall visually survey for floating weeds and kelp. Intended impact (i.e., where the Navy is aiming) shall not be within 600 yds (585 m) of known or observed floating weeds and kelp, and algal mats.

(B) For exercises using targets towed by a vessel or aircraft, target-towing vessels/aircraft shall maintain a trained Lookout for marine mammals, if applicable. If a marine mammal is sighted in the vicinity, the tow aircraft/vessel shall immediately notify the firing vessel, which shall suspend the exercise until the area is clear.

(C) A 600-yd radius buffer zone shall be established around the intended target.

(D) 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.

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

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

(A) Lookouts shall visually survey for floating weeds and kelp, and algal mats. Intended impact will not be within 200 yds (183 m) of known or observed floating weeds and kelp, and algal mats.

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

(C) 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.

(D) 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.

(E) 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.

(iii) 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 expedite the recovery of any parachute deploying aerial targets to reduce the potential for entanglement of marine mammals.

(C) Target towing aircraft shall maintain a Lookout, if applicable. 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.

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

(A) If surface vessels are involved, Lookouts will visually survey for floating kelp in the target area. Impact shall not occur within 200 yds (183 m) of known or observed floating weeds and kelp or algal mats.

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

(C) If surface vessels are involved, Lookout(s) shall visually survey the buffer zone for marine mammals prior to and during the exercise.

(D) Aerial surveillance of the buffer zone for marine mammals shall be conducted prior to commencement of the exercise. Aircraft crew/pilot shall maintain visual watch during exercises. Release of ordnance through cloud cover is prohibited: aircraft must be able to actually see ordnance impact areas.

(E) The exercise shall be conducted only if marine mammals and are not visible within the buffer zone.

(v) Small Arms Training (grenades, explosive and non-explosive rounds) – Lookouts will visually survey for floating weeds or kelp, algal mats, and marine mammals. Weapons shall not be fired in the direction of known or observed floating weeds or kelp, algal mats, or marine mammals.

(vi) 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 (457 m) or lower, if safe to do so, and at the slowest safe speed. Release of ordnance through cloud cover is prohibited; aircraft must be able to actually see ordnance impact areas. Survey aircraft should employ most effective search tactics and capabilities.

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

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

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

(B) Aircraft shall visually survey the target area for marine mammals. Visual inspection of the target area shall be made by flying at 1,500 (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 (1,646 m) of sighted marine mammals.

(viii) Demolitions, Mine Warfare, and Mine Countermeasures (up to a 20-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-yd 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 (see Stranding Plan for details).

(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 (2.41 km) shall be established around each target. This 1.5 nm (2.41 km) zone includes a buffer of 0.5 nm (0.93 km) to account for errors, target drift, and animal movement. In addition to the 1.5 nm (2.41 km) exclusion zone, a further safety zone, which extends from the exclusion zone at 1.5 nm (2.41 km) out an additional 0.5 nm (0.93 km), shall be surveyed. Together, the zones (exclusion and safety) extend out 2 nm (3.7 km) 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 protected species 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 harmed.

(D) Aerial surveillance shall 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 would be used. These aircraft would 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.

(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 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 500 yds (457 m) 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 1,000 yds (914 m) of observed marine mammal activity, the Navy shall deploy the receiver ONLY (i.e., not the source) and monitor while conducting a visual search. When marine mammals are no longer detected within 1,000 yds (914 m) of the intended post position, the source sonobuoy (AN/SSQ-110A/SSQ-125) will be co-located with the receiver.

(D) When operationally feasible, Navy crews shall conduct continuous visual and aural monitoring of marine mammal activity. This shall include monitoring of 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 1,000 yds (914 m) 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 1,000 yds (914 m) safety buffer. Aircrews may shift their multi-static active search to another post, where marine mammals are outside the 1,000 yds (914 m) safety buffer.

(G) For IEER (AN/SSQ-110A), aircrews shall make every attempt to manually detonate the unexploded charges at each post in the pattern prior to departing the operations area by using the “Payload 1 Release” command followed by the “Payload 2 Release” command. Aircrews shall refrain from using the “Scuttle” command when two payloads remain at a given post. Aircrews will ensure that a 1,000-yd (914 m) safety buffer, visually clear of marine mammals, is maintained around each post as is done during active search operations.

(H) Aircrews shall only leave posts with unexploded charges in the event of a sonobuoy malfunction, an aircraft system malfunction, or when an aircraft must immediately depart the area due to issues such as fuel constraints, inclement weather, 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 cannot 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.

4 The Navy shall abide by the letter of the “Stranding Response Plan for Major Navy Training Exercises in the SOCAL Range Complex” (attached here), to include the following measures:

(i) Shutdown Procedures – When an Uncommon Stranding Event (USE – as defined in 50 CFR § 216.271 and Attachment A) occurs during a Major Training Exercise (MTE) (Sustainment, SHAREM, IAC2, JTFEX, or COMPTUEX) in the SOCAL Range Complex, the Navy shall implement the procedures described below.

(A) The Navy shall implement a Shutdown (as defined 50 CFR § 216.274) when advised by a NMFS Office of Protected Resources Headquarters Senior Official designated in the SOCAL Range Complex Stranding Communication Protocol of the need to implement shutdown procedures because a USE involving live animals has been identified and that at least one live animal is located in the water. NMFS and Navy shall communicate, as needed, regarding the identification of the USE and the potential need to implement shutdown procedures.

(B) Any shutdown in a given area shall remain in effect in that area until NMFS advises the Navy that the subject(s) of the USE at that area die or are euthanized, or that all live animals involved in the USE at that area have left the area (either of their own volition or herded).

(C) If the Navy finds an injured or dead marine mammal floating at sea during an MTE, the Navy shall notify NMFS immediately or as soon as operational security considerations allow. 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(s) is/are dead), location, time of first discovery, observed behaviors (if alive), and photo or video (if available). Based on the information provided, NMFS shall determine if, and advise the Navy whether a modified shutdown is appropriate on a case-by-case basis.

(D) In the event, following a USE, that: a) qualified individuals are attempting to herd animals back out to the open ocean and animals are not willing to leave, or b) animals are seen repeatedly heading for the open ocean but turning back to shore, NMFS and the Navy shall coordinate (including an investigation of other potential anthropogenic stressors in the area) to determine if the proximity of MFAS/HFAS activities or explosive detonations, though farther than 14 nm from the distressed animal(s), is likely decreasing the likelihood that the animals return to the open water. If so, NMFS and the Navy shall further coordinate to determine what measures are necessary to further minimize that likelihood and implement those measures as appropriate.

(ii) Within 72 hours of NMFS notifying the Navy of the presence of a USE, the Navy shall provide available information to NMFS (per the SOCAL Range Complex Communication Protocol) regarding the location, number and types of acoustic/explosive sources, direction and speed of units using MFAS/HFAS, and marine mammal sightings information associated with training activities occurring within 80 nm (148 km) and 72 hours prior to the USE event. Information not initially available regarding the 80 nm (148 km), 72 hours, period prior to the event shall be provided as soon as it becomes available. The Navy shall provide NMFS investigative teams with additional relevant unclassified information as requested, if available.

Monitoring and Reporting – When conducting operations identified in 50 CFR § 216.270(c) and Condition 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) As outlined in the SOCAL Range Complex Stranding Communication Plan, the Navy must notify NMFS immediately (or as soon as clearance procedures allow) if the specified activity identified in 50 CFR § 216.270(c) and Condition 4 is thought to have resulted in the mortality or injury of any marine mammals, or in any take of marine mammals not identified in 50 CFR § 216.272(c) and Condition 5.

(b) The Navy shall implement the SOCAL Range Complex Monitoring Plan.

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

(d) General 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 training exercise utilizing MFAS, HFAS, or underwater explosive detonations. 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). The Navy shall consult the Stranding Response Plan to obtain more specific reporting requirements for specific circumstances.

(e) Annual SOCAL Range Complex Monitoring Plan Report – The Navy shall submit an annual report on October 1, 2011 describing the implementation and results (through August 1 of the same year) of the SOCAL Range Complex Monitoring Plan. The report will also include any analysis conducted or conclusions reached based on the previous years' data that were not completed in time for the previous years monitoring report. 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 SOCAL Range Complex Monitoring Plan shall, at a minimum, provide the same marine mammal observation data required in 50 CFR § 216.275(f)(1). The SOCAL Range Complex Monitoring Plan Report may be provided to NMFS within a larger report that includes the required Monitoring Plan Reports from multiple Range Complexes.

(f) Annual SOCAL Range Complex Exercise Report – The Navy shall submit an Annual SOCAL Range Complex Exercise Report on October 1, 2011 (covering data gathered through August 1, 2011). This report shall contain information identified in 50 CFR § 216.275(f)(1) through (5).

(1) MFAS/HFAS Major Training Exercises – This section shall contain the following information for Integrated, Coordinated, and Major Training Exercises (MTEs), which include Ship ASW Readiness and Evaluation Measuring (SHAREM), Sustainment Exercises, Integrated ASW Course Phase II (IAC2), Composite Training Unit Exercises (COMPTUEX), and Joint Task Force Exercises (JTFEX) conducted in the SOCAL Range Complex:

(i) Exercise Information (for each MTE):

(A) Exercise designator

(B) Date that exercise began and ended

(C) Location

(D) Number and types of active sources used in the exercise

(E) Number and types of passive acoustic sources used in exercise

(F) Number and types of vessels, aircraft, etc., participating in exercise

(G) Total hours of observation by watchstanders

(H) Total hours of all active sonar source operation

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

(J) Wave height (high, low, and average during exercise)

(ii) Individual marine mammal sighting info (for each sighting in each MTE)

(A) Location of sighting

(B) Species (if not possible – indication of whale/dolphin/pinniped)

(C) Number of individuals

(D) Calves observed (y/n)

(E) Initial Detection Sensor

(F) Indication of specific type of platform observation made from (including, for example, what type of surface vessel, i.e., FFG, DDG, or CG)

(G) Length of time observers maintained visual contact with marine mammal

(H) Wave height (in feet)

(I) Visibility

(J) Sonar source in use (y/n).

(K) Indication of whether animal is <200yd, 200-500yd, 500-1,000yd, 1,000-2,000yd, or >2,000yd from sonar source in 4(a)(1) above.

(L) Mitigation Implementation – Whether operation of sonar sensor was delayed, or sonar was powered or shut down, and how long the delay was.

(M) If source in use (J) is hull-mounted, true bearing of animal from ship, true direction of ship's travel, and estimation of animal's motion relative to ship (opening, closing, parallel)

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

(iii) An evaluation (based on data gathered during all of the MTEs) of the effectiveness of mitigation measures designed to avoid exposing marine mammals to mid-frequency sonar. This evaluation shall identify the specific observations that support any conclusions the Navy reaches about the effectiveness of the mitigation.

(2) ASW Summary – This section shall include the following information as summarized from both MTEs and 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 SOCAL Range Complex. The Navy shall include (in the SOCAL Range Complex annual report) a brief annual progress update on the status of the development of an effective and unclassified method to report this information until an agreed-upon (with NMFS) method has been developed and implemented.

(3) 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 (738 m for SINKEX in the SOCAL Range Complex); 2) the required exclusion zone (1 nm for SINKEX in the SOCAL Range Complex); (3) the required observation distance (if different than the exclusion zone (2 nm (3.7 km) for SINKEX in the SOCAL Range Complex); and (4) greater than the required observed distance. For example, in this case, the observer would indicate if <738 m, from 738 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.

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

(i) Total number of IEER events conducted in the SOCAL Range Complex

(ii) Total expended/detonated rounds (buoys)

(iii) Total number of self-scuttled IEER rounds

(5) 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 SOCAL Range Complex.

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

(g) Sonar Exercise Notification – The Navy shall submit to the NMFS Office of Protected Resources (specific contact information to be provided in LOA) either an electronic (preferably) or verbal report within fifteen calendar days after the completion of any MTE (Sustainment, IAC2, SHAREM, COMPTUEX, or JTFEX) indicating:

(1) Location of the exercise

(2) Beginning and end dates of the exercise

(3) Type of exercise (e.g., SHAREM, JTFEX, etc.)

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

(i) Comprehensive National ASW Report – By June, 2014, the Navy shall submit a draft National Report that analyzes, compares, and summarizes the active sonar data gathered (through January 1, 2014) from the watchstanders and pursuant to the implementation of the Monitoring Plans for the SOCAL Range Complex, the Atlantic Fleet Active Sonar Training, the HRC, the Marianas Range Complex, the Northwest Training Range, and the Gulf of Alaska.

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

(k) 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[2] 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 that comprise them, the viability (that is, the probability of extinction or probability of persistence) of listed

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[2] 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 scientific and commercial data available" in a subsequent subsection titled "Evidence Available for the Consultation"

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 individuals 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 2000, Brommer *et al*. 1998, 2002; Clutton-Brock 1998, Coulson *et al*. 2006, Kotiaho *et al*. 2005, McGraw and Caswell 1996, Newton and Rothery 1997, Oli and Dobson 2003, 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 or experience reductions in the rates at which they grow, mature, or become reproductively active, we would expect those reductions to also reduce the abundance, reproduction rates, and 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 responses 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[3]. 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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[3] 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

NMFS initially identified several aspects of the training exercises the U.S. Navy plans to undertake on the Southern California Range Complex during the twelve-month period beginning in January 2011 that represent potential hazards to threatened or endangered species or critical habitat that has been designated for them:

1. ships and ship traffic associated with an exercise;
2. active sonar systems that would be employed during an exercise;
3. underwater detonations associated with an exercise;
4. aircraft operations that occur during an exercise,
5. amphibious landings, and
6. gunfire and missile exercises.

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.

We conducted independent analyses to estimate probable exposures of endangered and threatened species to vessel traffic associated with military readiness activities and some mid-frequency active sonar. We did not have the technical ability to develop our own exposure models for underwater detonations, some of the sonar systems that employ detonations, or sonar systems whose source levels and frequencies are classified.

For these systems, we used the "take" estimates the U.S. Navy included in its application for an MMPA Letter of Authorization for our exposure estimates. The narratives that follow describe how we approached our exposure and response analyses for vessel traffic and the active sonar systems we modeled.

Exposure to Navy Vessel Traffic

We did not estimate the number of 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 210 meters (689 feet or the distance at which received levels would be about 190 dB) of a Navy vessel moving at speeds greater than 14 knots would have probabilities of being struck that would be substantially greater than zero. That probability would increase as the distance between a whale and the ship decreased (that is, as the estimated received level increased).

At a distance of 210 meters and with a speed of about 14 knots, a ship's crew and a whale would have about 23 seconds to avoid a collision (assuming the ship was perpendicular to the whale and the whale was not moving).

Exposure to Mid-Frequency Active Sonar

Despite the numerous surveys that have been conducted in Southern California and reports from whale-watch vessels in these waters, there is almost no empirical information on the distribution and abundance of marine mammals relative to active sonar associated with Navy training exercises on the Southern California Range Complex. We do not know whether or to what degree the distribution or abundance of marine animals changes before, during, or after an exercise or whether those changes follow the same pattern or whether the pattern varies from species to species. As a result, we cannot rely on empirical observations to estimate the number of endangered or threatened marine animals that might be exposed to active sonar during the activities the U.S. Navy plans to conduct on the Southern California Range Complex over the twelve-month period beginning in January 2011. Instead, 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.) that try to estimate the number of marine animals that might be exposed to active sound sources in the marine environment rely on computer models, computer simulations, or some kind of mathematical algorithm to estimate the number of animals that might be exposed to a sound source. All of these approaches rely on assumptions that oversimplify the circumstances that determine whether marine animals are likely to be exposed to an area ensonified by active sonar in the marine environment, although the reasons for that oversimplification are understandable.

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.

We could meet both conditions for the Southern California Range Complex and, in our January 2009 programmatic biological opinion on the range complex, we considered and presented the results of two different approaches to estimate the number of whales that might interact with sound fields associated with mid-frequency active sonar on the Southern California Range Complex. In this Opinion, however, we only present the results of our exposure analyses.

Our exposure model estimates the number of times 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. We relied on published sources of information and information provided by the U.S. Navy (which itself relied on published sources) to estimate the density (D) of endangered and threatened marine mammals in waters off Southern California. Densities are usually reported as the mean number of animals per season or year; however, because U.S. Navy training does not occur continuously for a season or a year, we had to adjust densities estimates to match the time interval of the training activities. To do that, we treated estimated densities as the rate parameter of a Poisson distribution, then estimated the probability of 0, 1, 2, 3, …, n animals occurring in a small increment of time per square kilometer. By multiplying these probabilities by the duration of a particular kind of exercise, we estimated the number of individual animals that we would expect to occur in a square kilometer during that kind of exercise.

Consider an example in which we estimated that blue whales had a density of 0.000356778 whales per square kilometer per year in an area and we wanted to estimate the probability of encountering 0, 1, 2, 3,…n blue whales during a 98-hour exercise. Using their density (0.000356778 whales per square kilometer per year) as the rate parameter (λ) of a Poisson distribution we would expect a 0.9996 probability of encountering 0 blue whales per square kilometer in a 98-hours time interval, a 0.0004 probability of encountering 1 whale per square kilometer, and a 0.0000 probability of encountering more than 1 blue whale in a 98-hour time interval.

We then rely on a component of an ecological model developed by Holling (1959) to estimate the number of animals that might be exposed within an ensonified area (or A from the Buckland equation presented earlier). 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 (2*r*; 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) = $(\text{distance})^2$ or 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.

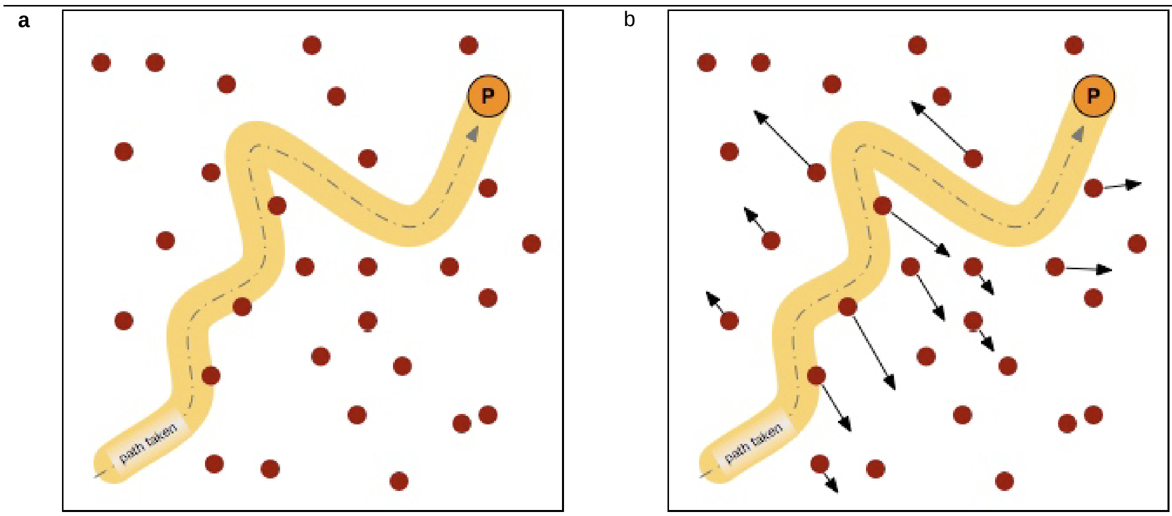

Figure 1. A representation of Hollings disc equation with a predator (denoted P) moving on a path (dashed line) through a field of potential prey (smaller circles). The thick orange line surrounding the predator's path represents the predator's sensory radius; increasing the size of this sensory radius 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.

NMFS adapted this component of the Holling's disc equation by treating Navy vessels as the "predators" in the model whose sensory field (2*r*, in square kilometers) represented the sound field of an active sonar system, whose 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 used the "detectability" of marine animals to capture the amount of time a marine mammal would spend at depths that overlap with 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, or the amount of time a pinniped might occur with its head underwater. This left us with the equation

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

With the adjustments to densities that we discussed earlier.

Our exposure model assumed ship speeds of 10 knots (or 18.25 kilometers per hour), which is the same assumption contained in the U.S. 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, which we adjusted to eliminate overlap. 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 (1) endangered or threatened species are likely to respond following exposure and the set of physical, physiological, behavioral, or social responses that are likely and (2) the quantity, quality, or availability of one or more of the physical or biological features that led us to conclude that the area was essential for the conservation of a particular listed species are likely to change in response to the exposure.

Conceptual Model for Response Analyses

To guide our response analyses, we constructed a conceptual model that is based on a model of animal behavior and behavioral decision-making and incorporates the cognitive processes involved in behavioral decisions (Figure 2) although we continue to recognize the risks presented by physical trauma and noise-induced losses in hearing sensitivity (threshold shift). Our conceptual model is also based on a conception of "hearing" that involves an animal's cognitive processing of auditory cues, rather than just mechanical processes of the ear and auditory nerve. As a result, our conceptual model recognizes that an animal's response — particularly its behavioral response — to an acoustic signal such as an active sonar ping will depend on much more than the decibel level perceived by an animal in the water column; it will depend on how the animal processes the signal, the behavior of the signal's source, the animal's behavioral state, its motivations, and other variables. Third, our 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).

This conceptual model begins with specific acoustic stimuli that we focus on in an assessment (Box 1 in Figure 2). Although we generally considered different acoustic stimuli separately, we considered a single source of multiple acoustic stimuli as an "acoustic object" that changed its acoustic signature over time[4]. For example, we treated pings produced by hull-mounted active sonar and sounds produced by the vessel to which the sonar was attached as a single "acoustic object" that produced continuous sounds (engine-noise, propeller cavitation, hull displacement, etc.) and periodic pings of active sonar. Because animals would be exposed to this complex of sounds produced by single, albeit moving, sources over time, we assumes the animals would generally respond to acoustic streams produced by individual acoustic objects moving through their environment (rather than to specific sounds produced by a ship, such as sonar ping or an underwater detonation). Multiple ships would represent different acoustic objects in the acoustic scene of endangered and threatened marine animals.

Acoustic stimuli can represent two different kinds of stressors: *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, acoustic stimuli like active sonar 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).

Our conceptual model explicitly recognizes that other acoustic and non-acoustic stimuli that occur in an animal's environment might determine whether a focal stimulus is salient to a focal animal (the line connecting Box 2b to Box 2 in Figure 2). The salience of an acoustic signal will depend, in part, on its signal-to-noise ratio and, given that signal-to-noise ratio, whether an animal will devote attentional resources to the signal or other acoustic stimuli (or ambient sounds) might compete for the animal's attention (the line connecting Box 2b to Box B1 in Figure 2)[5]. That is, an acoustic signal might not be salient (1) because of a signal-to-noise ratio or (2) because an animal does not devote attentional resources to the signal, despite its signal-to-noise ratio. Absent information to the contrary, we generally assume that an acoustic stimulus that is "close" to an animal (within 10 – 15 kilometers) would remain salient regardless of competing stimuli and would compete for an animal's attentional resources. By extension, we also assume that any behavioral change we might observe in an animal would have been caused by a focal

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[4] The concept of an "acoustic object" is derived from studies conducted by Alain and Arnott (2000) who recognized that animals perceive groups of sounds emanating from single acoustic sources.

[5] See Blumstein and Bouskila (1996) for a detailed review of the literature on how animals process and filter sensory information, which affects the subjective salience of sensory stimuli. See Clark and Dukas (2003), Dukas (1998, 2002, 2004), and Roitblat (1987) for more extensive reviews of the literature on attentional processes and the consequences of limited attentional resources in animals.

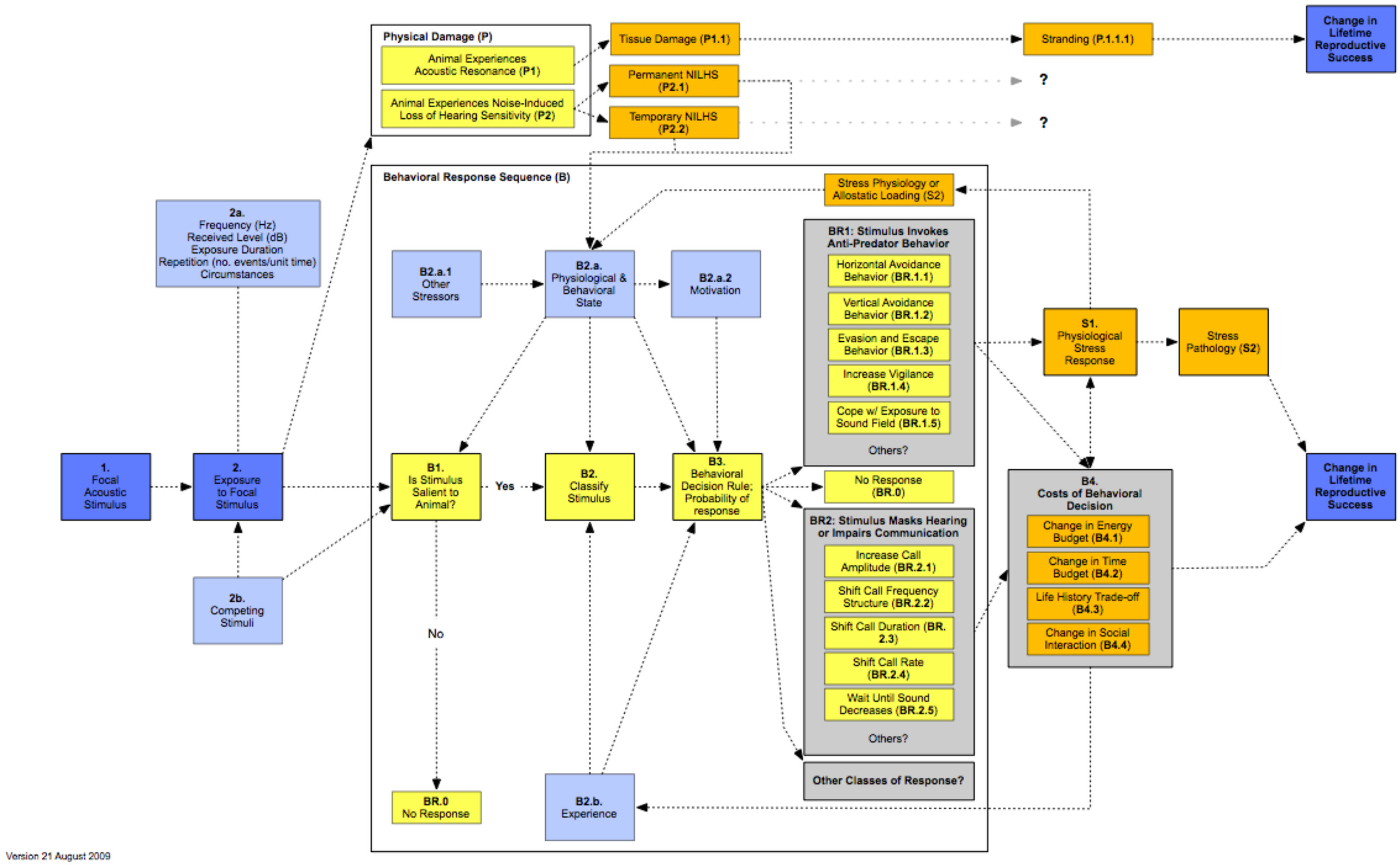

Figure 2. Conceptual model of the potential responses of endangered and threatened species upon being exposed to active sonar and the pathways by which those responses might affect the fitness of individual animals that have been exposed. See text in "Application of this Approach" and "Response Analyses"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

stimulus rather than competing stimuli.However, as the distance between the source of a specific acoustic signal and a receiving animal increases, we assume that the receiving animal is less likely to devote attentional resources to the signal.

If we conclude (or if we assume) that an acoustic stimulus, such as mid-frequency active sonar, was salient to an animal or population of animals, we would then ask how an animal might classify the stimulus as a cue about its environment (Box B2 in Figure 2) because an animal's response to a stimulus in its environment depends upon whether and how the animal converts the stimulus into 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).

By incorporating a more expansive concept of "hearing," our conceptual model departs from our earlier model and other models. Other conceptions of the sensory modality usually called "hearing" have focused on the mechanical processes associated with structures in the ear that transduce sound pressure waves into vibrations and vibrations to electro-chemical impulses. Those conceptions of hearing have produced assessments that focus almost exclusively on active sonar while discounting other acoustic stimuli associated with U.S. Navy training activities that marine animals might also perceive as relevant. A conception of hearing that focuses on mechanical processes has also led to a focus on the intensity of the sound ─ its received level (in decibels) ─ as the primary assessment metric and noise-induced hearing loss as an assessment endpoint.

Among other considerations, a focus on received level and losses in hearing sensitivity failed to recognize several other variables that affect how animals are likely to respond to acoustic stimuli:

1. "hearing" includes the cognitive 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.
2. animals can "decide" which acoustic cues they will focus on and their decision will reflect the salience of a cue, its spectral qualities, and the animal's physiological and behavioral state when exposed to the cue.
3. animals not only perceive the received level (in dB) of a sound source, they also perceive their distance from a sound source. Further, animals are more likely to devote attentional resources to sounds that are close than sounds that are distant, regardless of their ability to detect a sound.
4. both received levels and the spectral qualities of sounds degrade over distance so the sound perceived by a distant receiver is not the same sound at the source.

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, sounds produced by a source that is approaching them, sounds from multiple sources that are all approaching, 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 in its auditory field.

This process of “classifying a stimulus” (Box B2 in Figure 2) 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 in the circumstances. 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 in Figure 2). Our use of the term “behavioral decision rule” follows Blumstein and Bouskila (1996), Dill (1987), McFarland (1982), 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 assume that any change in behavioral state 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 in 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 circum-stances in which animals are regularly or chronically confronted with stress regimes that animals would adapt to by engaging in sub-optimal behavior, we assume that a change in behavior that resulted from exposure to a particular stressor or stress regime would either contribute to sub-optimal behavior or would cause animals to engage in behavior that is even further from optimal.

Method for Estimating the Probability of Particular Responses

We employed Bayesian inference for discrete random variables to estimate the probability of the proximate responses identified in our conceptual model (Figure 2) given an exposure event from the data that were available (see Bolstad 2007 for an introduction to Bayesian inference). We employed this method because it allowed us to work with all of the data that are available with a minimum number of assumptions and allows us to readily incorporate new data as it becomes available while providing transparency and analytical rigor. To satisfy the requirements of this method, our response analyses consisted of four steps:

Step A: Create a classification system that encompasses the entire suite of physical, physiological, and behavioral responses that have been reported in the literature (see Table 1).

Bayesian inference requires us to produce a set of variables that are exhaustive and mutually exclusive. To satisfy the first of these criteria, we conducted electronic and manual searches of the published and unpublished literature to identify reports of the physical, physiological, and behavioral responses of marine mammals, sea turtles, anadromous fish, and invertebrates when exposed to high-, mid-, and low-frequency anthropogenic acoustic stimuli. From each report, we recorded the different physical, physiological, behavioral, and social responses that were observed (Table 1, column 2). To satisfy the second of these criteria, we created a classification system that organized these responses into mutually-exclusive categories (see Table 1, column 3).

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

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

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

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

Table 1. 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 (eliminated in Step C described in text)
4	Noise-induced hearing loss (T)	Not used for formal analyses (eliminated in Step C described in text)
5	Reduced auditory field (reduced active space)	Not used for formal analyses (eliminated in Step C described in text)
6	Signal masking	Not used for formal analyses (eliminated in Step C described in text)
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

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

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

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

In this equation, $\Pr(R_i)$ on the right-hand side of the numerator, is called the *prior probability* of a response which is the probability of the different responses that we would have expected before we began our data

Table 2. An Illustration of the Bayesian model that was employed to estimate the probability of specific responses given exposure (in this example) to active sonar. This model assumed that every response was equally probable (uninformed prior probability) which is reflected in Column 4 of the Table.

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

analyses. We consider two prior probabilities in our analyses: (1) an uninformed prior, which assumed that responses in each of our response categories (Table 1, column 3) were equally probable, and (2) priors derived from the relative frequency of responses formally or informally reported in the literature, which includes notes, anecdotal reports (for example, reports from newspapers or posted on list servers), etc.

Table 2 illustrates our analyses. Our “data” (Column 3) represent the number of reports of the different categories of responses. Column 4 represents the “prior probabilities” of these data; because we initially assumed the responses are equally probable, these prior probabilities are recorded as 0.1111 (or, more precisely, 1/9). The last column in Table 2 represents the posterior probabilities or the probability that an animal exposed to active sonar (in this case) would exhibit a particular category of response.

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

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

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, integrate 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 an individual produces 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 our analyses of the effects of the proposed action on endangered species, threatened species, and critical habitat that has been designated for these species, we considered all lines of evidence available through published and unpublished sources that provide evidence of the potential effects of stressors produced by military readiness activites or the absence of such effects. Our January 2009 programmatic biological opinion summarizes the general approach we used to identify and appraise information that would be relevant for our analyses, which included electronic and manual searches using internet search engineers (for example, Google, Google Scholar, Yahoo, Bing) and dedicated bibliographic search engines (such as the Library of Congress' *First Search* and *Dissertation Abstracts* databases, SCOPUS, *Web of Science*, and Cambridge Abstract's *Aquatic Sciences and Fisheries Abstracts* database services).

Since we issued our January 2009 programmatic biological opinion, several relevant journal articles and reports have become available (Bejder et al. 2009, Di Iorio and 2010, Doyle *et al*. 2008, Kvadsheim *et al*. 2010, Palsson *et al*. 2009), a major international conference on the effects of noise on aquatic ecosystems occurred that revealed new insights into the effects of sound on aquatic ecosystems, and preliminary results of studies of the behavioral responses of marine mammals to active sonar that are being conducted on the Southern California Range Complex became available (B. Southall, personal communication, 2010, 2011). When information from these studies changed statements or conclusions we reached in our programmatic opinion, we present those results in this Opinion. Otherwise, this Opinion summarizes and relies upon the more extensive review of the information available that appears in the 2009 programmatic biological opinion.

For this consultation, we conducted additional searches using the search protocols we described in our January 2009 programmatic opinion. 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 that were not designed to control those variables. We ranked carefully-designed field experiments higher than computer simulations. Studies that were based on large sample sizes with small variances were generally ranked higher than studies with small sample sizes or large variances.

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

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 biological opinions consider "cumulative impacts" (in the NEPA sense of the term).

The U.S. Council on Environmental Quality defined "cumulative effects" (which we refer to as "cumulative impacts" to distinguish between NEPA and ESA uses of the same term) as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions" (40 CFR 1508.7). The effects analyses of biological opinions considered the "impacts" on listed species and designated critical habitat that result from the incremental impact of an action by identifying natural and anthropogenic stressors that affect endangered and threatened species throughout their range (the *Status of the Species*) and within an Action Area (the *Environmental Baseline*, which articulate the pre-existing *impacts* of activities that occur in an Action Area, including the past, contemporaneous, and future *impacts* of those activities). We assess the effects of a proposed action by adding their direct and indirect effects to the *impacts* of the activities we identify in an *Environmental Baseline* (50 CFR 402.02), in light of the impacts of the status of the listed species and designated critical habitat throughout their range; as a result, the results of our effects analyses are equivalent to those contained in the "cumulative impact" sections of NEPA documents.

2.5 Action Area

The action area for this biological opinion encompasses the marine, coastal, and terrestrial area contained within the Southern California Range Complex (see Figure 3). We assume that any of the proposed activities that are likely to occur landward of the mean higher high water line are addressed in separate section 7 consultations with the U.S. Fish and Wildlife Service.

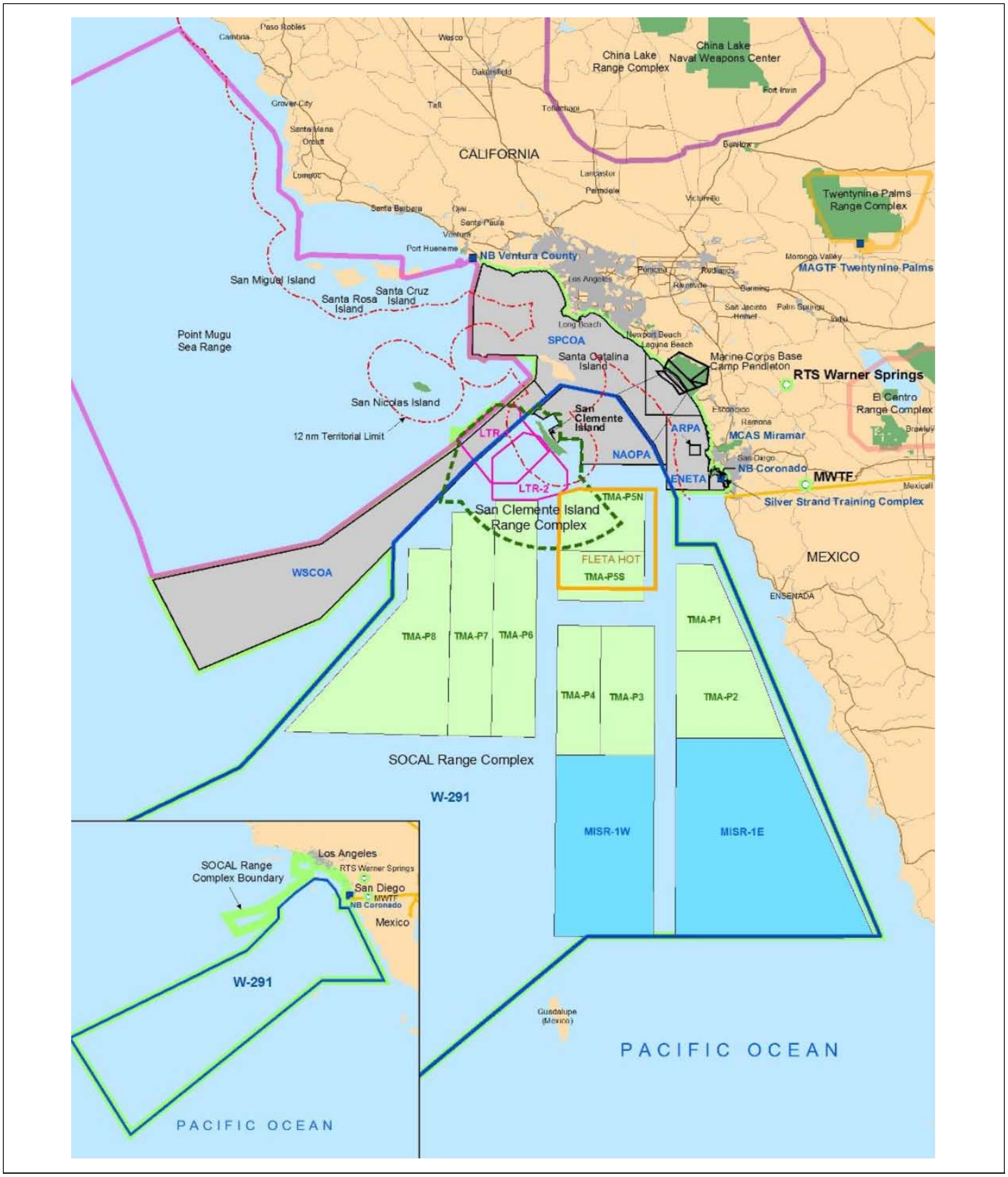

Figure 3. The Southern California Operating Area

3.0 Status of Listed Resources

NMFS has determined that the actions the U.S. Navy proposes to conduct on the Southern California Range Complex during the twelve-month period beginning in January 2011 may affect the following species provided protection under the ESA:

Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
Killer whale, Southern Resident	*Orcinus orca*	Endangered
North Pacific right whale	*Eubalaena japonica*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Steller sea lion, eastern population	*Eumetopias jubatus*	Threatened
Guadalupe fur seal	*Arctocephalus townsendii*	Threatened
Green sea turtle	*Chelonia mydas*	Threatened
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Loggerhead sea turtle	*Caretta caretta*	Endangered
Olive ridley sea turtle	*Lepidochelys olivacea*	Endangered
Green sturgeon, southern	*Acipenser medirostris*	Threatened
Chinook salmon, California coastal	*Oncorhynchus tschawytscha*	Threatened
Chinook salmon, Central Valley Spring		Threatened
Chinook salmon, Sacramento River		Endangered
Steelhead, South-Central California	*Oncorhynchus mykiss*	Threatened
Steelhead, Southern California		Endangered
Black Abalone	*Haliotis cracherodii*	Endangered
White Abalone	*Haliotis sorensenii*	Endangered

No crtical habitat for endangered or threatened species under NMFS' jurisdiction has been designated in the action area. However, NMFS has proposed to designate critical habitat for leatherback sea turtles and black abalone in the action area.

3.1 Species Not Considered Further in this Opinion

As described in the Approach to the Assessment, NMFS uses two criteria to identify those endangered or threatened species or critical habitat that are not likely to be adversely affected by the various activities the U.S. Navy proposes to conduct on the Southern California Range Complex during the twelve-month period beginning in January 2011. The first criterion was *exposure* or some reasonable expectation of a co-occurrence betweeon 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 critical habitat is not likely to be adversely affected by those activities. The second criterion is the probability of a *response* given exposure, which considers *susceptibility*: species that may be exposed to sound transmissions from active sonar, for example, but are likely to be unaffected by the sonar (at sound pressure levels they are likely to be exposed to) are also not likely to be adversely affected by the sonar. We applied these criteria to the species listed at the beginning of this section; this subsection summarizes the results of those evaluations.

NORTH PACIFIC RIGHT WHALES. Historically, the endangered North Pacific right whale occurred in waters off Southern California (Clapham *et al.* 2004; Scarff 1986). Despite many years of systematic aerial and ship-based surveys for marine mammals off the western coast of the U.S., only seven documented sightings of right whales were made from 1990 through 2000 (Waite *et al*. 2003). The relative rarity of reports of this species off Southern California and the extremely low population numbers of this species suggests that these right whales have a very low probability of being exposed to ship and aircraft traffic and sonar transmissions associated with the activities considered in this Opinion.

In the event right whales are exposed to mid-frequency sonar, the information available on right whale vocalizations suggests that right whales produce moans less than 400 Hz in frequency (Watkins and Schevill 1972; Thompson *et al.* 1979; Spero 1981). Based on this information right whales exposed to received levels of active mid-frequency sonar are not likely to hear mid-frequency (1 kHz–10 kHz) sounds; therefore, they are not likely to respond physiologically or behaviorally to those received levels. Consequently, we conclude that the proposed activities may affect, but are not likely to adversely affect endangered northern right whales so this species will not be considered in greater detail in the remainder of this opinion.

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 cold eastern currents (Perry *et al*. 1999).

Our analyses led us to conclude that sei whales could be exposed to vessel disturbance or sound fields produced by active sonar on the Southern California Range Complex over the next twelve months, but their density in the action area for this consultation is sufficiently low that such exposure is not likely to occur. Therefore, we will not discuss this species further in this Opinion.

SOUTHERN RESIDENT KILLER WHALES. Three populations of killer whales may occur in the waters of the Southern California Range Complex: Eastern North Pacific (ENP) Southern Residents, ENPOffshores, and ENP transients. Of these only the ENP Southern Resident killer whales are listed under the ESA. This population is most commonly seen in the inland waters of Washington state and southern Vancouver Island, although individuals from this population have been observed in Monterey Bay, California in January, 2000 and March, 2003, near the Farallon Islands in February 2005 and off Point Reyes in January 2006 (Pacific Fishery Management Council and NMFS 2006). Although one killer whale from ENP Transient killer whales (which are not listed pursuant to the ESA) was captured in the California/Oregon drift gillnet fishery in 1995 (Carretta *et al*. 2006), no Southern Resident killer whales have been reported to have interacted with any California-based fisheries.

STELLER SEA LIONS – EASTERN POPULATION. Steller sea lions are also not expected to be present in the action area. Steller sea lions range along the North Pacific Rim from northern Japan to California (Loughlin *et al*. 1984), with centers of abundance and distribution in the Gulf of Alaska and Aleutian Islands, respectively. In U.S. waters, there are two separate stocks of Steller sea lions: an eastern U.S. stock, which includes animals east of Cape Suckling, Alaska (144^{o}W longitude), and a western U.S. stock, which includes animals at and west of Cape Suckling (Loughlin 1997). The closest rookery to the action area is Año Nuevo Island, which declined by 85% between 1970 and 1987 (LeBoeuf *et al.* 1991). Steller sea lions are rarely sighted in Southern California waters and have not been reported to have interacted with fisheries off southern California fisheries in more than a decade: the last documented interaction with California-based fisheries was in northern California, in 1994 in the California-Oregon drift gillnet fishery (NMFS 2000). Because their probability of occurring in waters off southern California is very small[6], Steller sea lions are not likely to be exposed to training activities on the Southern California Range Complex and, as a result, are not likely to be adversely affected by the proposed training activities.

GREEN STURGEON. Green sturgeon range from the Bering Sea, Alaska, to Enseñada, Mexico. In 2006, NMFS listed the southern distinct population segment of green sturgeon as a threatened species (71 FR 17757); the northern population of green sturgeon is not listed as endangered or threatened. The southern population of green sturgeon consists of coastal and Central Valley green sturgeon populations south of the Eel River and is only known to spawn in the Sacramento River.

A few green sturgeon have been observed off the southern California coast, including fish less than 100 cm total length (Fitch and Lavenberg 1971, cited in Moyle *et al.* 1995; Fitch and Schultz 1978, cited in Moyle *et al.* 1995). Green sturgeon abundance increases north of Point Conception, California (Moyle *et al.*, 1995). The data NMFS collected to support its proposal to designate critical habitat for the southern population of green sturgeon led NMFS to conclude that these green sturgeon occupy coastal bays and estuaries from Monterey Bay, California, to Puget Sound, Washington. Although this does not mean that individuals from this population never occur in waters southern of Monterey Bay, it does suggest that they rarely occur in these waters. Because their probability of

6 Some ambiguity can accompany this usage of the word "rare" because it might denote a species that occurs regularly in an area, but occurs at low densities or it can denote a species that has a low probability of occurring in an area, regardless of its density. We use the word "rare" only in the latter sense; we would report species in the former sense as occurring regularly, but at low densities.

occurring in waters off southern California is very small, southern green sturgeon are not likely to be exposed to training activities on the Southern California Range Complex and, as a result, are not likely to be adversely affected by the proposed training activities.

CHINOOK SALMON AND STEELHEAD. The best scientific and commercial data available led us to conclude that listed chinook salmon and steelhead rarely occur in the action area and, as a result, had probabilities of being exposed that were sufficiently small to be discountable. Nevertheless, we considered all of the information available from published (for example, salmon stock assessment reports from the Pacific Fisheries Management Council 2006a, 2006b, 2005, 2004) and unpublished sources (unpublished data from the California Department of Fish and Game on commercial landings of salmon) on the probability of listed chinook salmon and steelhead being exposed to mid-frequency active sonar; we also considered their probability of responding to that exposure. As low-frequency hearing specialists, that probability was also very small (Hastings and Popper 2005); however, we concluded that establishing that these species had discountable probabilities of being exposed to mid-frequency sonar was sufficient to summarize the basis for conclusion on these species.

BLACK ABALONE. Historically, black abalone occurred from about Point Arena in northern California to Bahia Tortugas and Isla Guadalupe, Mexico. Black abalone are rare north of San Francisco and south of Punta Eugenia, and unconfirmed sightings have been reported as far north as Coos Bay, Oregon. The northernmost documented record of black abalone (based on museum specimens) is from Crescent City (Del Norte County, California, USA; Geiger 2004). Most experts agree that the current range of black abalone extends from Point Arena (Mendocino County, California, USA) south to Northern Baja California, Mexico. Black abalone may exist, but are considered extremely rare, north of San Francisco (Morris *et al.*, 1980) to Crescent City, California, USA and south of Punta Eugenia to Cabo San Lucas, Baja California, Mexico (P. Raimondi, personal communication). Within this broad geographic range, black abalone generally inhabit coastal and offshore island intertidal habitats on exposed rocky shores where bedrock provides deep, protective crevice shelter (Leighton, 2005).

Black abalone could be exposed to cable-laying activities associated with the establishment of the proposed West Coast Shallow Water Training Range; however, that training range is not scheduled to be installed until the Undersea Warfare Training Range (USWTR) the U.S. Navy plans to install in the Jacksonville Range Complex (which is located off Jacksonville, Florida) is installed. Because the installation of USWTR is not scheduled to be complete for several more years, this installation is not likely to affect black abalone over the next 12 months. Even when the training range is installed, the U.S. Navy has committed to avoid rocky substrate, particularly intertidal rocky substrate, to avoid exposing abalone to bottom disturbance associated with laying cable for the training range.

Black abalone could be exposed to underwater detonations associated with major training exercises; however, because the number of underwater detonations is very small, the Navy has a practice of avoiding rocky habitat, and the density of black abalone is very low, the probability of black abalone being exposed to these activities is sufficiently small to be discountable. Similarly, the U.S. Navy has committed to restrict activities such as amphibious assaults, insertion and extraction, and Naval Fire Support to areas that would not support black abalone (U.S. Navy 2008b), so black abalone are not likely to be exposed to stressors associated with these activities. As a result, black abalone may be affected by the military readiness activities the U.S. Navy proposes to conduct on the Southern

California Range Complex, but is not likely to be adversely affected by those activities. Therefore, this species will not be considered in greater detail in the remainder of this opinion.

WHITE ABALONE. Historically, white abalone occurred from Point Conception, California to Punta Abreojos, Baja California, Mexico. They are the deepest-living of the west coast abalone species (Hobday and Tegner 2000): they had been caught at depths of 20-60 m (66-197 ft) but had been reported as having had the highest abundance at depths of 25-30 m (80-100 ft; Cox 1960, Tutschulte 1976). At these depths, white abalone are found in open low relief rock or boulder habitat surrounded by sand (Tutschulte 1976, Davis *et al*. 1996).

Over the past 30 years, the white abalone populations have declined precipitously in abundance primarily as a result of exploitation. Surveys conducted at Tanner and Cortez Banks have yielded numbers of white abalone in the low hundreds (Butler *et al*. 2006). Surveys conducted off the western side of San Clemente Island in August 2004 yielded only 6 animals at 37-50 m depth (Navy 2005 *in* Navy 2006a). The effects of activities associated with the Undersea Warfare Operations on invertebrates are not known, particularly the impacts of sound.

Other operations undertaken as part of Composite Training Unit or Joint Task Force Exercises, such as those involving underwater detonations, are not likely to affect white abalone because the number of bottom-placed charges are few, these chanrges are not likely to adversely affect rocky habitat, and Sinking Exercises occur in at least 3,000 m of water, where white abalone are non-existent.

White abalone could be exposed to cable-laying activities associated with the establishment of the proposed West Coast Shallow Water Training Range, which would occur in Tanner and Cortes Banks which support the last extant colonies of white abalone in the U.S. However, if the U.S. Navy avoids rock substrate, as stated in their EIS, white abalone would not be exposed to bottom disturbance associated with laying cable for the training range. We assume, however, that the U.S. Navy plans to fulfill this commitment to avoid rocky substrate by surveying areas before they lay cable. Consequently, we conclude that the proposed Composite Training Unit or Joint Task Force Exercises may affect, but is not likely to adversely affect endangered white abalone because their probability of occurring in the action area during the proposed exercies is also sufficiently small to be discountable. Therefore, this species will not be considered 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 are or will be common to all of the species we discuss in this Opinion. Because of this commonality, we present this narrative here rather than in each of the species-specific narratives that follow.

The IPCC estimated that average global land and sea surface temperature has increased by 0.6°C (±0.2) since the mid-1800s, with most of the change occurring since 1976. This temperature increase is greater than what would be expected given the range of natural climatic variability recorded over the past 1,000 years (Crowley 2000). The IPCC reviewed computer simulations of the effect of greenhouse gas emissions on observed climate variations that have been recorded in the past and evaluated the influence of natural phenomena such as solar and volcanic activity. Based on their review, the IPCC concluded that natural phenomena are insufficient to explain the increasing trend in land and sea surface temperature, and that most of the warming observed over the last 50 years is likely to be attributable to human activities (IPCC 2001). Climatic models estimate that global temperatures would increase between 1.4 to 5.8°C from 1990 to 2100 if humans do nothing to reduce greenhouse gas emissions (IPCC 2001). These projections identify a suite of changes in global climate conditions that are relevant to the future status and trend of endangered and threatened species (Table 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.

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 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.

The Antarctic Peninsula, which is the northern extension of the Antarctic continent, contains the richest areas of krill on the Southern Ocean. The extent of se ice cover around this Peninsula has the highest degree of variability relative to other areas within the distribution of krill. Relatively small changes in climate conditions are likely to exert a strong influence on the seasonal pack-ice zone in the Peninsula area, which is likely to affect densities of krill in this region. Because krill are important prey for baleen whales or form a critical component of the food chains on which baleen whales depend, increasing the variability of krill densities or causing those densities to decline dramatically is likely to have adverse effect on populations of baleen whales on 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 influence the abundance of marine mammal prey such as zooplankton and fish. In the 1970s and 1980s, the North Atlantic Oscillation Index has been positive and sea surface temperatures increased. These 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 additional activities the U.S. Navy proposes to undertake on the Southern California Range Complex from January 2011 to January 2012. In each narrative, we present a summary of information on the distribution and population structure of each species to provides 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 status reviews, recovery plans for the blue whale (NMFS 1998a), fin whales (2007, 2010), fin and sei whale (NMFS 1998b, NMFS 2007), humpback whale (NMFS 1991a), right whale (NMFS 1991b), sperm whale (2010), a status report on large whales prepared by Perry *et al.* (1999), recovery plans for sea turtles (NMFS and USFWS 1998a, 1998b, 1998c, 1998d, and 1998e), and recovery plans for listed salmon. 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) summarize 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 Under-water 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 central North Pacific Ocean, blue whale vocalizations 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 Hawai'ian 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 North Pacific Ocean, blue whales forage in offshore waters from Alaska to California in the summer and fall, then migrate south from Mexico to Costa Rica in winter (Calambokidis et al. 1990, Calambokidis 1995, NMFS 2006, Reilly and Thayer 1990). Blue whales occupy waters off California primarily from June through November; based on calling intensity, the reach a peak in density in September (Burtenshaw *et al*. 2004). From December through May, blue whales are infrequent in waters off California (Forney and Barlow 1998; Larkman and Veit 1998). In waters off southern California, blue whales commonly occur in waters off the Channel Islands and Santa Rosa and San Miguel Islands where currents provide dense layers of the euphausiids on which they forage.

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).

A population or “stock” of endangered blue whales occurs in waters surrounding the Hawai’ian archipelago (from the main Hawai’ian 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 Hawai’i 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 Hawai'ian 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 stranding in Hawai'ian waters.

The International Whaling Commission also groups all of the blue whales in the North Atlantic Ocean into one "stock" and groups blue whales on 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 includes 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 blue whales and was ultimately responsible for listing blue whales as an endangered species. As early as the mid-seventeenth century, the Japanese were capturing blue, fin, and other large whales using a fairly primitive open-water netting technique (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 1991 to 1995 and from 1998-2002 (Barlow *et al.* 1997).

In September 2007, three blue whale mortalities were confirmed to be caused by ship strikes in the Santa Barbara Channel off Southern California. These deaths were part of a larger Unusual Mortality Event, declared by the Working Group on Marine Mammal Unusual Mortality Events. There are no records of ship strikes for blue whales in the western North Pacific but any mortalities caused by ship strikes in that region are not likely to have been reported.

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 numbers about 200,000 animals before whaling. Similarly, estimates of the global abundance of blue whales are uncertain. Since the cessation of whaling, the global population of blue whales has been estimated to range from 11,200 to 13,000 animals (Maser *et al.* 1981; 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 to 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 to 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 on 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 on 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, and Allee effects, among others, that cause their population size to become a threat in and of itself) or if blue whales are threatened more by exogenous threats such as anthropogenic activities (primarily whaling or 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: 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 blue 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.

3.3.1 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).

Aggregations of fin whales are found throughout the year off southern and central California (Dohl *et al*. 1983, Forney *et al*. 1995; Barlow 1997). In surveys conducted off San Clemente Island from 1998–1999, fin whales were the second most-common baleen whale that had been observed (after gray whales) and were most frequently observed during warm-water months (Carretta *et al*. 2000).

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 on the Southern Ocean. Globally, fin whales are sub-divided into three major groups: Atlantic, Pacific, and Antarctic. Within these major areas, different organizations use different population structure.

In the North Atlantic Ocean, the International Whaling Commission recognizes seven management units or “stocks” of fin whales: (1) Nova Scotia, (2) Newfoundland-Labrador, (3) West Greenland, (4) East Greenland-Iceland, (5) North Norway, (6) West Norway-Faroe Islands, and (7) British Isles-Spain-Portugal. In addition, the population of fin whales that resides in the Ligurian Sea, in the northwestern Mediterranean Sea is believed to be genetically distinct from other fin 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” are 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 demonstrated 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.

Mizroch *et al.* (1984) identified four fin whale “feeding aggregations” in the Pacific Ocean: (1) eastern and western groups that move along the Aleutians (Berzin and Rovnin 1966; Nasu 1974); (2) an East China Sea group; (3) a group that moves north and south along the west coast of North America between California and the Gulf of Alaska (Rice 1974); and (4) a group centered in the Sea of Cortez (Gulf of California).

Hatch (2004) reported that fin whale vocalizations among five regions of the eastern North Pacific were heterogeneous: the Gulf of Alaska, the northeast North Pacific (Washington and British Columbia), the southeast North Pacific (California and northern Baja California), the Gulf of California, and the eastern tropical Pacific.

Sighting data show no evidence of migration between the Sea of Cortez and adjacent areas in the Pacific, but seasonal changes in abundance in the Sea of Cortez suggests that these fin whales might not be isolated (Tershy *et al.* 1993). Nevertheless, Bérubé *et al.* (2002) concluded that the Sea of Cortez fin whale population is genetically distinct from the oceanic population and have lower genetic diversity, which suggests that these fin whales might represent an isolated population.

In its recovery plan for fin whales, NMFS recognized three populations in U.S. Pacific waters: Alaska (Northeast Pacific), California/Oregon/Washington, and Hawai’i (Barlow *et al.* 1997; Hill *et al.* 1997). We assume that individuals from the latter “population” of fin whales are the whales that would be exposed to the activities considered in 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. Although these results are based on studies of fin whales in the northeast Atlantic, there are no comparable estimates for fin whales in the Pacific Ocean. 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, Tomilin 1967).

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 on 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.

From 1904 to 1975, the International Whaling Commission estimates that 703,693 fin whales were captured and killed in Antarctic whaling operations (IWC 1990). Whaling on the Southern Oceans originally targeted humpback whales, but by 1913, those whales had became rare so whalers shifted their focus to fin and blue whales (Mizroch *et al.* 1984b). From 1911 to 1924, whalers killed 2,000–5,000 fin whales each year. After the introduction of factory whaling ships in 1925, the number of whales killed each year increased substantially: from 1931 to 1972, whalers killer about 511,574 fin whales (Kawamura 1994). In 1937 alone, whalers are reported to have killed more than 28,000 fin whales. From 1953 to 1961, the number of fin whales killed each year averaged around 25,000. In 1962, whalers appeared to shift their focus to sei whale as fin whales became scarce. By 1974, whalers killed fewer than 1,000 fin whales.

Recently released Soviet whaling records indicate a discrepancy between reported and actual fin whale catch numbers by whalers from the former USSR in southern waters between 1947 and 1980 (Zemsky *et al.* 1995). The former USSR previously reported 52,931 whales caught; however, the data that was released recently suggests that only 41,984 were killed.

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 planned 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 have 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%) were 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 (NMFS 2007). We may never know the size of the fin whale population prior to whaling. The most current estimate of the population size of fin whales in the Pacific Ocean is 85,200 (no coefficient of variance or confidence interval was provided) based on the history of catches and trends in catches per unit of effort (IWC 1979). Based on surveys conducted south of 30°S latitude between 1978 and 1988, fin whales in the Southern Ocean were estimated to number about 400,000 (IWC 1979; no coefficient of variance or confidence interval was provided).

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 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 there were 3,583 fin whales in the western Mediterranean (standard error = 967; 95% confidence interval = 2,130 - 6,027), which is similar to an estimate published by Notarbartolo-di-Sciara *et al.* (2003). In the Mediterraneans’ Ligurian Sea (which includes the Pelagos Whale Sanctuary and the Gulf of Lions), Forcada *et al.* (1995) estimated there were 901 fin whales (standard error = 196.1).

Regardless of which of these estimates, if any, come closest to actual population sizes, these estimates suggest that the global population of fin whales consists of tens of thousands of individuals. Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, fin whales appear to exist at population sizes that are large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as “small” populations (that is, “small” populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that fin whales are likely to be threatened more by exogenous threats such as anthropogenic activities (primarily whaling, entanglement, and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) than endogenous threats caused by the small size of their population.

Nevertheless, based on the evidence available, the number of fin whales that are recorded to have been killed or injured in the past 20 years by human activities or natural phenomena, does not appear to be increasing the extinction probability of fin whales, although it may slow the rate at which they recover from population declines that were caused by commercial whaling.

Diving and Social Behavior

The 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 dives 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 is 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.

3.3.2 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.

A discrete feeding aggregation of humpback whales appears to occur off California, Oregon, and Washington State (Calambokidis *et al*. 1996, 2007). In waters off southern California, humpback whales are most commonly sighted north of the Channel Islands; their migration to northern feeding areas generally starts in March with a migration to southern wintering areas bringing them through waters off southern California in November and December (Calambokidis et al. 2001, 2007).

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 the 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" 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).

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. 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, humpback whales are likely to be entangled and, in some cases, killed by gear used in modern fisheries.

There are also reports of entangled humpback whales from the Hawai'ian Islands. 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 Hawai'i rescued an entangled humpback, removing two crab pot floats from the whale. From 2001 through 2006, there were 23 reports of entangled humpback whales in Hawai'ian waters; 16 of these reports were from 2005 and 2006.

Many of the entangled humpback whales observed in Hawai'ian waters brought the gear with them from higher latitude feeding grounds; for example, the whale the U.S. Navy rescued in 1996 had been entangled in gear that was traced to a recreational fisherman in southeast Alaska. Thus far, 6 of the entangled humpback whales observed in the Hawai'ian Islands have been confirmed to have been entangled in gear from Alaska. Nevertheless, humpback whales are also entangled in fishing gear in the Hawai'ian Islands. Since 2001, there have been 5 observed interactions between humpback whales and gear associated with the Hawai'i-based longline fisheries (NMFS 2008). In each instance, however, all of the whales were disentangled and released or they were able to break free from the gear without reports of impairment of the animal's ability to swim or feed.

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 a 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, and 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 on 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, the size of the North Pacific humpback whale population was estimated to range from 1,407 to 2,100 (Baker 1985; Darling and Morowitz 1986; Baker and Herman 1987). By the mid-1990s, the population was estimated to consist of about 6,000 whales (standard error = 474) in the North Pacific (Calambokidis *et al.* 1997; Cerchio 1998; Mobley *et al.* 1999).

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.

In the North Atlantic, Stevick *et al.* (2003) estimated the size of the 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.

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, and 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 water 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 source 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 source 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.

3.3.3 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 are found year-round in waters off California, with peak abundance from April through mid-June and from the end of August to mid-November (NMFS 2006). Sperm whales are reported to be relatively rare over the continental shelf in southern California, but relatively abundant in deeper waters offshore (Appler et al. 2004, Bonnell and Dailey 1993, Carretta et al. 2000, Forney 2007).

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 over 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 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 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 on 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 on 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. On 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. In 1977, Berzin wrote, “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 females 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.

The groups of closely related females and their offspring develop dialects specific to the group (Weilgart and Whitehead 1997) and females other than birth mothers will guard young at the surface (Whitehead 1996) and will nurse young calves (Reeves and Whitehead 1997).

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.

3.3.4 Guadalupe fur seal

Distribution

Guadalupe fur seals are found on Guadalupe Island (Mexico) in the eastern Pacific Ocean off Mexico; a few individuals have been known to range as far north as Sonoma County, California, south to Los Islotes Islands in Baja California, Mexico. A few Guadalupe fur seals occupy California sea lion rookeries in the Channel Islands of California (Stewart *et al.* 1987 in Reeves *et al.* 1992).

Population Structure

The population is considered a single stock because all are recent descendents from one breeding colony at Isla Guadalupe, Mexico.

Threats to the Species

NATURAL THREATS. Guadalupe fur seals are known to be hunted by sharks and killer whales (Gallo-Reynosoand Figueroa-Carranza. 1992), although the potential effects of predation on this population is not known.

ANTHROPOGENIC THREATS. The size of the population prior to the commercial harvests of the 19th century is not known, but estimates range from 20,000 to 100,000 animals (Wedgeforth 1928; Hubbs 1956; Fleischer 1987).Commercial sealing during the 19th century reduced the once-abundant Guadalupe fur seal to near extinction in 1894. Sealing on the California coast was first recorded in 1805 and Native Americans left the remains of

Guadalupe fur seals in their middens (Bonner 1994). The species was evidently exterminated from southern California waters by 1825. Commercial sealing continued, although with declining returns, in Mexican waters through 1894. Incomplete sealing records suggest that perhaps as many as 52,000 fur seals were killed on Mexican islands between 1806 and 1890, mostly before 1848; from 1877 to 1984, only some 6,600 fur seals were harvested (Reeves *et al.* 1992).

Due to its full protection in Mexico and in the U.S., it is presumed that Guadalupe fur seals are not presently hunted.

Status

Guadalupe fur seals were listed as threatened under the Endangered Species Preservation Act of 1966 on March 11, 1967. This listing was extended in 1973 under the Endangered Species Act of 1973. In the U.S., Guadalupe fur seals *(Arctocephalus townsendi)* were listed as threatened under the ESA in 1985. The State of California lists the Guadalupe fur seal as a fully protected mammal in the Fish and Game Code of California (Chapter 8, Section 4700, d), and it is also listed as a threatened species in the California Fish and Game Commission Code of Regulations (Title 14, Section 670.5, b, 6, H). The Guadalupe fur seal is also protected under CITES and is fully protected under Mexican law.

Guadalupe Island was declared a pinniped sanctuary by the Mexican government in 1975. Critical habitat has not been designated for this species in the U.S.

By 1897, the Guadalupe fur seal was believed to be extinct. None was seen until a fisherman found slightly more than two dozen at Guadalupe Island in 1926. Counts of Guadalupe fur seals have been made sporadically since 1954. A few of these counts were made during the breeding season, but the majority was made at other times of the year. Documented seal counts in the literature generally provide only the total of all Guadalupe fur seals counted (*i.e.*, the counts are not separated by age/sex class). The counts made during the breeding season, when the maximum number of animals occur on the rookery, were used to examine population growth. The natural logarithm of the counts was regressed against a year to calculate the growth rate of the population. These data indicate that the population of Guadalupe fur seals is increasing exponentially at an average annual growth rate of 13.7 percent. Sub-sampling of the rookery indicate that only 47-55 percent of the seals present (*i.e.*, hauled out) were counted during the census (Gallo 1994). The minimum size of the population in Mexico can be estimated as the actual count of 3,028 hauled out seals [The actual count data were not reported by Gallo (1994); this number was derived by multiplying the estimated number hauled out by 47 percent, the minimum estimate of the percent counted] (Carretta *et al.* 2006). In the United States, a few Guadalupe fur seals are known to inhabit California sea lion rookeries in the Channel Islands (Stewart *et al.* 1997).

Strandings of Guadalupe fur seals have occurred along the central and northern California coast, suggesting that the seal may be expanding its range (Hanni *et al.* 1997). The severe reduction of the Guadalupe fur seals has evidently had a less substantial effect on its gene pool, when compared to other similarly depleted pinniped species, as relatively high levels of genetic variability have been reported (Reeves *et al.* 2002).

Diving and Social Behavior

Guadalupe fur seals are shallow divers that forage in the upper 20 to 30 meters of the water column. They have mean dive depths of about 17 meters (for lactating females), with modal depths of 3.1 meters (Gallo-Reynoso 1994). The mean duration of their dives was 2.6 minutes. Like other otariids, Guadalupe fur seals are social breeders: a single male will breed with several females.

Vocalizations and Hearing

Like most pinnipeds, Guadalupe fur seals produce a variety of in-air sounds that include barks, roars, and coughs (Peterson *et al.* 1968). Many of these sounds consist of multiple harmonics with frequencies less than 7 kHz and dominant frequencies below 1 kHz (Peterson *et al*. 1968). Male Guadalupe fur seals vocalize frequency during the breeding season and produce four different call types, especially during male-male interactions (Croxall and Gentry 1987). Females produce a pup attraction call and female attraction calls, each seemingly pulsed with the fundamental frequency below ~2 kHz (Croxall and Gentry 1987). Other call types include a boundary bluff, a bark, and a growl which seem correlated to some form of territorial behavior.

There is no published information on the hearing range of Guadalupe fur seals, although it is most likely similar to other fur seals. Northern fur seals produce underwater clicks, and in-air barking, coughing, and roaring sounds (Schusterman 1978; Richardson et al. 1995). The underwater hearing range of the northern fur seal ranges from 0.5Hz to 40 kHz (Moore and Schusterman 1987; Babushina *et al.* 1991) and the threshold is 50 to 60 dB re 1 μPa-m (Moore and Schusterman 1987). The best underwater hearing occurs between 4 and 17 to 28 kHz (Moore and Schisterman 1987; Babushina *et al.* 1991). The maximum sensitivity in air is at 3 to 5 kHz for northern fur seals (Babushina *et al.* 1991), after which there is anomalous hearing loss at around 4 to 5 kHz (Moore and Schusterman 1987; Babushina 1999).

3.3.5 Green Sea Turtle

Distribution

Green turtles are found in the Pacific Ocean, Atlantic Ocean, Indian Ocean, Carribean Sea, and Mediterranean Sea, primarily in tropical or, to a lesser extent, subtropical waters. These regions can be further divided into nesting aggregations within the eastern, central, and western Pacific Ocean; the western, northern, and eastern Indian Ocean; Mediterranean Sea; and eastern, southern, and western Atlantic Ocean, including the Carribean Sea.

Green turtles appear to prefer waters that usually remain around 20☜C in the coldest month. During warm spells (e.g., El Niño), green turtles may be found considerably north of their normal distribution. Stinson (1984) found green turtles to appear most frequently in U.S. coastal waters with temperatures exceeding 18°C. An east Pacific green turtle equipped with a satellite transmitter was tracked along the California coast and showed a distinct preference for waters with temperatures above 20°C (Eckert, unpublished data).

Further, green sea turtles seem to occur preferentially in drift lines or surface current convergences, probably because of the prevalence of cover and higher densities of their food items associated with these oceanic phenomena. For example, in the western Atlantic Ocean, drift lines commonly contain floating *Sargassum* capable of providing small turtles with shelter and sufficient buoyancy to raft upon (NMFS and USFWS 1998). Underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas that are relatively free of strong currents and disturbance from natural predators and humans. Available information indicates that green turtle resting areas are in proximity to their feeding pastures (NMFS 2000).

Population Structure

The population dynamics of green sea turtles and all of the other sea turtles we consider in this Opinion are usually described based on the distribution and habit of nesting females, rather than their male counterparts. The spatial structure of male sea turtles and their fidelity to specific coastal areas is unknown; however, we describe sea turtle populations based on the nesting beaches that female sea turtles return to when they mature. Because the patterns of increase or decrease in the abundance of sea turtle nests over time are determined by internal dynamics rather than external dynamics, we make inferences about the growth or decline of sea turtle populations based on the status and trend of their nests.

Primary nesting aggregations of green turtles (i.e. sites with greater than 500 nesting females per year) include: Ascension Island (south Atlantic Ocean), Australia, Brazil, Comoros Islands, Costa Rica, Ecuador (Galapagos Archipelago), Equatorial Guinea (Bioko Island), Guinea-Gissau (Bijagos Archipelago), Scattered Islands of the Indian Ocean (formally, the Îles éparses de l'océan indien: Tromelin Island, Europa Island), Indonesia, Malaysia, Myanmar, Oman, Philippines, Saudi Arabia, Seychelles Islands, Suriname, and United States (Florida; Seminoff 2002, NMFS and USFWS 1998a).

Smaller nesting aggregations include: Angola, Bangladesh, Bikar Atoll, Brazil, Chagos Archipelago, China, Costa Rica, Cuba, Cyprus, Democratic Republic of Yemen, Dominican Republic, d'Entrecasteaux Reef, French Guiana, Ghana, Guyana, India, Iran, Japan, Kenya, Madagascar, Maldives Islands, Mayotte Archipelago, Mexico, Micronesia, Pakistan, Palmerston Atoll, Papua New Guinea, Primieras Islands, Sao Tome é Principe, Sierra Leone, Solomon Islands, Somalia, Sri Lanka, Taiwan, Tanzania, Thailand, Turkey, Scilly Atoll, United States (Hawai'i), Venezuela, and Vietnam (Seminoff 2002).

Molecular genetic techniques have helped researchers gain insight into the distribution and ecology of migrating and nesting green turtles. In the Pacific Ocean, green sea turtles group into two distinct regional clades: (1) western Pacific and South Pacific islands, and (2) eastern Pacific and central Pacific, including the rookery at French Frigate Shoals, Hawai'i. In the eastern Pacific, greens forage coastally from San Diego Bay, California in the north to Mejillones, Chile in the South. Based on mtDNA analyses, green turtles found on foraging grounds along Chile's coast originate from the Galapagos nesting beaches, while those greens foraging in the Gulf of California originate primarily from the Michoacan nesting stock. Green turtles foraging in San Diego Bay and along the Pacific coast of Baja California originate primarily from rookeries of the Islas Revillagigedos (Dutton 2003).

Threats to the Species

NATURAL THREATS. The various habitat types green sea turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural threats. The beaches on which green 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 green sea turtles, including adults, are also killed by sharks and other large, marine predators.

Green turtles in the northwest Hawai'ian Islands are afflicted with a tumor disease, fibropapilloma, which is of an unknown etiology and often fatal, as well as spirochidiasis, both of which are the major causes of strandings of this species. The presence of fibropapillomatosis among stranded turtles has increased significantly over the past 17 years, ranging from 47-69 percent during the past decade (Murakawa *et al.* 2000). Green turtles captured off Molokai from 1982-96 showed a massive increase in the disease over this period, peaking at 61% prevalence in 1995 (Balazs *et al.* 1998). Preliminary evidence suggests an association between the distribution of fibropapillomatosis in the Hawai'ian Islands and the distribution of toxic benthic dinoflagellates (*Prorocentrum* spp.) known to produce a tumor promoter, okadaic acid (Landsberg *et al.* 1999). Fibropapillomatosis is considered to decrease growth rates in afflicted turtles and may inhibit the growth rate of Hawai'ian green turtle populations (Balazs *et al.* 1998).

ANTHROPOGENIC THREATS. Three human activities are known to threaten green sea turtles: overharvests of individual animals, incidental capture in commercial fisheries, and human development of coastlines. Historically, the primary cause of the global decline of green sea turtles populations were the number of eggs and adults captured and killed on nesting beaches in combination with the number of juveniles and adults captured and killed in coastal feeding areas. Some population of green sea turtles still lose large numbers of eggs, juveniles, and adults to subsistence hunters, local communities that have a tradition of harvesting sea turtles, and poachers in search of turtle eggs and meat.

Directed harvests of eggs and other life stages of green sea turtles were identified as a "major problem" in American Samoa, Guam, Palau, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Republic of the Marshall Islands, and the Unincorporated Islands (Wake, Johnston, Kingman, Palmyra, Jarvis, Howland, Baker, and Midway). In the Atlantic, green sea turtles are captured and killed in turtle fisheries in Colombia, Grenada, the Lesser Antilles, Nicaragua, St. Vincent and the Grenadines (Bräutigam and Eckert 2006); the turtle fishery along the Caribbean coast of Nicaragua, by itself, has captured more than 11,000 green sea turtles each year for the past 10 years (Bräutigam and Eckert 2006, Lagueux 1998).

Severe overharvests have resulted from a number of factors in modern times: (1) the loss of traditional restrictions limiting the number of turtles taken by island residents; (2) modernized hunting gear; (3) easier boat access to remote islands; (4) extensive commercial exploitation for turtle products in both domestic markets and international trade; (5) loss of the spiritual significance of turtles; (6) inadequate regulations; and (7) lack of enforcement (NMFS and USFWS 1998a).

Green sea turtles are also captured and killed in commercial fisheries. Gillnets account for the highest number of green sea turtles that are captured and killed, but they are also captured and killed in trawls, traps and pots, longlines, and dredges. Along the Atlantic coast of the U.S., NMFS estimated that almost 19,000 green sea turtles are captured in shrimp trawl fisheries each year in the Gulf of Mexico, with 514 of those sea turtles dying as a result of their capture. Each year, several hundred green sea turtles are captured in herring fisheries; mackerel, squid, and butterfish fisheries; monkfish fisheries; pound net fisheries, summer flounder and scup fisheries; Atlantic pelagic longline fisheries; and gillnet fisheries in Pamlico Sound. Although most of these turtles are released alive, these fisheries are expected to kill almost 100 green sea turtles each year; the health effects of being captured on the sea turtles that survive remain unknown.

Green sea turtles are also threatened by domestic or domesticated animals which 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

Green turtles are listed as threatened under the ESA, except for breeding populations found in Florida and the Pacific coast of Mexico, which are listed as endangered. Using a precautionary approach, Seminoff (2002) estimates that the global green turtle population has declined by 34% to 58% over the last three generations (approximately 150 years) although actual declines may be closer to 70% to 80%. Causes for this decline include harvest of eggs, subadults and adults, incidental capture by fisheries, loss of habitat, and disease.

While some nesting populations of green turtles appear to be stable or increasing in the Atlantic Ocean (e.g. Bujigos Archipelago (Guinea-Bissau), Ascension Island, Tortuguero (Costa Rica), Yucatan Peninsula (Mexico), and Florida), declines of over 50% have been documented in the eastern (Bioko Island, Equatorial Guinea) and western Atlantic (Aves Island, Venezuela). Nesting populations in Turkey (Mediterranean Sea) have declined between 42% and 88% since the late 1970s. Population trend variations also appear in the Indian Ocean. Declines greater than 50% have been documented at Sharma (Republic of Yemen) and Assumption and Aldabra (Seychelles), while no changes have occurred at Karan Island (Saudi Arabia) or at Ras al Hadd (Oman). The number of females nesting annually in the Indian Ocean has increased at the Comoros Islands, Tromelin and maybe Europa Island (Iles Esparses; Seminoff 2002).

Green turtles are thought to be declining throughout the Pacific Ocean, with the exception of Hawai'i, as a direct consequence of a historical combination of overexploitation and habitat loss (Eckert 1993, Seminoff 2002). They are also thought to be declining in the Atlantic Ocean. However, like several of the species we have already discussed, the information available on the status and trend of green sea turtles do not allow us to make a definitive statement about the global extinction risks facing these sea turtles or risks facing particular populations (nesting aggregations) of these turtles. With the limited data available on green sea turtles, we do not know whether green sea turtles exist at population sizes large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself) or if green sea turtles are threatened more by exogenous threats such as anthropogenic activities (entanglement, habitat loss, overharvests, etc.) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate). Nevertheless, with the exception of the Hawai'ian nesting aggregations, we assume that green sea turtles are endangered because of both anthropogenic and natural threats as well as changes in their population dynamics.

Diving Behavior

Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, it is presumed that those in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters in depth (NMFS and USFWS 1998). The maximum recorded dive depth for an adult green turtle was 110 meters (Berkson 1967 *in* Lutcavage and Lutz 1997), while subadults routinely dive 20 meters for 9-23 minutes, with a maximum recorded dive of 66 minutes (Brill *et al.* 1995 *in* Lutcavage and Lutz 1997).

Vocalizations and Hearing

The information on green turtle hearing is very limited. 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).

In a study of the auditory brainstem responses of subadult green sea turtles, Bartol and Ketten (2006) reported responses to frequencies between 100 and 500 Hz; with highest sensitivity between 200 and 400 Hz. They reported that two juvenile green turtles had hearing sensitivities that were slightly broader in range: they responded to sounds at freqnencies from 100 to 800 Hz, with highest hearing sensitivities from 600 to 700 Hz.

These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles have 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).

3.3.6 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. Leatherback sea turtles also occur in the Mediterranean Sea, although they are not known to nest there. The four main populations have been further divided into the following genetic groupings: western Pacific, Eastern Pacific, Costa Rican, Northern Caribbean, Guianan, Brazilian, West African, South African, Indian Ocean (genetic structure remains unknown), and Indo-Pacific or Malaysian, which may be extinct (Dutton 2006). Within each of these genetic groupings, we further divide leatherback sea turtles by nesting aggregation.

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 captured, injured, or killed 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 2008). Leatherback sea turtles have also been and are expected to continue to be captured and killed in the deep-set based longline fisheries based out of Hawai'i and American Samoa.

Shrimp trawls in the Gulf of Mexico capture the largest number of leatherback sea turtles: each year, they have been estimated to capture about 3,000 leatherback sea turtles with 80 of those sea turtles dying as a result. Along the Atlantic coast of the U.S., NMFS estimated that about 800 leatherback sea turtles are captured in pelagic longline fisheries, bottom longline and drift gillnet fisheries for sharks as well as lobster, deep-sea red crab, Jonah crab, dolphin fish and wahoo, and Pamlico Sound gillnet fisheries. Although most of these turtles are released alive, these fisheries combine to kill about 300 leatherback sea turtles each year; the health effects of being captured on the sea turtles that survive remain unknown.

Leatherback sea turtles are known to drown in fish nets set in coastal waters of Sao Tome, West Africa (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 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 turtle is listed as endangered under the ESA throughout its 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 calssified 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 Behavior

The maximum dive depths for post-nesting female leatherbacks 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). Wood turtles have 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).

3.3.7 Loggerhead Sea Turtle

Distribution

Loggerheads are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. Major nesting grounds are generally located in temperate and subtropical regions, with scattered nesting in the tropics (*in* NMFS and USFWS 1998).

Population Structure

Loggerhead sea turtles, like other sea turtles, are divided into regional groupings that represent major oceans or seas: the Atlantic Ocean, Pacific Ocean, Indian Ocean, Caribbean Sea and Mediterranean Sea. In these regions, the population structure of loggerhead turtles are usually based on the distribution of their nesting aggregations (see Table 4). In the Pacific Ocean, loggerhead turtles are represented by a northwestern Pacific nesting aggregation (located in Japan) which may be comprised of separate nesting groups (Hatase *et al.* 2002) and a smaller south-western nesting aggregation that occurs in Australia (Great Barrier Reef and Queensland), New Caledonia, New Zealand, Indonesia, and Papua New Guinea. One of the largest loggerhead nesting aggregations in the world is found in Oman, in the Indian Ocean.

Loggerhead sea turtles that occur on the Southern California Range Complex will represent animals from the northwestern Pacific Ocean.

Based on genetic analyses of loggerhead sea turtles along the southeastern coast of the United States might originate from one of the five major nesting aggregations in the western North Atlantic: (1) a northern nesting aggregation that occurs from North Carolina to northeast Florida, about 29°N; (2) a south Florida nesting aggregation, occurring from 29°N on the east coast to Sarasota on the west coast; (3) a Florida panhandle nesting aggregation, occurring at Eglin Air Force Base and the beaches near Panama City, Florida; (4) a Yucatán nesting aggregation, occurring on the eastern Yucatán Peninsula, Mexico; and (5) a Dry Tortugas nesting aggregation that occurs in the islands of the Dry Tortugas near Key West, Florida (NMFS 2001).

Loggerhead sea turtles from the northern nesting aggregation, which represents about 9% of the loggerhead nests in the western North Atlantic, comprise between 25 and 59% of the loggerhead sea turtles captured in foraging areas from Georgia to waters of the northeastern United States (Bass *et al.* 1998, Norrgard 1995, Rankin-Baransky 1997, Sears 1994, Sears *et al.* 1995). About 10% of the loggerhead sea turtles in foraging areas off the Atlantic coast of central Florida will have originated from the northern nesting aggregation (Witzell 1999). Loggerhead sea turtles associated with the South Florida nesting aggregation, in contrast, occur in higher frequencies in the Gulf of Mexico (where they represent about 10% of the loggerhead sea turtles captured) and the Mediterranean Sea (where they represent about 45-47% of the loggerhead sea turtles captured).

Table 4. Nesting populations of loggerhead sea turtles that have been identified using molecular genetics (after Hutchinson and Dutton 2007)

Ocean Basin	Population
Atlantic (eastern) (the Cape Verde rookeries appear to be genetically distinct, the other rookeries listed have not been evaluated)	
1	Cape Verde
2	Greece
3	Libya
4	Turkey
5	West African coast
Atlantic (western) and Caribbean	
6	Northern (U.S.) including rookeries from southern Virginia south to Florida
7	Florida peninsula which includes rookeries from the northeastern border of Florida south to southwestern Florida
8	Dry Tortugas, which includes the islands of Key West
9	Northern Gulf of Mexico, which extends from northwestern Florida into Texas
10	Cay Sal bank in thee western Bahamas
11	Quintana Roo, which includes all rookeries on Mexico's Yucatan Peninsula
12	Brazil
13	Additional rookeries in Caribbean Central America, the Bahamian Archipelago, Cuba, Colombia, Venezuela, and the eastern Caribbean Islands have not been classified
Indian Ocean (none of these rookeries have been evaluated genetically)	
14	Oman
15	Yemen
16	Sri Lanka
17	Madagascar
18	South Africa and (possibly) Mozambique
Pacific Ocean	
19	Western Australia
20	Eastern Australia, which may include rookeries from New Caledonia
21	North Pacific or Japan, which includes all rookeries in the Japanese Archipelago
22	Solomon Islands

Threats to the Species

NATURAL THREATS. The various habitat types loggerhead sea turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural and anthropogenic threats. The beaches on which loggerhead 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. For example, in 1992, all of the eggs over a 90-mile length of coastal Florida were destroyed by storm surges on beaches that were closest to the eye of Hurricane Andrew (Milton *et al.* 1994). Hatchlings are hunted by predators like herons, gulls, dogfish, and sharks. Adult loggerhead sea turtles are also killed by sharks and other large, marine predators. Loggerhead sea turtles are also killed by cold stunning, exposure to biotoxins, sharks and other large, marine predators.

ANTHROPOGENIC THREATS. A wide variety of human activities adversely affect hatchlings and adult female turtles when they are on land, including beach erosion, beach armoring and nourishment; artificial lighting; beach cleaning; human presence on nesting beaches; beach driving; coastal construction and fishing piers that alter patterns of erosion and accretion on nesting beaches; exotic dune and beach vegetation; and poaching. As the size of the human population in coastal areas increases, that population brings with it secondary threats such as exotic fire ants, feral hogs, dogs, and the growth of populations of native species that tolerate human presence (*e.g.*, raccoons, armadillos, and opossums) and which feed on turtle eggs.

When they are in coastal or marine waters, loggerhead turtles are affected by a completely different set of human activities that include discharges of toxic chemicals and other pollutants into the marine ecosystem; underwater explosions; hopper dredging, offshore artificial lighting; entrainment or impingement in power plants; entanglement in marine debris; ingestion of marine debris; boat collisions; poaching, and interactions with commercial fisheries. Of these, interactions with fisheries represents a primary threat because of number of individuals that are captured and killed in fishing gear each year.

Loggerhead sea turtles are also captured and killed in commercial fisheries. In the Pacific Ocean, between 2,600 and 6,000 loggerhead sea turtles are estimated to have been captured and killed in longline fisheries in 2000 (Lewison *et al.* 2004). Shallow-set Hawai'i based longline fisheries are estimated to have captured and killed several hundred loggerhead 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 fewer than 5 loggerhead sea turtles each year. Between 2004 and 2008, shallow-set fisheries based out of Hawai'i are estimated to have captured about 45 loggerhead sea turtles, killing about 10 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 2008). Loggerhead 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 trawl fisheries account for the highest number of loggerhead sea turtles that are captured and killed, but they are also captured and killed in trawls, traps and pots, longlines, and dredges. Along the Atlantic coast of the U.S., NMFS estimated that almost 163,000 loggerhead sea turtles are captured in shrimp trawl fisheries each year in the Gulf of Mexico, with 3,948 of those sea turtles dying as a result of their capture. Each year, several hundred loggerhead sea turtles are also captured in herring fisheries; mackerel, squid, and butterfish fisheries; monkfish fisheries; pound net fisheries, summer flounder and scup fisheries; Atlantic pelagic longline fisheries; and gillnet fisheries in Pamlico Sound. Although most of these turtles are released alive, these fisheries combine to capture about 2,000 loggehead sea turtles each year, killing almost 700; the health effects of being captured on the sea turtles that survive remain unknown.

In the pelagic environment, loggerhead sea turtles are exposed to a series of longline fisheries that include the U.S. Atlantic tuna and swordfish longline fisheries, an Azorean longline fleet, a Spanish longline fleet, and various fleets in the Mediterranean Sea (Aguilar *et al.* 1995, Bolten *et al.* 1994, Crouse 1999). In the benthic environment in waters off the coastal U.S., loggerheads are exposed to a suite of fisheries in federal and state waters including trawl, purse seine, hook and line, gillnet, pound net, longline, dredge, and trap fisheries.

Like all of the other sea turtles we have discussed, loggerhead 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 most recent reviews show that only two loggerhead nesting beaches have greater than 10,000 females nesting per year: South Florida (U.S.) and Masirah Island (Oman). The status of the Oman nesting colony has not been evaluated recently so the current size of this population and its trend are unknown. Nesting colonies in the U.S. have been reported to produce 68,000 to 90,000 nests per year. Recent analyses of nesting data from southeast Florida nesting colonies, which are the largest nesting colonies in the western Atlantic Ocean, suggest that this nesting population is declining. Long-term nesting data suggest similar declines in loggerhead nesting in North Carolina, South Carolina, and Georgia.

In the Eastern Atlantic, the Cape Verde Islands support an intermediately-sized loggerhead nesting colony. In 2000, researchers tagged over 1,000 nesting females on just 5 km (3.1 mi) of beach on Boavista Island (Ehrhart *et al.* 2003). In the Western Atlantic (excluding the U.S.), Brazil supports an intermediately-sized loggerhead nesting assemblage. Published and unpublished reports provide an estimate of about 4,000 nests per year in Brazil (Ehrhart *et al.* 2003). Loggerhead nesting throughout the Caribbean is sparse.

In the Mediterranean, loggerhead nesting is confined almost exclusively to the eastern portion of the Mediterranean Sea. The main nesting assemblages occur in Cyprus, Greece, and Turkey. However, small numbers of loggerhead nests have been recorded in Egypt, Israel, Italy, Libya, Syria, and Tunisia. Based on the recorded number of nests per year in Cyprus, Greece, Israel, Tunisia, and Turkey, loggerhead nesting in the Mediterranean ranges from about 3,300 to 7,000 nests per season (Margaritoulis *et al.* 2003). Loggerheads nest throughout the Indian Ocean and, with the exception of Oman, the number of nesting females is small. Most trends in loggerhead nesting populations in the Indian Ocean are unknown.

Loggerhead populations in Honduras, Mexico, Colombia, Israel, Turkey, Bahamas, Cuba, Greece, Japan, and Panama have been declining. Balazs and Wetherall (1991) speculated that 2,000 to 3,000 female loggerheads may nest annually in all of Japan; however, more recent data suggest that only approximately 1,000 female loggerhead turtles may nest there (Bolten *et al.* 1996; Sea Turtle Association of Japan 2002). Monitoring of nesting beaches at Gamoda (Tokushima Prefecture) has been ongoing since 1954. Surveys at this site showed a marked decline in the number of nests between 1960 and the mid-1970s. Since then, the number of nests has fluctuated, but has been downward since 1985 (Bolten *et al.* 1996; Sea Turtle Association of Japan 2002). Monitoring on several other nesting beaches, surveyed since the mid-1970s, revealed increased nesting during the 1980s before declining during the early 1990s. The number of nests at Gamoda remains very small, fluctuating between near zero (1999) to about 50 nests (1996 and 1998; Kamezaki *et al.* 2003).

Scattered nesting has also been reported on Papua New Guinea, New Zealand, Indonesia, and New Caledonia; however, population sizes on these islands have not been ascertained. Survey data are not available for other nesting assemblages in the south Pacific (NMFS and USFWS 1998). In addition, loggerheads are not commonly found in U.S. Pacific waters, and there have been no documented strandings of loggerheads off the Hawai'ian Islands in nearly 20 years (1982-1999 stranding data, G. Balazs, NMFS, personal communication, 2000). There are very few records of loggerheads nesting on any of the many islands of the central Pacific, and the species is considered rare or vagrant on islands in this region (NMFS and USFWS 1998).

For several years, NMFS' biological opinions have established that most loggerhead sea turtles populations 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 loggerhead 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.

The information available suggests that loggerhead 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 nesting aggregations of loggerhead sea turtles in the Pacific Ocean exist at 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. These small sizes would increase the extinction probability of these nesting aggregations.

The status of loggerhead sea turtles in the Atlantic Ocean remains uncertain and controversial. For years, the south Florida nesting aggregation, which is the only major nesting aggregation in the western Atlantic Ocean, had been assumed to be stable or increasing. However, more recent data demonstrate that this nesting population is currently declining and probably has been declining for several years. Between 1998 and 2007, nest counts of loggerhead sea turtles in the State of Florida have declined by almost 50 percent to the lowest levels in the 19 years of Florida's monitoring program (Fish and Wildlife Research Institute 2007). Given that (1) the nesting aggregations that account for almost 90 percent of loggerhead nesting in the western Atlantic Ocean are declining, (2) the other nesting aggregations in the western Atlantic Ocean are substantially much smaller, and (3) large numbers of sea turtles from these smaller populations are captured or killed in commercial and other fisheries in the United States each year, we suspect that the extinction probabilities of loggerhead sea turtle populations in the Atlantic Ocean are only slightly lower than those of populations in the Pacific Ocean. The principle difference between the Atlantic and the Pacific may be this: loggerhead sea turtle populations in the Atlantic Ocean may currently be large enough to avoid the small population dynamics we have discussed previously, but the intensity of the anthropogenic pressure on their populations (in the form of numbers captured and killed in fisheries alone) appear to be large enough to accelerate the extinction probabilities of these populations.

Diving Behavior

Studies of loggerhead diving behavior indicate varying mean depths and surface intervals, depending on whether they were located in shallow coastal areas (short surface intervals) or in deeper, offshore areas (longer surface intervals). The maximum recorded dive depth for a post-nesting female was 211-233 meters, while mean dive depths for both a post-nesting female and a subadult were 9-22 meters. Routine dive times for a post-nesting female were between 15 and 30 minutes, and for a subadult, between 19 and 30 minutes (Sakamoto *et al.* 1990 *cited in* Lutcavage and Lutz 1997). Two loggerheads tagged by Hawai'i-based longline observers in the North Pacific and attached with satellite-linked dive recorders were tracked for about 5 months. Analysis of the dive data indicate that most of the dives were very shallow - 70% of the dives were no deeper than 5 meters. In addition, the loggerheads spent approximately 40% of their time in the top meter and nearly all of their time at depths shallower than 100 meters. On 5% of the days, the turtles dove deeper than 100 meters; the deepest daily dive recorded was 178 meters (Polovina *et al.* 2003).

Polovina *et al.* (2004) reported that tagged turtles spent 40 percent of their time at the surface and 90 percent of their time at depths shallower than 40 meters. On only five percent of recorded dive days loggerheads dove to depths greater than 100 meters at least once. In the areas that the loggerheads were diving, there was a shallow thermocline at 50 meters. There were also several strong surface temperature fronts the turtles were associated with, one of 20°C at 28°N latitude and another of 17°C at 32°N latitude.

Vocalizations and Hearing

The information on loggerhead turtle hearing is very limited. Bartol *et al.* (1999) studied the auditory evoked potential of loggerhead sea turtles that had been captured in pound nets in tributaries to the Chesapeake Bay in Maryland and Virginia and concluded that loggerhead sea turtles had most sensitive hearing between 250 and 1000 Hz, with rapid decline above 1000 Hz (Bartol *et al.* 1999). This is similar to the results produced by Ridgway *et al.* (1969) who studied the auditory evoked potentials of three green sea turtles (in air and through mechanical stimulation of the ear). They concluded that the maximum sensitivity of green sea turtles 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.

These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). wood turtles have 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).

3.3.8 Olive ridley Sea Turtle

Distribution

Olive ridley turtles occur in the tropical waters of the Pacific and Indian Oceans from Micronesia, Japan, India, and Arabia south to northern Australia and southern Africa. In the Atlantic Ocean, they occur off the western coast of Africa and the coasts of northern Brazil, French Guiana, Surinam, Guyana, and Venezuela in South America, and occasionally in the Caribbean Sea as far north as Puerto Rico. In the eastern Pacific Ocean, Olive ridley turtles are found from the Galapagos Islands north to California. While Olive ridley turtles have a generally tropical to subtropical range, individual turtles have been reported as far as the Gulf of Alaska (Hodge and Wing, 2000).

Olive ridley turtles nest along continental margins and oceanic islands. The largest nesting aggregation in the world occurs in the Indian Ocean along the northeast coast of India where more than 600,000 Olive ridley turtles nested in a single week in 1991 (Mrosovsky 1993). The second most important nesting area occurs in the eastern Pacific along the west coast of Mexico and Central America. Olive ridley turtles also nest along the Atlantic coast of South America, western Africa, and the western Pacific (Sternberg 1981, Groombridge 1982).

In the eastern Pacific, Olive ridley turtles nest along the Mexico and Central American coast, with large nesting aggregations occurring at a few select beaches located in Mexico and Costa Rica. Few turtles nest as far north as southern Baja California, Mexico (Fritts *et al*. 1982) or as far south as Peru (Brown and Brown 1982). The post-nesting migration routes of Olive ridleys traversed thousands of kilometers of deep oceanic waters, ranging from Mexico to Peru, and more than 3,000 kilometers out into the central Pacific (Plotkin, *et al*. 1993). Although they are the most abundant north Pacific sea turtle, surprisingly little is known of the oceanic distribution and critical foraging areas of Olive ridley turtles.

Most records of Olive ridley turtles are from protected, relative shallow marine waters. Deraniyagalia (1939) described the habitat of Olive ridley turtles as shallow waters between reefs and shore, larger bays, and lagoons. Nevertheless, Olive ridley turtles have also been observed in the open ocean. Because Olive ridley turtles throughout the eastern Pacific Ocean depend on rich upwelling areas off South America for food, Olive ridley turtles sighted offshore may have been foraging.

Population Structure

Olive ridley sea turtles exist as two separate populations: one that occurs in the western Pacific and Indian Ocean (northern Australia, Malaysia, Thailand, and the State of Orissa in India) and another that occurs along the Pacific coast of the Americas from Mexico to Columbia (Chaloupka *et al*. 2004).

Threats to the Species

NATURAL THREATS. The various habitat types Olive ridley sea turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural threats. The beaches on which Olive ridley 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. Adult Olive ridley sea turtles are also killed by sharks and other large, marine predators.

ANTHROPOGENIC THREATS. In India, uncontrolled mechanized fishing in areas of high sea turtle concentration, primarily illegally operated trawl fisheries, has resulted in large scale mortality of adult Olive ridley turtles during the last two decades. Since 1993, more than 50,000 Olive ridleys have stranded along the coast, at least partially because of near-shore shrimp fishing (Shanker and Mohanty 1999). Fishing in coastal waters off Gahirmatha was restricted in 1993 and completely banned in 1997 with the formation of a marine sanctuary around the rookery. However, mortality due to shrimp trawling reached a record high of 13,575 ridleys during the 1997-1998 season and none of the approximately 3,000 trawlers operating off the Orissa coast use turtle excluder devices in their nets despite mandatory requirements passed in 1997 (Pandav and Choudhury 1999).

Historically, an estimated 10 million Olive ridleys inhabited the waters in the eastern Pacific off Mexico (Cliffton *et al*. 1982 in NMFS and USFWS 1998). However, human-induced mortality caused this population to decline. From the 1960s to the 1970s, several million adult Olive ridleys were harvested by Mexico for commercial trade with Europe and Japan. (NMFS and USFWS 1998). Although Olive ridley meat is palatable, it was not widely sought after; its eggs, however, are considered a delicacy. Fisheries for Olive ridley turtles were also established in Ecuador during the 1960s and 1970s to supply Europe with leather. (Green and Ortiz-Crespo 1982).

The nationwide ban on commercial harvest of sea turtles in Mexico, enacted in 1990, has improved the situation for the Olive ridley. Surveys of important Olive ridley nesting beaches in Mexico indicate increasing numbers of nesting females in recent years (Marquez *et al*. 1995; Arenas *et al*. 2000). Annual nesting at the principal beach, Escobilla Beach, Oaxaca, Mexico, averaged 138,000 nests prior to the ban, and since the ban on harvest in 1990, annual nesting has increased to an average of 525,000 nests (Salazar *et al*. in press). At a smaller Olive ridley nesting beach in central Mexico, Playon de Mismalayo, nest and egg protection efforts have resulted in more hatchlings, but the population is still seriously decremented and is threatened with extinction (Silva-Batiz *et al*. 1996). Nevertheless some authors have suggested that Olive ridley turtles in Mexico should be considered recovered (Arenas *et al*. 2000).

The main threats to turtles in Thailand include egg poaching, harvest and subsequent consumption or trade of adults or their parts (i.e. carapace), indirect capture in fishing gear, and loss of nesting beaches through development (Aureggi *et al*. 1999). During the 1996-97 survey, only six Olive ridley nests were recorded, and of these, half were poached, and one was predated by feral dogs. During the 1997-98 survey, only three nests were recorded.

Olive ridley nests in Indonesia are subject to extensive hunting and egg collection. In combination with rapid rural and urban development, these activities have reduced the size of the nesting population in the region as well as their nesting success.

Status of the Species

Olive ridley turtle populations on the Pacific coast of Mexico are listed as endangered under the ESA; all other populations are listed as threatened. The International Union for Conservation of Nature and Natural Resources has classified the Olive ridley sea turtle as "endangered" (IUCN Red List 2000).

Where population densities are high enough, nesting takes place in synchronized aggregations known as arribadas. The largest known arribadas in the eastern Pacific are off the coast of Costa Rica (~475,000 - 650,000 females estimated nesting annually) and in southern Mexico (~800,000 nests per year at La Escobilla, in Oaxaca, Mexico (Millá án 2000)). In Costa Rica, 25,000 to 50,000 Olive ridleys nest at Playa Nancite and 450,000 to 600,000 turtles nest at Playa Ostional each year (NMFS and USFWS 1998d). Based on a review of 11 years of data on Olive ridley sea turtles nesting at Playa Ostional, Ballestero *et al*. (2000) report that the data are too limited for a statistically valid determination of a trend; although the number of nesting turtles has appeared to decline over a six-year period.

At a nesting site in Costa Rica, an estimated 0.2 percent of 11.5 million eggs laid during a single arribada produced hatchlings (in NMFS and USFWS 1998d). In addition, some female Olive ridleys nesting in Costa Rica have been found afflicted with the fibropapilloma disease (Aguirre, *et al*. 1999). At Playa La Flor, the second most important nesting beach for Olive ridleys on Nicaragua, Ruiz (1994) documented 6 arribadas (defined as 50 or more females resting simultaneously). The main egg predators were domestic dogs and vultures (*Coragyps atratus* and *Cathartes aura*).

In the western Pacific, information on the size of Olive ridley nesting aggregations are limited although they do not appear to be recovering (with the exception of the nesting aggregation at Orissa, India). There are a few sightings of Olive ridleys from Japan, but no report of egg-laying. Similarly, there are no nesting records from China, Korea, the Philippines, Taiwan, Viet Nam, or Kampuchea and nesting records in Indonesia are not sufficient to assess population trends (Eckert 1993, Suwelo 1999). In Thailand, Olive ridleys occur along the southwest coast, on the Surin and Similan islands, and in the Andaman Sea. On Phra Thong Island, on the west coast of Thailand, the number of nesting turtles have declined markedly from 1979 to 1990.

Olive ridley turtles have been observed in Indonesia and surrounding waters, and some Olive ridley turtles have been documented as nesting in this region recently. On Jamursba-Medi beach, on the northern coast of Irian Jaya, 77 Olive ridley nests were documented from May to October, 1999 (Teguh 2000 in Putrawidjaja 2000).

Olive ridley turtles nest on the eastern and western coasts of peninsular Malaysia; however, nesting has declined rapidly in the past decade. The highest density of nesting was reported to be in Terengganu, Malaysia, and at one time yielded 240,000 eggs (2,400 nests, with approximately 100 eggs per nest; see Siow and Moll 1982, in Eckert 1993), while only 187 nests were reported from the area in 1990 (Eckert 1993). In eastern Malaysia, Olive ridleys nest very rarely in Sabah and only a few records are available from Sarak (in Eckert 1993).

Olive ridleys are the most common species found along the east coast of India, migrating every winter to nest en-masse at three major rookeries in the state of Orissa, Gahirmatha, Robert Island, and Rushikulya (Pandav and Choudhury 1999). According to Pandav and Choudhury (1999), the number of nesting females at Gahirmatha has declined in recent years, although after three years of low nestings, the 1998-1999 season showed an increasing trend (Noronha *Environmental News Service*, April 14, 1999), and the 1999-2000 season had the largest recorded number of Olive ridleys nesting in 15 years (*The Hindu*, March 27, 2000; *The Times of India*, November 15, 2000). During the 1996-1997 and 1997-98 seasons, there were no mass nestings of Olive ridleys. During the 1998-1999 nesting season, around 230,000 females nested during the first arribada, lasting approximately a week (Pandav and Kar 2000); unfortunately, 80% of the eggs were lost due to inundation and erosion (B. Pandav, personal communication, in Shanker and Mohanty 1999). During 1999-2000, over 700,000 Olive ridleys nested at Nasi islands and Babubali island, in the Gahirmatha coast.

Diving Behavior

Although Olive ridley turtles are probably surface feeders, they have been caught in trawls at depths of 80-110 meters (NMFS and USFWS 1998), and a post-nesting female reportedly dove to a maximum depth of 290 meters. The average dive length for an adult female and adult male is reported to be 54.3 and 28.5 minutes, respectively (Plotkin 1994, in Lutcavage and Lutz 1997).

Vocalizations and Hearing

There is no information on Olive ridley sea turtle vocalizations or hearing. 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). Wood turtles have 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).

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 and threatened species in the action area.

A number of human activities have contributed to the current status of populations of large whales 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 whale populations. The following discussion summarizes the principal phenomena that are known to affect the likelihood that endangered and threatened species are likely to survive and recover in the wild.

Natural Mortality

Natural mortality rates in cetaceans, especially large whale species, are largely unknown. Although cannot identify the specific natural phenomena that result in the death of endangered and threatened species in the action area, we assume those phenomena include parasites, predation, and red tide toxins. 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. Whales also appear to strand from natural (as compared with anthropogenic) causes.

Human-Induced Mortality

Commercial Whaling

Large whale population numbers in the proposed action areas have historically been impacted by commercial exploitation, mainly in the form of whaling. Prior to current prohibitions on whaling, such as the International Whaling Commission's 1966 moratorium, most large whale species had been depleted to the extent it was necessary to list them as endangered under the ESA of 1966. For example, from 1900 to 1965 nearly 30,000 humpback whales were taken in the Pacific Ocean with an unknown number of additional animals taken prior to 1900 (Perry *et al.*

1999). Sei whales are estimated to have been reduced to 20% (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific (Tillman 1977). In addition, 9,500 blue whales were reported killed by commercial whalers in the North Pacific between 1910-1965 (Ohsumi and Wada 1972); 46,000 fin whales between 1947-1987 (Rice 1984); and 25,800 sperm whales (Barlow *et al* 1997). North Pacific right whales once numbered 11,000 animals but commercial whaling has now reduced their population to 29-100 animals (Wada 1973). Although commercial whaling no longer targets the large, endangered whales in the proposed action areas, historical whaling may have altered the age structure and social cohesion of these species in ways that continue to influence them.

Entrapment and Entanglement in Commercial Fishing Gear

Entrapment and entanglement in commercial fishing gear is one of the most frequently documented sources of human-caused mortality in large whale species. For example, an estimated 78 rorquals were killed annually in the offshore southern California drift gillnet fishery during the 1980s (Heyning and Lewis 1990). From 1996-2000, 22 humpback whales of the Central North Pacific population were found entangled in fishing gear (Angliss *et al.* 2002). From 1998 to 2005, five fin whales, 12 humpback whales, and 6 sperm whales were either seriously injured or killed in fisheries off the mainland west coast of the U.S. (California Marine Mammal Stranding Network Database 2006). To date, there are no reports of sei whales having been killed in interactions with any eastern North Pacific fisheries, although the absence of reports does not mean that no sei whales have interacted with fisheries or died as a result of any interactions.

Several fisheries in the action area capture and kill sea turtles. In a biological opinion on the California-Oregon draft gillnet fisheries that NMFS issued on 30 September 1997, NMFS concluded that this fishery would capture 30 leatherback sea turtles and 18 loggerhead turtles each year. Of these, NMFS concluded that 19 leatherback sea turtles and three loggerhead sea turtles would die each year as a result of their capture. In an 8 December 1999 biological opinion on the Eastern Tropical Pacific U.S. tuna purse seine fishery on listed species, NMFS concluded that 35 green sea turtles and 133 olive ridley sea turtles would be captured each year in this fishery between 2000 and 2010; two leatherback sea turtles would be captured roughly every ten years; three loggerhead sea turtles would be captured every seven years (NMFS 1999). Ses turtles are also captured and killed in the California set gillnet fisheries for halibut and angel shark and the California-based longline fisheries.

Ship Strikes

Collisions with commercial ships are an increasing threat to many large whale species, particularly as shipping lanes cross important large whale breeding and feeding habitats or migratory routes. We struggle to estimate the number of whales that are killed or seriously injured in ship strikes within the U.S. Exclusive Economic Zone and have virtually no information on interactions between ships and commercial vessels outside of U.S. waters in the North Pacific Ocean.

We have more information on ship strikes within U.S. waters. Since 1975, U.S. Navy vessels are reported to have struck and injured or killed 13 whales in waters of Southern California; 2 of these 13 strikes occurred in 2009. Of these 13 records, 1 fin whale was struck, 5 gray whales have been struck, and the species was not identified in the remaining 7 strikes, although one of these whales was later identified as a fin whale (J. Cordaro, personal communication, 2010). We discuss the implications and consequences of these strikes on endangered whales in the Action Area in the Effects of the Action section of this Opinion.

Habitat Degradation

Chronic exposure to the neurotoxins associated with paralytic shellfish poisoning from zooplankton prey has been shown to have detrimental effects on marine mammals. Estimated ingestion rates are sufficiently high to suggest that the PSP toxins are affecting marine mammals, possibly resulting in lower respiratory function, changes in feeding behavior and a lower reproduction fitness (Durbin *et al.* 2002). Other human activities, including discharges from wastewater systems, dredging, ocean dumping and disposal, aquaculture and additional impacts from coastal development are also known to impact marine mammals and their habitat. In the North Pacific, undersea exploitation and development of mineral deposits, as well as dredging of major shipping channels pose a continued threat to the coastal habitat of right whales. Point-source pollutants from coastal runoff, offshore mineral and gravel mining, at-sea disposal of dredged materials and sewage effluent, potential oil spills, as well as substantial commercial vessel traffic, and the impact of trawling and other fishing gear on the ocean floor are continued threats to marine mammals in the proposed action area.

The impacts from these activities are difficult to measure. However, some researchers have correlated contaminant exposure to possible adverse health effects in marine mammals. Studies of captive harbor seals have demonstrated a link between exposure to organochlorines (*e.g.*, DDT, PCB, and polyaromatic hydrocarbons) and immunosuppression (Ross *et al.* 1995, Harder *et al.* 1992, De Swart *et al.* 1996). Organochlorines are chemicals that tend to bioaccumulate through the food chain, thereby increasing the potential of indirect exposure to a marine mammal via its food source. During pregnancy and nursing, some of these contaminants can be passed from the mother to developing offspring. Contaminants like organochlorines do not tend to accumulate in significant amounts in invertebrates, but do accumulate in fish and fish-eating animals. Thus, contaminant levels in planktivorous mysticetes have been reported to be one to two orders of magnitude lower compared to piscivorous odontocetes (Borell, 1993, O'Shea and Brownell, 1994, O'Hara and Rice, 1996; O'Hara *et al.* 1999).

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). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003). The military uses sound to test the construction of new vessels as well as for naval operations. In some areas where oil and gas production takes place, noise originates from the drilling and production platforms, tankers, vessel and aircraft support, seismic surveys, and the explosive removal of platforms (NRC 2003). Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson *et al.* 1995). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Baker *et al.* 1983, Bauer and Herman 1986, Hall 1982, Krieger and Wing 1984), but the long-term effects, if any, are unclear or not detectable. Carretta *et al.* (2001) and Jasny *et al.* (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate.

Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans (Simmonds and Hutchinson 1996). The 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 are 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) 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.

US Navy Activities on the Southern California Range Complex. The U.S. Navy has been conducting training and other activities on the Southern California Range Complex for more than 70 years. This training, which includes anti-submarine warfare exercises, anti-air warfare exercises, anti-surface warfare exercises, and amphibious warfare exercises, exists as major training events, coordinated training events, unit-level training, and research, development, test, and evaluation. The U.S. Navy estimates that it currently conducts about 8 major training exercises, seven integrated exercises, and numerous unit-level training and maintenance exercise on the Southern California Range Complex each year. In total, training activities on the Southern California Range Complex produces an estimated 3,010 hours of mid-frequency active sonar each year from several sources (see Table 2-10 of the U.S. Navy's Final EIS for the Southern California Range Complex; U.S. Navy 2008).

Although the U.S. Navy did not estimate the number of times different endangered or threatened species might be exposed to mid-frequency active sonar during these training activities, we would expect about 14,000 instances in which endangered or threatened marine mammals would be exposed to Navy training activities during the cold season and another 3,600 exposure events during the warm season. The largest number of exposure events (about 70 percent or about 9,900 exposure events during the cold season and about 1,891 exposure events during the warm season) would involve blue whales, with 2,100 exposure events involving sperm whales (about 15 percent of the exposure events), and 1,900 exposure events involving fin whales (about 13.7 percent of the exposures)

Of this total number of exposure events involving mid-frequency active sonar, the U.S. Navy estimated that blue whales would experience behavioral harassment in about 480 exposure events each year, fin whales would experience behavioral harassment in about 135 exposure events, sperm whales would experience behavioral harassment in about 120 exposure events, and Guadalupe fur seals would experience behavioral harassment in about 772 exposure events. Because blue whales are low-frequency hearing specialists who are not likely to to devote attentional resources to stimuli in this frequency range, we assume that blue whales that experienced changes in behavior would respond more to vessel traffic or other cues associated with an exercise rather than the active sonar itself.

Further, the U.S. Navy estimated that three blue whales would have been behaviorally harassed each year as a result of being exposed to underwater detonations associated with training activities on the Southern California Range Complex and another two blue whales would have experienced temporary losses in hearing sensitivity as a result of being exposed to those detonations. Two fin whales would have been behaviorally harassed each year as a result of being exposed to underwater detonations associated with training activities on the Southern California Range Complex and another fin whale would have experienced temporary losses in hearing sensitivity as a result of being exposed to those detonations. Two sperm whales would have would have been behaviorally harassed each year as a result of being exposed to underwater detonations associated with training activities on the Southern California Range Complex and another two sperm whales would have experienced temporary losses in hearing sensitivity as a result of being exposed to those detonations. Two Guadalupe fur seals would have would have been behaviorally harassed each year as a result of being exposed to underwater detonations associated with training activities on the Southern California Range Complex and another two fur seals would have experienced temporary losses in hearing sensitivity as a result of being exposed to those detonations.

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.

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, a workshop sponsored by the Center for Marine Conservation and the NMFS was held in Monterey, California 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.

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.

Scientific Research

Marine mammals have been the subject of field studies for decades. The primary objective of most of these studies has generally been monitoring populations or gathering data for behavioral and ecological studies. Over time, NMFS has issued dozens of permits for various non-lethal forms of "take" of marine mammals in the proposed action area from a variety of activities, including aerial and vessel surveys, photo-identification, remote biopsy sampling, and attachment of scientific instruments.

For example, existing permits authorized different investigators to harass, pursue, shoot, and wound about 400 endangered North Pacific right whales each year for photo-identification and behavioral observation; harass, pursue, and shoot up to 60 of these right whales per year to place tags; harass, pursue, shoot, and wound 15 cows and calves to take biopsy samples; and harass and pursue 2,300 of these whales incidental to other activities. Since the right whale population in the North Pacific has been estimated to consist of between 29 and 100 individuals (less than 30 individual whales have been identified since the 1950s), existing permits allow investigators to harass each of these endangered whales several times for different research purposes.

Existing permits authorize investigators to make close approaches of other endangered whales species for photographic identification, behavioral observations, passive acoustic recording, aerial photogrammetry, and underwater observation.

BLUE WHALES. Existing permits authorize blue whales to be behaviorally harassed (as that term is defined for the purposes of the Marine Mammal Protection Act) in 6,885 instances in the eastern or central Pacific Ocean and harassed during close approaches for biopsy samples in 1,040 instances (with an additional 35 blue whale calves harassed during close approaches for biopsy samples as well).

FIN WHALES. Existing permits authorize fin whales to be behaviorally harassed (as that term is defined for the purposes of the Marine Mammal Protection Act) in 13,745 instances in the eastern or central Pacific Ocean and harassed during close approaches for biopsy samples in 2,025 instances (with an additional 80 fin whale calves harassed during close approaches for biopsy samples as well).

HUMPBACK WHALES. Existing permits authorize humpback whales to be behaviorally harassed (as that term is defined for the purposes of the Marine Mammal Protection Act) in 29,115 instances in the eastern or central Pacific Ocean and harassed during close approaches for biopsy samples in 4,250 instances (with an additional 525 humpback whale calves harassed during close approaches for biopsy samples as well).

SEI WHALES. Existing permits authorize sei whales to be behaviorally harassed (as that term is defined for the purposes of the Marine Mammal Protection Act) in 3,500 instances in the eastern or central Pacific Ocean and harassed during close approaches for biopsy samples in 457 instances (with an additional 8 sei whale calves harassed during close approaches for biopsy samples as well).

SPERM WHALES. Existing permits authorize sperm whales to be behaviorally harassed (as that term is defined for the purposes of the Marine Mammal Protection Act) in 17,750 instances in the eastern or central Pacific Ocean and harassed during close approaches for biopsy samples in 905 instances (with an additional 75 sperm whale calves harassed during close approaches for biopsy samples as well).

The actual number of close approaches does not appear to have closely approximated the number of close approaches authorized by existing permits. Nevertheless, because existing permits authorize the number of close approaches discussed in the preceding paragraphs, nothing prevents the different whale species from being exposed to those levels of close approaches by different investigators each year.

After decades of this research, the consequences of these levels of close approaches on the population ecology of endangered whales remains unknown (Moore and Clarke 2002). This is particularly problematic because so much research occurs in areas that are critical to the population ecology of whales, such as the calving areas in Hawai’i and feeding areas off California and Alaska. Events or activities that disrupt the behavior of animals in these critical areas could have substantial, long-term consequences for their ecology.

The Impact of the Baseline on Listed Resources

Although listed resources are exposed to a wide variety of past and present state, Federal or private actions and other human activities that have already occurred or continue to occur in the action area as well as Federal projects in the action area that have already undergone formal or early section 7 consultation, and State or private actions that are contemporaneous with this consultation, the impact of those activities on the status, trend, or the demographic processes of threatened and endangered species remains largely unknown.

Historically, commercial whaling had occurred in the action area and had caused all of the large whales to decline to the point where the whales faced risks of extinction that were high enough to list them as endangered species. Since the end of commercial whaling, the primary threat to these species has been eliminated. However, all of the whale species have not recovered from those historic declines and scientists cannot determine if those initial declines continue to influence current populations of most large whale species. Species like Pacific right whales have not begun to recover from the effects of commercial whaling on their populations and continue to face very high risks of extinction in the foreseeable future because of their small population sizes (on the order of 50 individuals) and low population growth rates. Relationships between potential stressors in the marine environments and the responses of these species that may keep their populations depressed are unknown.

Recent attention has focused on the emergence of a wide number of anthropogenic sound sources on the Southern California Range Complex and their role as a pollutant in the marine environment. Relationships between specific sound sources, or anthropogenic sound generally, and the responses of marine mammals to those sources are still subject to extensive scientific research and public inquiry but no clear patterns have emerged. In contrast the individual and cumulative impacts of human activities in Southern California have only been subjected to limited levels of scientific investigation. As a result, the potential consequences of these activities on threatened and endangered marine mammals remains uncertain.

Few of the anthropogenic phenomena on the Southern California Range Complex that represent potential risks to endangered whales in those waters seem likely to kill whales. Instead, most of these phenomena — close approaches by whale-watching and research vessels, anthropogenic sound sources, pollution, and many fishery interactions — would affect the behavioral, physiological, or social ecology of whales in these waters. The second line of evidence consists of reports that suggest that the response of whales to many of the anthropogenic activities on the Southern California Range Complex are probably short-lived, which suggests that the responses would not be expected to affect the fitness of individual whales. Most of these reports relate to humpback whales during their winter, breeding season; there are very few reports of the behavioral responses of other whale species to human activity in the action area. For example, annual reports from the North Gulf Oceanic Society and two other investigators reported that most whales did not react to approaches by their vessels or only small numbers of whales reacted. That is, in their 1999 report on their research activities, the North Gulf Oceanic Society reported observing signs that whales were "disturbed" in only 3 out of 51 encounters with whales and that the whales' behavioral responses consisted of breaching, slapping tail and pectoral fin, and diving away from research vessels.

Gauthier and Sears (1999), Weinrich *et al.* (1991, 1992), Clapham and Mattila (1993), Clapham *et al.* (1993) concluded that close approaches for biopsy samples or tagging did not cause humpback whales to respond or caused them to exhibit “minimal” responses when approaches were “slow and careful.” This caveat is important and is based on studies conducted by Clapham and Mattila (1993) of the reactions of humpback whales to biopsy sampling in breeding areas in the Caribbean Sea. These investigators concluded that the way a vessel approaches a group of whales had a major influence on the whale’s response to the approach; particularly cow and calf pairs. Based on their experiments with different approach strategies, they concluded that experienced, trained personnel approaching humpback whales slowly would result in fewer whales exhibiting responses that might indicate stress.

At the same time, several lines of evidence suggest that these human activities might have greater consequences for individual whales (if not for whale populations). Several investigators reported behavioral responses to close approaches that suggest that individual whales might experience stress responses. Baker *et al.* (1983) described two responses of whales to vessels, including: (1) “horizontal avoidance” of vessels 2,000 to 4,000 meters away characterized by faster swimming and fewer long dives; and (2) “vertical avoidance” of vessels from 0 to 2,000 meters away during which whales swam more slowly, but spent more time submerged. Watkins *et al.* (1981) found that both fin and humpback whales appeared to react to vessel approach by increasing swim speed, exhibiting a startled reaction, and moving away from the vessel with strong fluke motions.

Bauer (1986) and Bauer and Herman (1986) studied the potential consequences of vessel disturbance on humpback whales wintering off Hawai’i. They noted changes in respiration, diving, swimming speed, social exchanges, and other behavior correlated with the number, speed, direction, and proximity of vessels. Results were different depending on the social status of the whales being observed (single males when compared with cows and calves), but humpback whales generally tried to avoid vessels when the vessels were 0.5 to 1.0 kilometer from the whale. Smaller pods of whales and pods with calves seemed more responsive to approaching vessels.

Baker *et al.* (1983) and Baker and Herman (1987) summarized the response of humpback whales to vessels in their summering areas and reached conclusions similar to those reached by Bauer and Herman (1986): these stimuli are probably stressful to the humpback whales in the action area, but the consequences of this stress on the individual whales remains unknown. Studies of other baleen whales, specifically bowhead and gray whales, document similar patterns of short-term, behavioral disturbance in response to a variety of actual and simulated vessel activity and noise (Richardson et. al, 1985; Malme *et al.* 1983). For example, studies of bowhead whales revealed that these whales oriented themselves in relation to a vessel when the engine was on, and exhibited significant avoidance responses when the vessel’s engine was turned on even at a distance of about 3,000 ft (900 m). Weinrich *et al.* (1992) associated “moderate” and “strong” behavioral responses with alarm reactions and stress responses, respectively.

Jahoda *et al.* (2003) studied the response of 25 fin whales in feeding areas in the Ligurian Sea to close approaches by inflatable vessels and to biopsy samples. They concluded that close vessel approaches caused these whales to stop feeding and swim away from the approaching vessel. The whales also tended to reduce the time they spent at surface and increase their blow rates, suggesting an increase in metabolic rates that might indicate a stress response to the approach. In their study, whales that had been disturbed while feeding remained disturbed for hours after the exposure ended. They recommended keeping vessels more than 200 meters from whales and having approaching vessels move at low speeds to reduce visible reactions in these whales.

Beale and Monaghan (2004) concluded that the significance of disturbance was a function of the distance of humans to the animals, the number of humans making the close approach, and the frequency of the approaches. These results would suggest that the cumulative effects of the various human activities in the action area would be greater than the effects of the individual activity. None of the existing studies examined the potential effects of numerous close approaches on whales or gathered information on levels of stress-related hormones in blood samples that are more definitive indicators of stress (or its absence) in animals.

There is mounting evidence that wild animals respond to human disturbance in the same way that they respond to predators (Beale and Monaghan 2004, Frid 2003, Frid and Dill 2002, Gill *et al.* 2000, Gill and Sutherland 2001, Harrington and Veitch 1992, Lima 1998, Romero 2004). These responses manifest themselves as stress responses (in which an animal perceives human activity as a potential threat and undergoes physiological changes to prepare for a flight or fight response or more serious physiological changes with chronic exposure to stressors), 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). These responses have been associated with abandonment of sites (Sutherland and Crockford 1993), reduced reproductive success (Giese 1996, Mullner *et al.* 2004), and the death of individual animals (Daan *et al.* 1996, Feare 1976, Waunters *et al.* 1997).

The strongest evidence of the probable impact of the Environmental Baseline on humpback whales consists of the estimated growth rate of the humpback whale population in the North Pacific Ocean. In the 1980s, the size of the North Pacific humpback whale population was estimated to range from 1,407 to 2,100 (Baker 1985; Darling and Morowitz 1986; Baker and Herman 1987). By the mid-1990s, the population was estimated to consist of about 6,000 whales (standard error = 474) in the North Pacific (Calambokidis *et al.* 1997; Cerchio 1998; Mobley *et al.* 1999). The most recent estimate places the current population of humpback whales in the North Pacific Ocean at about 18,300 whales, not counting calves (Calambokidis *et al.* 2008).

The stress regime created by the activities discussed in this *Environmental Baseline* continues to have a serious and adverse impact on leatherback and loggerhead sea turtles. For several years, NMFS' biological opinions have established that the leatherback and loggerhead sea turtle populations in the Pacific Ocean face high probabilities of extinction as a result of both environmental and demographic stochasticity. Demographic stochasticity, or chance variation in the birth or death of an individual of the population, is facilitated by the increases in mortality rates of leatherback, loggerhead, and Olive ridley sea turtles 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.

The information available suggests that leatherback and loggerhead 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 and loggerhead sea turtles in the Pacific Ocean 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 number of individuals of borh species that continue to be captured and killed in fisheries in the action area contributes to the increased extinction risk of both of these species.

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 are 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 a 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 Baseline* 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. Because this Opinion has previously concluded that the proposed action is not likely to adversely affect critical habitat that has been designated for listed species, critical habitat is not considered in the analyses that follow.

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, the Marine Mammal Protection Act of 1972, as amended, defines "harassment" as "any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering" [16 U.S.C. 1362(18)(A)]. For military readiness activities, this definition of "harassment" has been amended to mean, in part, "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered" (Public Law 106-136, 2004). 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 regulatory definition of harass.[3]

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 behavior that are likely to result in animals that fail to feed, fail to breed

[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).

successfully, or fail to complete their life history because those changes may have adverse consequences for populations of those species.

5.1 Potential Stressors

There are several potential stressors associated with the proposed U.S. Navy training exercises on the Southern California Range Complex (Table 5). This listing is not exhaustive; however, it represents the stressors for which some information is available. Further, the stressors on this list are not mutually exclusive because some sources of stressors may produce multiple stressors. For example, surface vessels represent one stressor because of their weight and speed (risk of potential collisions), a second form of stressor because of the sounds associated with their passage (bow wave and engine noise), and a third form of stressor when they engage their active sonar systems; further, these stressors might interact to create a suite of environmental cues that represents a unique environmental stimulus that is different from each individual cue.

The U.S. Navy has conducted training exercises on the Southern California Range Complex (the Action Area) for several decades and these potential stressors have been associated with most, if not all, of those exercises. As a result, it is more accurate to say that the U.S. Navy proposes to continue to conduct training exercises on the Southern California Range Complex and the potential stressors listed in Table 7 would continue to be associated with those exercises.

Table 5. Potential stressors associated with the activities the U.S. Navy proposes to conduct on the Southern California Range Complex during the twelve-month period beginning in January 2011

	Potential Stressor	Proposed Activity			
		COMPTUEX/JTFEX	Coordinated Training	Unit-Level Training	RDT&E
1	Surface vessel traffic	X	X	X	X
2	Aircraft traffic	X	X	X	X
3	High-frequency active sonar	X	X	X	X
4	Mid-frequency active sonar	X	X	X	X
5	Pressure waves associated with explosions	X	X	X	X
6	Sound fields produced by explosions	X	X	X	X
7	Transmitted sounds from in-air explosions	X	X	X	X
8	Disturbance associated with human presence on beaches (during amphibious exercises)	X	X	X	-
9	Parachutes released during deployment of sonobuoys	X	X	X	X

What follows is a more detailed description of the stressors listed in Table 5 in greater detail. Following those descriptions, we present the results of our exposure analyses, followed by the results of our response analyses. As outlined in the introductory paragraph of this section, we conclude our effects analyses with an *Integration and Synthesis* that presents the results of our risk analyses.

5.1.1 Surface Vessel Traffic

Most of the activities the U.S. Navy proposes to conduct on the Southern California Range Complex involve some level of activity from surface vessels, submarines, or both. Under the baseline condition, Carrier Strike Groups include one aircraft carrier, one carrier air wing, four strike fighter squadrons, one electronic combat squadron, one airborne early warning squadron, two combat helicopter squadrons, two logistics aircraft, five surface combatant ships (guided missile cruisers, destroyers, and frigates), one attack submarine, and one logistics support ship. Under the baseline condition, Expeditionary Strike Groups include three amphibious ships, landing craft – utility, landing craft - air cushioned, amphibious assault vehicle or expeditionary fighting vehicle, three surface combatant ships, three combat helicopter detachments, one attack submarine, one marine expeditionary unit (Special Operations Capable) of 2,200 Marines, ground combat and combat logistics elements, and composite aviation squadron of fixed-wing aircraft and helicopters. Under the baseline condition, Surface Strike Groups include three surface ships, surface combatants, amphibious ships, one combat helicopter detachment, and one attack submarine. An expeditionary strike force may combine with more than one carrier strike group, expeditionary strike group, or surface strike group.

Vessel traffic associated with the proposed training exercises actually represents a suite of stressors or stress regimes that pose several potential hazards to endangered and threatened species on the Southern California Range Complex. First, the size and speed of these surface vessels pose some probability of collisions between marine mammals and sea turtles. Second, this amount of traffic represents an acute or chronic source of disturbance to marine animals on the Southern California Range Complex, although it is not clear what environmental cue marine animals might respond to: the sounds of waters being displaced by the ships, the sounds of the ships' engines, or a combination of environmental cues surface vessels produce while they transit.

Probability of Collisions. 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 (and aircraft) 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 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 measures the U.S. Navy proposes to implement to avoid ship strkes should reduce their frequency, these measures are not likely to eliminate the probability of a whale being struck, injured, or killed by U.S. Navy vessels on the Southern California Range Complex.

Since 1975, U.S. Navy vessels are reported to have struck and injured or killed 13 whales in waters of Southern California; 2 of these 13 strikes occurred in 2009. Of these 13 records, 1 fin whale was struck, 5 gray whales have been struck, and the species was not identified in the remaining 7 strikes. Based on these data, whales have been struck by U.S. Navy vessels in 36 percent of the 36 years between 1975 and 2011. Based on this relative frequency, a U.S. Navy vessel would have slightly less than a 70 percent probability of not striking a whale in any given year, a 25.2 percent probability of striking one whale in any given year, a 4.5 percent probability of striking two whales in a given year, and a 0.6 percent probability of striking more than two whales in any given year.

For the purposes of our analyses, 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 210 meters (689 feet or the distance at which received levels would be about 190 dB) of a Navy vessel moving at speeds greater than 14 knots would have probabilities of being struck that would be substantially greater than zero. That probability would increase as the distance between a whale and the ship decreased (that is, as the estimated received level increased).

Disturbance. 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;

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);

6. *the type of vessel* (displacement versus planing), which marine mammals may interpret as evidence of a vessel's maneuverability.

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. Further, without considering differences in sound fields associated with any active sonar that is used during these exercises, the available evidence suggests that major training exercises, unit- and intermediate-level exercises, and RDT&E activities would represent different stress regimes because of differences in the number of vessels involved, vessel maneuvers, and vessel speeds.

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.

Sounds emitted by large vessels can be characterized as low-frequency, continuous, and tonal, and sound pressure levels at a source will vary according to speed, burden, capacity and length (Richardson *et al.* 1995). Vessels ranging from 135 to 337 meters (*Nimitz*-class aircraft carriers, for example, have lengths of about 332 meters) generate peak source sound levels from 169-200 dB between 8 Hz and 430 Hz. Given the sound propagation of low frequency sounds, a large vessel in this sound range can be heard 139-463 kilometers away (Ross 1976 *in* Polefka 2004).

We recognize that Navy vessels almost certainly incorporate quieting technologies that reduce their acoustic signature (relative to the acoustic signature of similarly-sized vessels) in order to reduce their vulnerability to detection by enemy vessels (Southall 2005). Nevertheless, we do not assume that any quieting technology would be sufficient to prevent marine mammals from detecting sounds produced by approaching Navy vessels and perceiving those sounds as predatory stimuli.

5.1.2 Disturbance from Aircraft

Most of the activities the U.S. Navy proposes to conduct on the Southern California Range Complex also involve some level of activity from aircraft that include helicopters, maritime patrols, and fighter jets. Under the proposed alternative, the U.S. Navy plans to conduct about 3,970 air combat maneuvers, 1,690 anti-submarine warfare tracking exercises, and 245 anti-submarine torpedo exercises among other exercises. Low-flying aircraft produce sounds that marine mammals can hear when they occur at or near the ocean's surface. Helicopters generally tend to produce sounds that can be heard at or below the ocean's surface more than fixed-wing aircraft of similar size and larger aircraft tend to be louder than smaller aircraft. Underwater sounds from aircraft are strongest just below the surface and directly under the aircraft. Sounds from aircraft would not have physical effects on marine mammals but represent acoustic stimuli (primarily low-frequency sounds from engines and rotors) that have been reported to affect the behavior of some marine mammals.

Although several studies have demonstrated the potential adverse effects of aircraft on pinnipeds on haul-out sites or rookeries, Richardson *et al.* (1995) reported that there is no evidence that single or occasional aircraft flying above large whales and pinnipeds in-water cause long-term displacement of these mammals. However, several authors have reported that sperm whales do not react to fixed-wing aircraft or helicopters in some circumstances (Clarke 1956, Gambell 1968, Green *et al.* 1992) and react in others (Clarke 1956, Fritts *et al.* 1983, Mullin *et al.* 1991, Patenaude *et al.* 2006, Richter *et al.* 2003, 2006, Smultea *et al.* 2008, Würsig *et al.* 1998).

Although we recognize sounds produced by aircraft as a potential stressor, we do not have sufficient information to estimate the probability of marine animals being exposed to this stressor associated with the training exercises and other activities the U.S. Navy plans to conduct on the Southern California Range Complex during the twelve-month period beginning in January 2011 .

5.1.3 High-frequency active sonar

Several of the pingers associated with torpedoes, particularly MK-48 torpedoes, and other ordnance the U.S. Navy plans to use on the Southern California Range Complex each year over the twelve-month period beginning in January 2011 produce high-frequency sounds (see Table 6).

5.1.4 Mid-frequency active sonar

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. Several sonar systems are likely to be employed during the activities the U.S. Navy plans to conduct on the Southern California Range Complex, but two systems in particular pose potential risks to listed resources (we should note that other navies that might be involved in the proposed exercises, such as Canada, employ similar active sonar systems as well, but we do not have the information necessary to describe those systems).

The AN/SQS-53 is a large, active-passive, bow-mounted sonar that has been operational since 1975 (see Table 6). AN/SQS-53 is the U.S. Navy's most powerful surface ship sonar and is installed on Ticonderoga (22 units) and Arleigh Burke I/II/IIIa (51 units) class vessels in the U.S. Navy (Polmar 2001, D`Spain *et al.* 2006). This sonar transmits at center frequencies of 2.6 kHz and 3.3 kHz at sources levels up to 235 dB_{RMS} re: 1 μPa at 1 meter. The sonar has pulse durations between 1 and 2 seconds, with about 24-second intervals between pulses. AN/SQS-53 operates at depths of about 7 meters.

The AN/SQS-53 is a computer-controlled, hull-mounted surface-ship sonar that has both active and passive operating capabilities, providing precise information for anti-submarine warfare weapons control and guidance. The system is designed to perform direct-path anti-submarine warfare search, detection, localization, and tracking from a hull-mounted transducer array. The AN/SQS-53 sonar is installed on Arleigh Burke Class guided missile destroyers and Ticonderoga Class guided missile cruisers. The AN/SQS-53 Kingfisher is a modification that provides a surface ship with the ability to detect objects.

Table 6. Description and attributes of sonar sources proposed for use on the Southern California Range Complex

Sonar Source	Depth	Center Freq	Source Level	Emission Spacing	Vertical Directivity	Horizontal Directivity
MK-48	27 m	>10 kHz	classified	144 m	Omni	Omni
AN/SQS-53 (search mode)	7 m	3.5 kHz	235 dB	154 m	Omni	240° Forward-looking
AN/SQS-53 (Kingfisher mode)	7 m	3.5 kHz	235 dB	4.6 m	20° Width 42° D/E	120° Forward-looking
AN/SQS-56	6 m	7.5 kHz	225 dB	154 m	Omni	240° Forward-looking
AN/SSQ-62	27 m	8 kHz	201 dB	450 m	Omni	Omni
AN/AQS-22	27 m	4.1 kHz	217 dB	15 m	Omni	Omni
AN/BQQ-10	7 m	classified	classified	n/a	Omni	Omni
AN/BQQ-15	7 m	>10 kHz	classified	n/a	Omni	Omni
AN/SSQ-125	varies	classified	classified	450 m	Omni	Omni
SLQ-25 NIXIE	varies	classified	classified	n/a	n/a	n/a

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 center frequencies of 6.8 kHz, 7.5 kHz, and 8.2 kHz. at 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 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 duration, rise times, and wave form of sonar transmissions that would be used during Navy training exercise are classified; however, the characteristics of the transmissions that were used during the Bahamas exercises might help illustrate attributes of the transmissions from these two sonar sources. During the Bahamas exercises, these two sonars transmitted 1 – 2 second pulses once every 24 seconds (D’Spain *et al.* 2006). Pulses had rise times of 0.1 – 0.4 seconds and typically consisted of three waveforms with nominal bandwidths up to 100 Hz (D’Spain *et al.* 2006). Both sonar create acoustic fields that are omnidirectional in azimuth, although AN/SQS-53 also can create beams covering 120˚ azimuthal sectors that can be swept from side to side during transits (D’Spain *et al.* 2006). Waveforms of both sonar systems are frequency modulated with continuous waves (D’Spain *et al.* 2006).

Sound Propagation

Near an ocean's surface (roughly the uppermost 150 feet), the sound field will be normally dominated by sound generated by wave action, rain, and other surface activity; that would mask most anthropogenic sounds. Below the surface area of this mixed layer, depth (pressure) dominates the sound speed profile and the sound's speed *increases* with depth. Below the mixed layer, sea temperatures drop rapidly in an area referred to as the thermocline. In this region, temperature dominates the sound speed profile and speed decreases with depth. Finally, beneath the thermocline, the temperature becomes fairly uniform and increasing pressure causes the sound speed profile to increase with depth.

Acoustic waveguides, which include surface ducts as well as the SOFAR (sonar fixing and ranging) channel and deep sound channel of deep waters, focus sound from sources within the waveguide to long ranges. Surface ducts are acoustic waveguides that occur in the uppermost part of the water column when water near the surface are mixed by convection by surface wave activity generated by atmospheric winds. This mixing forms a surface layer with nearly constant temperatures so that sound speeds in the layer increase with depth. If sufficient energy is subsequently reflected downward from the surface, the sound can become "trapped" by a series of repeated upward refractions and downward reflections to create surface ducts or "surface channels". Surface ducts commonly form in the winter because the surface is cooled relative to deeper water; as a result, surface ducts are predictable for certain locations at specific times of the year.

Sound trapped in a surface duct can travel for relatively long distances with its maximum range of propagation dependent on the specifics of the sound speed profile, the frequency of the sound, and the reflective characteristics of the surface. As a general rule, surface duct propagation will increase as the temperature becomes more uniform and depth of the layer increases. For example, a sound's transmission is improved when windy conditions create a well-mixed surface layer or in high-latitude midwinter conditions where the mixed layer extends to several hundred feet deep.

5.1.5 Explosions (including pressure waves and sound field)

The U.S. Navy plans to continue to employ several kinds of explosive ordnance on the Southern California Range Complex (Table 7). 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 warhead, 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 on the Southern California 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. To remain consistent with previous models the Navy has used, the Navy used source depths of one foot for gunnery rounds. For missiles and bombs, the Navy used source depths of 2 meters. For MK-48 torpedoes, which detonate immediately below a target's hull, the Navy used nominal depths of 50 feet for their analyses.

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.

Table 7. Explosive ordnance, net weight and depths of detonations of the ordnance (from U.S. Navy 2007, 2008a)

Ordnance	Net Explosive Weight	Detonation Depth
5" Naval gunfire	9.54 lbs	1 ft
76 mm Rounds	1.6 lbs	1 ft
Maverick	78.5 lbs	2 m
Harpoon	448 lbs	2 m
MK-82	238 lbs	2 m
MK-83	574 lbs	2 m
MK-84	945 lbs	2 m
MK-48	851 lbs	50 ft
Demolition Charges	20 lbs	Bottom

Underwater Detonations Associated with a SINKEX

The U.S. Navy plans to conduct sinking exercises (SINKEX) as part of major training exercises on the Southern California Range Complex. In a SINKEX, a decommissioned surface ship is towed to a specified deep-water location and there used as a target for a variety of weapons. Although no SINKEXs are ever the same, the *Programmatic SINKEX Overseas Environmental Assessment* (March 2006) for the Western North Atlantic describes a representative case derived from past exercises.

In a SINKEX, weapons are typically fired in order of decreasing range from the source with weapons fired until the target is sunk (Table 8). A torpedo may be used after all munitions have been expended if the target is still afloat. Since the target may sink at any time during the exercise, the actual number of weapons used can vary widely. In the representative case, however, all of the ordnances are assumed expended; this represents the worst case of maximum exposure.

Because SINKEXs are one of the cases in which simply adding energy associated with individual types of ordnance might not be appropriate, the U.S. Navy used a "representative" sinking exercise as the basis for its modeling. To the degree that an actual SINKEX involves more or less ordnance, those estimates would vary upward or downward.

Table 8. Representative sequence of weapons fired during a Sink Exercise (from U.S. Navy 2007, 2008a)

Time (in hours local)	Event Description
0900	Range Control Officer receives reports that the exercise area is clear of non-participant ship traffic, marine mammals, and sea turtles.
0909	Hellfire missile fired, hits target.
0915	2 HARM missiles fired, both hit target (5 minutes apart).
0930	1 Penguin missile fired, hits target.
0940	3 Maverick missiles fired, 2 hit target, 1 misses (5 minutes apart).
1145	1 SM-1 fired, hits target.
1147	1 SM-2 fired, hits target.
1205	5 Harpoon missiles fired, all hit target (1 minute apart).
1300-1335	7 live and 3 inert MK 82 bombs dropped – 7 hit target, 2 live and 1 inert miss target (4 minutes apart).
1355-1410	4 MK 83 bombs dropped – 3 hit target, 1 misses target (5 minutes apart).
1500	Surface gunfire commences – 400 5-inch rounds fired (one every 6 seconds), 280 hit target, 120 miss target.
1700	MK 48 Torpedo fired, hits, and sinks target.

5.1.6 Disturbance Associated with Human Presence on Beaches

The U.S. Fish and Wildlife Service has jurisdiction over sea turtles and many other endangered or threatened species when they are above mean higher high water (generally, when they are on a beach). We assume that any effects of the activities the U.S. Navy proposes above mean higher high water on the Southern California Range Complex have been or will be addressed in separate consultations with the U.S. Fish and Wildlife Service.

5.1.7 Parachutes Released During Deployment of Sonobuoys

When AN/SQS-62 DICASS 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.

5.2 Exposure, Response, and Risk Analyses

The narratives that follow present the results of our analyses of the effects of the military readiness activities that would be authorized by the Permits Division’s proposed Letter of Authorization on endangered and threatened species. The narratives are organized by species or species group (in the case of sea turtles) that are likely to be adversely affected by those military readiness activities; within each species or species group, each narrative is organized by exposure, response, and risk (jeopardy) analyses. These narratives do not repeat the extensive reviews of the available scientific and commercial literature that formed the foundation for the response analyses we presented in our January 2009 Programmatic Opinion. Interested readers should refer to that document for those reviews.

Before we present the results of our exposure, response, and risk analyses, however, we summarize how we conducted our exposure analyses and discuss whether and to what degree the measures the U.S. Navy proposes to implement or that the Permits Division proposes to include in its proposed MMPA authorization would be expected to avoid or minimize the number of endangered or threatened species that might otherwise be exposed to the U.S. Navy's training activities on the Southern California Range Complex.

EXPOSURE TO 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 being 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, marine mammals are probably aware of the engine noise and noise produced by displacement of U.S. Navy vessels that are underway. 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).

We present the results of our exposure analyses in the narratives that follow. However, based on the number of training events that occur on the Southern California Range Complex, the number of vessels involved in those training events, and the pattern of ship strikes over the past several decades, we conclude that we cannot discount the probability of a U.S. Navy vessel striking an endangered whale on the Southern California Range Complex.

EXPOSURE TO ACTIVE SONAR. To estimate the number of times endangered or threatened species might be exposed to mid-frequency active sonar, we followed the procedures we describe in the "Exposure to Mid-Frequency Active Sonar" subsection of the *Approach to the Assessment* chapter of this Opinion.

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 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 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.

MITIGATION MEASURES TO MINIMIZE THE LIKELIHOOD OF EXPOSURE TO EXPLOSIONS. The Navy proposes to employ a suite of measures to protect endangered and threatened marine mammals and sea turtles from being exposed to underwater detonations and mining operations during the activities they plan to conduct on the Southern California Range Complex (including sinking exercises). These measures involve site-selection procedures, exclusion zones, and monitoring protocols that comply with Marine Protection, Research, and Sanctuaries Act permits as well as procedures developed and tested during the ship shock trial on the USS WINSTON S CHURCHILL. These monitoring protocols were studied extensively (Clarke and Norman 2005) and those studies concluded that the monitoring protocols effectively insured that marine mammals or sea turtles did not occur within 3.7 kilometers of the underwater detonations.

By incorporating safety zones, monitoring, and shut down procedures similar to those associated with the USS WINSTON S CHURCHILL shock trials into underwater detonations and mining operations that occur on the Southern California Range Complex over the twelve-month period beginning in January 2011, the U.S. Navy should prevent marine mammals and sea turtles from being exposed to energy from underwater detonations associated with the two proposed sinking exercises. Based on the information available, these mitigation and monitoring protocols are likely to prevent endangered or threatened marine mammals and sea turtles from being exposed to detonations associated with these exercises, which would reduce or eliminate their probability of being adversely affected by these detonations.

Nevertheless, the Navy estimated the number of marine mammals that might be exposed to explosions associated with this ordnance. If the mitigation measures the Navy plans on employing are as effective on the Southern California Range Complex as they were during the ship shock trial on the USS WINSTON S CHURCHILL, these are overestimates of the number of animals that are likely to be exposed.

Blue Whale

PROBABLE EXPOSURE. Blue whales appear to migrate to waters offshore of Washington, Oregon, and northern California to forage. We assume the blue whales that might be exposed to active sonar associated with Navy training activities on the Southern California Range Complex will be individuals from the eastern North Pacific population or stock, which occur in waters from California to Alaska in summer and fall and migrate to offshore waters from Mexico to Costa Rica during winter months (Calambokidis *et al*. 1990, NMFS 2006). The blue whales that occur off southern California reach their peak abundance from June to November (Burtenshaw *et al*. 2004) and their lowest abundance during cold-water months (Calambokidis 1995, Forney and Barlow 1998, Larkman and Veit 1998). Because blue whales forage in waters off southern California and reproduce elsewhere, we assume the blue whales that occur in the action area would be adults, juveniles, or calves, but would not consist of cows accompanied by neonate calves.

Most of the blue whales that occur in waters off Southern California 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 would be exposed to stressors associated with military readiness activities on the Southern California Range Complex during all or portions of the winter season; some of these individuals would also be exposed to stressors on the Northwest Training Range Complex during the summer season.

Our analyses led us to reach the following conclusions about the potential stressors blue whales might be exposed to on the Southern California Range Complex and the number of instances in which blue whales might be exposed:

1. As we discussed in the *Approach to the Assessment* chapter of this Opinion, we did not estimate the number of 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 develop exposure models and run simulations 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 210 meters (689 feet or the distance at which received levels would be about 190 dB) of a Navy vessel moving at speeds greater than 14 knots would have probabilities of being struck that would be substantially greater than zero. That probability would increase as the distance between a whale and the ship decreased (that is, as the estimated received level increased).

   Based on these assumptions, in 128 instances, blue whales might occur close enough to a Navy vessel that is underway to have some risk of being struck by the vessel. About 60 percent of these exposure events (76 exposure events) are likely to occur during the warm season, with the remaining 52 exposure events occurring during the cold season. These 128 exposure events might involve separate whales, or a smaller number of whales that are each exposed multiple times, or some combination of these two options.

2. The mid-frequency active sonar training the U.S. Navy proposes to conduct on the Southern California Range Complex was likely to result in about 15,120[7] instances in which blue whales would be exposed to sound fields produced by this sonar at received levels greater than 140 dB, which corresponds to distances closer than 140 or 40 kilometers in the cold or warm seasons, respectively. Slightly more than half of these exposure events would occur during major training exercises, with the balance occurring during unit-level training activities. About 84 percent of these exposures (12,685 exposure events) would occur during the cold season (November to April), with the balance occurring during the warm season (2,440 exposure events).

   Because of the size of the blue whale population along the Pacific coast of the U.S., these 15,120 exposure events almost certainly mean that a smaller number of whales would each be exposed to the sound fields produced by U.S. Navy vessels multiple times. For example, blue whales that occur on the Southern

[7] The numbers presented in this section may not sum to the total reported because of rounding. For example, some estimates were 7,421, which was presented 7,420 because the error in the data supporting the estimate does not allow that level of precision.

California Range Complex are likely to be exposed to energy from active sonar several times during major training exercises (although separate exposure events would probably occur at different distances from ships, so they would involve different received levels). During unit-level training exercises, which involve fewer ships and fewer sonar pings, individual whales might be exposed to the sound field produced by the ships once or a smaller number of times than would occur during a major training exercise.

Of the 12,685 exposure events that are likely to occur during the cold season, about 7,420 exposure events would occur at received levels between 140 and 150 dB or distances between 6.7 and 44 kilometers from the source of a sonar ping; about 3,400 of the exposure events would occur at received levels between 150 and 160 dB, when blue whales would occur between 6.7 and 19 kilometers of the source of a sonar ping; about 1,650 of the exposure events would occur at received levels between 160 and 180 dB, when blue whales would occur between 680 meters and 6.7 kilometers of the source of a sonar ping; and about 167 exposure events would occur at received levels between 180 and 190 dB, when blue whales would occur between 210 and 680 meters of the source of a sonar ping. At received levels between 190 and 210 dB, blue whales would occur between 20 and 60 meters and at received levels greater than 210 dB, blue whales would occur between 0 and 20 meters; at these distances, we assume the risks of a ship strike would exceed any risks associated posed by active sonar transmissions.

Of the 2,440 exposure events that are likely to occur during the warm season, about 1,450 exposure events would occur at received levels between 140 and 150 dB or distances between 8.3 and 40 kilometers from the source of a sonar ping; about 590 of the exposure events would occur at received levels between 150 and 160 dB, when blue whales would occur between 0.5 and 1.3 kilometers of the source of a sonar ping; and about 320 of the exposure events would occur at received levels between 160 and 180 dB, when blue whales would occur between 200 and 1,300 meters of the source of a sonar ping. At received levels between 180 and 210 dB, blue whales would occur between 0 and 200 meters of a Navy vessel; at these distances, we assume the risks of a ship strike would exceed any risks associated posed by active sonar transmissions.

Because the abundance of blue whales reach their peak abundance from June to November, which encompasses only a portion of the cold season, we have more confidence in our exposure estimates for the warm season than for the cold season and believe the number of exposure events we estimated for the cold season substantially over-estimate the actual number of exposure events (unless the Navy conducts 4 major training exercises in the month of October, which does not seem probable).

3. We would expect two instances in which blue whales might be exposed to underwater detonations on the Southern California Range Complex at received levels that would result in “behavioral harassment.” We would expect another two instances 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 re $1\mu Pa^2$-s (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.

These four instances in which blue whales might be exposed to pressure waves or sound fields associated with underwater detonations might involve the same whale or separate whales.

PROBABLE RESPONSES OF BLUE WHALES TO CLOSE APPROACHES BY VESSELS. The most important question is whether the 96 instances in which blue whales might occur within 210 meters (689 feet or the distance at which received levels would be about 190 dB) of a Navy vessel moving at speeds greater than 14 knots are likely to be struck rather than experience a close approach.

Vanderlaan and her co-authors (2008) developed a method for estimating the probability of an encounter an endangered whale (specifically North Atlantic right whales) and surface vessels, including the probability that the whale is killed given that it is struck. We do not have the data that would be required to use the approach Vanderlaan and her co-authors developed to estimate the probability of a whale encountering a vessel; however, we estimated the probability of an encounter between a Navy vessel by analyzing the number of times U.S. Navy vessels have struck whales in waters off Southern California since 1975 (the first record of a ship strike reported by Jensen and Silber [2004] or Laist [2001]). This allowed us to estimate the probability of a collision between a Navy vessel and a whale over the 36-year interval between 1975 and 2010 (that last year for which data are available).

We then used this probability as the rate parameter of a Poisson distribution to estimate the probability of 0, 1, 2, 3,…n ship strikes involving U.S. Navy vessels over the next 12-months. We entered these probabilities (probability of a ship strike > 0) in the equation developed by Vanderlaan and her co-authors to estimate the probability of a ship strike being lethal for the whale.[8]

Since 1975, U.S. Navy vessels are reported to have struck and injured or killed 13 whales in waters of Southern California; 2 of these 13 strikes occurred in 2009. Of these 13 records, 1 fin whale was struck, 5 gray whales have been struck, and the species was not identified in the remaining 7 strikes, although one of these whales was later identified as a fin whale (J. Cordaro, personal communication, 2010). Based on these data, a whale has been struck by U.S. Navy vessels in 36 percent of the 36 years between 1975 and 2011. Based on this relative frequency and recognizing the problems associated with making inferences from such limited data, there is slightly less than a 70 percent probability of a whale not being struck by a U.S. Navy vessel on the Southern California Range Complex over the next 12 months, a 25.2 percent probability of striking one whale being struck, a 4.5 percent probability of two whales being struck, and a 0.6 percent probability of more than two whales being struck. The data available do not allow us to estimate the probability of striking particular whale species.

Using these probabilities in the equation developed by Vanderlaan and her co-authors and assuming U.S. Navy vessels travel at speeds of about 14 knots, the probability of a fatal ship strike on the Southern California Range Complex would be about 21.23 percent between January 2011 and January 2012. This probability of a collision that is fatal to a whale increases to 29.24 percent with vessel speeds of 20 knots and to 30.17 with vessel speeds of 25 knots.

[8] Vanderlaan and her co-authors (2008) calculated the probability of an encounter being lethal as:

$$[Pr(Fatal|Encounter)] = 1/[1+exp^{-(-4.89+0.41x)}]$$

where x is the mean vessel speed, in knots, in a particular cell. This equation presupposes an estimate of the probability of an encounter.

The number of incidents are too limited for us to estimate a blue whale's probability of being struck, injured, or killed in a collision with a U.S. Navy vessel between January 2011 and January 2012 (or over the five-year duration of the MMPA permit). However, the data available suggest that gray whales are more likely to be struck, injured, or killed by a U.S. Navy vessel than any other species of whale (allowing that we could not identify the species in more than half of the collisions that have been reported).

Regardless of their probability of being struck by a ship, we assume that blue whales that find themselves this close to U.S. Navy vessels are likely to suddenly change their behavioral state to avoid an approaching vessel. We also assume that these whales will experience physiological stress responses before and after the avoidance response. 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 B1 of Figure 3). 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 S1.1 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 (the sequence of boxes beginning with Box S2 in Figure 2). 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 (the sequence of boxes beginning with Box S2 in Figure 2 illustrate the potential consequences of these stress responses for the fitness of individual animals). When would expect whales that occur on foraging areas to replenish their energy reserves fairly quickly.

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, 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).

PROBABLE RESPONSES OF BLUE WHALES 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 determine if endangered or threatened marine animals are likely to experience physical trauma, sensory impairment (permanent and temporary threshold shifts and acoustic masking), physiological responses (particular stress responses), behavioral responses, or social responses that are likely to directly or indirectly reduce the fitness of listed individuals. Our assessment of the probable responses of blue whales to active sonar considers the probability of responses in these categories.

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).

Based on the information available (which we review in greater detail in our 2009 Programmatic Opinion), blue whales and the other species considered in this Opinion are not likely to experience acoustic resonance. The evidence available suggests that this phenomenon poses potential risks to cetaceans that engage in deep or prolonged dives. Blue whales do not engage in this kind of diving behavior and, as a result, are not likely to suffer these consequences.

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

Acoustic exposures can result in three main forms of noise-induced losses in hearing sensitivity: permanent threshold shift, temporary threshold shift, and compound threshold shift (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 cell damage does not accompany TTS and losses in hearing sensitivity are short-term and are followed by a period of recovery to pre-exposure hearing sensitivity that can last for minutes, days, or weeks. More recently, however, Kujawa and Liberman (2009) reported on noise-induced degeneration of the cochlear nerve that is a delayed result of acoustic exposures that produce TTS, that occurs in the absence of hair cell damage, and that is irreversible. They concluded that the reversibility of noise-induced threshold shifts, or TTS, can disguise progressive neuropathology that would have long-term consequences on an animal's ability to process acoustic information. If this phenomenon occurs in a wide range of species, TTS may have more permanent effects on an animal's hearing sensitivity than earlier studies would lead us to recognize.

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 on whether animals that experience noise-induced hearing loss also alter their behavior and whether any altered behavior affects the fitness of individuals that experience the loss in hearing sensitivity, the limited information available would not lead us to expect temporary losses in hearing sensitivity to reduce the longevity or reproductive success of individual blue whales or of the other species considered in this Opinion.

Behavioral Responses. Marine mammals 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 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 combination 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, 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.

As we discussed previously, U.S. Navy vessels produce a variety of sounds while they are engaged in military readiness activities. A whale is more likely to perceive a U.S. Navy vessel as an acoustic object surrounded by an envelope of sound that changes over time; the sound field produced by some of those vessels would periodically include pings produced by active sonar (only some of the Navy vessels engaged in military readiness activities employ mid-frequency active sonar). In addition, animals would perceive the sound field produced by sonar pings differently depending on ambient noise levels and the acoustic properties of the ambient noise, the acoustic properties of the ping, how the ping propagates through the ocean environment, and how the spectral qualities of the ping change with time and distance (the frequency structure of a sonar ping degrades with time and distance. For example, lower frequency components of a sonar ping would propagate the furthest while higher-frequency components propagate over shorter distances. As a result, a sonar ping received 10 kilometers from its source would have very different acoustic properties than a sonar ping 100 meters from its source). Therefore, we assume that blue whales on the Southern California Range Complex would respond to all of the environmental cues produced by U.S. Navy vessels as they move through the ocean's surface while transmitting active sonar rather than just active sonar produced by those vessels.

Blue whales are not likely to respond to high-frequency sound sources associated with the military readiness activities the U.S. Navy proposes to conduct on the Southern California Range Complex because of their hearing sensitivities. However, despite numerous authors who concluded that blue whales are not likely to hear (or devote attentional resources to) mid-frequency active sonar because they are considered "low-frequency hearing specialists," preliminary results from the behavioral response study on the Southern California Range Complex suggest that blue whales not only hear mid-frequency active sonar transmissions, in some cases they respond to those transmissions (B. Southall, personal communication, 2010).

Numerous studies have demonstrated that the level of risk an animal perceives will result 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). However, most studies of the effects of anthropogenic sounds on marine mammals have treated received level as the sole or primary determinant of an animal's response, ignoring the importance of the distance between an animal receiving a signal and the source of the signal on the animal's probable response to the sound. Most studies of the effects of anthropogenic sounds on marine mammals have also ignored the rate; directionality, speed, or behavior of a sound source as it approaches an animal (with some noteworthy exceptions). Finally, most studies have ignored the context of acoustic exposure events, including ambient sound levels, signal-to-noise ratios, and the behavioral or physiological state of the animals being studied.

The information that is available for this consultation does not allow us to consider these variables. We can, however, consider the potential effect of distance: the greater the distance between an animal and a stimulus such as active sonar, the greater the probability that the animal will devote attentional resources to stimuli with sources in the local environment than to a mid-frequency stimulus from a distant source. For example, in 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, had most of their energy at frequencies below or above the hearing capacities of these species, or 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.

Similarly, Southall (B. Southall, personal communication, 2010) reported that blue whales observed during the behavioral response study on the Southern California Range Complex appeared to ignore sonar transmissions at received levels lower than about 150 dB, ignored received levels greater than these when they were engaged in some kinds of feeding behavior, but engaged in short, avoidance movements when engaged in other kinds of feeding behavior. Because Southall and his co-workers have not completed their analyses of their data, we do not know whether the lack of response was a function of the received level, the distance between the animal and the sound source (which would have been closer than the 19 kilometers discussed earlier because the source level used in the study was lower than the 235 dB nominal source level Navy vessels employ), the spectral qualities of the ship towing the sound source, the behavior of the ship towing the sound source, or some combination of all of these.

At the limits of the range of audibility, endangered and threatened marine mammals are likely to ignore cues that they might otherwise detect. At received levels below 140 dB, when the sources would be greater than 40 kilometers (24.9 miles) from whales receiving such signals, a whale that perceived a signal is also likely to ignore such a signal and devote its attentional resources to stimuli in its local environment. For the same reasons, we would expect blue whales exposed to active sonar signals at received levels below 150 dB during the cold season, which would occur between 19 and 140 kilometers (11.8 and 87 miles) of the source of a sonar ping, to ignore such signals.

Because of their distance from the source of active sonar, we also would not expect blue whales to change their behavior or experience losses in hearing sensitivity or physiological stress responses in the 7,420 instances in which blue whales might be exposed to received levels ranging from 140 and 150 dB during the cold season (at these received levels, whales exposed to mid-frequency active sonar would occur between 19 and 44 kilometers, or 11.8 and 27 miles, from Navy vessels).

The 3,400 instances in which blue whales might be exposed to received levels between 150 and 160 dB between January-April 2011 and October 2011-January 2012 (the cold season), might cause the blue whales to engage in low-level avoidance behavior (slight changes in their direction of travel) or short-term vigilance behavior that are not likely to result in adverse consequences for that animals exhibiting the behavior. These changes in behavior are more likely if the whales are migrating and less likely if the whales are actively foraging.

Of the blue whales that might be exposed to received levels between 160 and 180 dB during the 1,650 exposure events that are likely to occur between January-April 2011 and October 2011-January 2012, some whales are likely to reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming angle or direction to avoid U.S. Navy vessels, change their respiration rates, increase dive times, or reduce 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). We assume that these responses are more likely to occur when blue whales are aware of multiple vessels in their acoustic scene or when particular vessels are engaged in course changes that are unpredictable from the perspective of the whale.

Some blue whales may be less likely to engage in these responses on the Southern California Range Complex because they occur on the Southern California Range Complex to feed; while they forage, they are less likely to devote attentional resources to the periodic activities the U.S. Navy proposes to conduct on the range complex. The blue whales that are likely to be exposed on the Southern California Range Complex would have had prior experience with similar stressors resulting from their exposure on the Northwest Training Range Complex earlier in the year; that experience will make some blue whales more likely to avoid activities associated with the military readiness activities while other whales would be less likely to avoid those activities. 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.

Although sonar signals would not propagate as efficiently during the warm season, whales exposed to received levels below 140 dB during the warm season would occur between 8.3 and 40 kilometers (5.2 and 24.9 miles) and are not likely to devote attentional resources to degraded mid-frequency signals at such distances.

The 590 instances in which blue whales might be exposed to received levels between 150 and 160 dB between May and October 2011 (the warm season), the blue whales might engage in low-level avoidance behavior (slight changes in their direction of travel) or short-term vigilance behavior that are not likely to result in adverse consequences for that animals exhibiting the behavior. These changes in behavior are more likely if the whales are migrating and less likely if the whales are actively foraging.

Of the blue whales that might be exposed to received levels between 160 and 180 dB during the 320 exposure events that are likely to occur between May and October 2011, some whales are likely to reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming angle or direction to avoid U.S. Navy vessels, change their respiration rates, increase dive times, or reduce feeding behavior, and social interactions. We assume that these responses are more likely to occur when blue whales is aware of multiple vessels in their acoustic scene or when particular vessels are engaged in course changes that are unpredictable from the perspective of the whale.

PROBABLE RESPONSES OF BLUE WHALES TO UNDERWATER DETONATIONS. We would expect two instances in which blue whales might be exposed to underwater detonations on the Southern California Range Complex at received levels that would result in "behavioral harassment." We would expect another two instances 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 re 1µPa^2-s (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 RISK. Our consideration of probable exposures and responses of blue whales to stressors associated with the military readiness activities on the Southern California Range Complex are designed to help us answer the question of the whether those activities are likely to increase the extinction risks facing blue whales. Although the military readiness activities the U.S. Navy plans to conduct on the Southern California Range Complex January 2011 through January 2012 are likely to cause some individual blue whales to experience changes in their behavioral states that, in some circumstances, might have adverse consequences for free-ranging animals (Frid 2001, Frid and Dill 2002, Papouchis *et al*. 2001), particularly animals that are endangered or threatened with extinction. For blue whales on the Southern California Range Complex, however, these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual blue whales in ways or to a degree that would reduce their fitness because the whales are actively foraging in waters on and around the range complex or migrating through the range complex.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Whales have an ability to store substantial amounts of energy, which allows them to survive for months on stored energy during migration and while in their wintering areas, and their feeding patterns allow them to acquire energy at high rates. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like blue whales. As a result, the blue whales' probable responses to close approaches by Navy vessels and their probable exposure to active sonar and underwater detonations are not likely to reduce the current or expected future reproductive success of blue whales or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

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 such populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the species is the blue whale. As a result, the activities the U.S. Navy plans to conduct on the Southern California Range Complex from January 2011 through January 2012 are not likely to appreciably reduce the blue whales' likelihood of surviving and recovering in the wild.

Fin whale

PROBABLE EXPOSURE. 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 on the Southern California Range Complex appear to migrate between summer, foraging areas and winter rearing areas along the Pacific Coast of the United States; however, like blue whales, they are likely to occur in these waters throughout the year with higher densities (and higher probabilities) of exposure during the warm season. Because of their migratory habit, we assumed that some of these individuals would also be exposed to stressors on the Northwest Training Range Complex during the summer season.

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

1. As we discussed in the *Approach to the Assessment* chapter of this Opinion and in the preceding narrative for blue whales, we did not estimate the number of 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 develop exposure models and run simulations 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.

   Based on these assumptions, in 55 instances, fin whales might occur close enough to a Navy vessel that is underway to have some risk of being struck by the vessel. About 82 percent of these exposure events (45 exposure events) might occur during the warm season and 10 exposure events might occur during the cold season. These 55 exposure events might involve 55 separate fin whales, or a smaller number of whales that are each exposed multiple times, or some combination of the two.

2. The mid-frequency active sonar training the U.S. Navy proposes to conduct on the Southern California Range Complex was likely to result in about 3,900 instances in which fin whales would be exposed to sound fields produced by this sonar at received levels greater than 140 dB, which corresponds to distances closer than 140 or 40 kilometers in the cold or warm seasons, respectively. Slightly more than half of these exposure events would occur during major training exercises, with the balance occurring during unit-level training activities. About 63 percent of these exposures (2,475 exposure events) would occur during the cold season (November to April), with the balance occurring during the warm season (1,425 exposure events).

   Because of the size of the fin whale population along the Pacific coast of the U.S., these 3,900 exposure events almost certainly mean that a smaller number of whales would each be exposed to the sound fields produced by U.S. Navy vessels multiple times. For example, fin whales that occur on the Southern California Range Complex are likely to be exposed to energy from active sonar several times during major training exercises (although separate exposure events would probably occur at different distances from ships, so they would involve different received levels). During unit-level training exercises, which involve fewer ships and fewer sonar pings, individual whales might be exposed to the sound field produced by the ships once or a smaller number of times than would occur during a major training exercise.

Of the 2,475 exposure events that are likely to occur during the cold season, about 1,450 exposure events would occur at received levels between 140 and 150 dB or distances between 6.7 and 44 kilometers from the source of a sonar ping; about 665 exposure events would occur at received levels between 150 and 160 dB, when fin whales would occur between 6.7 and 19 kilometers of the source of a sonar ping; about 320 exposure events would occur at received levels between 160 and 180 dB, when fin whales would occur between 680 meters and 6.7 kilometers of the source of a sonar ping; and about 35 exposure events would occur at received levels between 180 and 190 dB, when fin whales would occur between 210 and 680 meters of the source of a sonar ping. At received levels between 190 and 210 dB, fin whales would occur between 20 and 60 meters and at received levels greater than 210 dB, fin whales would occur between 0 and 20 meters; at these distances, we assume the risks of a ship strike would exceed any risks associated posed by active sonar transmissions.

Of the 1,425 exposure events that are likely to occur during the warm season, about 850 exposure events would occur at received levels between 140 and 150 dB or distances between 8.3 and 40 kilometers from the source of a sonar ping; about 345 exposure events would occur at received levels between 150 and 160 dB, when fin whales would occur between 0.5 and 1.3 kilometers of the source of a sonar ping; and about 190 exposure events would occur at received levels between 160 and 180 dB, when fin whales would occur between 200 and 1,300 meters of the source of a sonar ping. At received levels between 180 and 210 dB, fin whales would occur between 0 and 200 meters of a Navy vessel; at these distances, we assume the risks of a ship strike would exceed any risks associated posed by active sonar transmissions.

3. We would expect two instances in which fin whales might be exposed to underwater detonations on the Southern California Range Complex at received levels that would result in "behavioral harassment." We would expect another two 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. We would not expect any fin whales to be exposed to received levels of 205 dB re $1\mu Pa^2$-s (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.

   These four instances in which fin whales might be exposed to pressure waves or sound fields associated with underwater detonations might involve the same whale or separate whales.

PROBABLE RESPONSES OF FIN WHALES TO CLOSE APPROACHES BY VESSELS. The most important question is whether the 55 instances in which fin whales might occur within 210 meters (689 feet or the distance at which received levels would be about 190 dB) of a Navy vessel moving at speeds greater than 14 knots are likely to be struck rather than experience a close approach.

Applying the approach we discussed in the preceding narrative for blue whales to the two fin whales have been reported to have been struck and killed by a U.S. Navy on the Southern California Range Complex since 1975, we would conclude that there is at least a 14.26 percent probability of one or more collisions between Navy vessels and fin whales over the next twelve months (this estimate would be higher if one or more of the unknown whales that have been struck and killed were, in fact, fin whales; so we consider this a minimum estimate). Using this probability in the equation developed by Vanderlaan and her co-authors (2008) and assuming U.S. Navy vessels travel at speeds of about 14 knots, the probability of a fin whale being struck and killed by a U.S. Navy vessel on the Southern California Range Complex would be about 4.45 percent between January 2011 and January 2012, assuming nominal ship speeds of 10 knots. These probabilities increase to 13,76 percent with vessel speeds of 20 knots and to 14,19 with vessel speeds of 25 knots.

Regardless of their probability of being struck by a ship, we assume that fin whales that find themselves this close to U.S. Navy vessels are likely to suddenly change their behavioral state to avoid an approaching vessel. We also assume that these whales will experience physiological stress responses before and after the avoidance response.

PROBABLE RESPONSES OF FIN WHALES TO ACTIVE SONAR. We have already discussed the purpose and structure of our response analyses in the *Approach to the Assessment* section of this Opinion and the preceding narrative for blue whales. Employing the same approach, we reached the following conclusions about the probable responses of fin whales exposed to active sonar.

Acoustic Resonance. For the reasons we discussed in the preceding narrative for blue whales, based on the information available (which we review in greater detail in our 2009 Programmatic Opinion), fin whales and the other species considered in this Opinion are not likely to experience acoustic resonance. The evidence available suggests that this phenomenon poses potential risks to smaller cetaceans such as some beaked whales rather than larger cetaceans such as fin whales.

Noise-Induced Loss of Hearing Sensitivity. For the reasons we discussed in the preceding narrative for blue whales, the limited information available would not lead us to expect temporary losses in hearing sensitivity to reduce the longevity or reproductive success of individual fin whales or of the other species considered in this Opinion.

Behavioral Responses. Fin whales are not likely to respond to high-frequency sound sources associated with the military readiness activities the U.S. Navy proposes to conduct on the Southern California Range Complex because of their hearing sensitivities. However, despite numerous authors who concluded that fin whales are not likely to hear (or devote attentional resources to) mid-frequency active sonar because they are considered “low-frequency hearing specialists,” preliminary results from the behavioral response study on the Southern California Range Complex suggest that fin whales not only hear mid-frequency active sonar transmissions, in some cases they respond to those transmissions (B. Southall, personal communication, 2010).

Like blue whales, we assume that fin whales can perceive mid-frequency active sonar transmissions, but are likely to ignore sonar transmissions at received levels lower than about 150 dB, ignore received levels greater than these when they were engaged in some kinds of feeding behavior, and engage in short, avoidance movements when engaged in other kinds of feeding behavior. Because of their distance from the source of active sonar, we also would not expect fin whales to change their behavior or experience losses in hearing sensitivity or physiological stress responses in the 1,450 instances in which fin whales might be exposed to received levels ranging from 140 and 150 dB during the cold season (at these received levels, whales exposed to mid-frequency active sonar would occur between 19 and 44 kilometers, or 11.8 and 27 miles, from Navy vessels).

The 665 instances in which fin whales might be exposed to received levels between 150 and 160 dB between January-April 2011 and October 2011-January 2012 (the cold season), might cause the fin whales to engage in low-level avoidance behavior (slight changes in their direction of travel) or short-term vigilance behavior that are not likely to result in adverse consequences for animals exhibiting the behavior. These changes in behavior are more likely if the whales are migrating and less likely if the whales are actively foraging.

Of the fin whales that might be exposed to received levels between 160 and 180 dB during the 320 exposure events that are likely to occur between January-April 2011 and October 2011-January 2012, some whales are likely to reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming angle or direction to avoid U.S. Navy vessels, change their respiration rates, increase dive times, or reduce 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). We assume that these responses are more likely to occur when fin whales are aware of multiple vessels in their acoustic scene or when particular vessels are engaged in course changes that are unpredictable from the perspective of the whale.

Some fin whales may be less likely to engage in these responses on the Southern California Range Complex because they occur on the Southern California Range Complex to feed; while they forage, they are less likely to devote attentional resources to the periodic activities the U.S. Navy proposes to conduct on the range complex. The fin whales that are likely to be exposed on the Southern California Range Complex would have had prior experience with similar stressors resulting from their exposure on the Northwest Training Range Complex earlier in the year; that experience will make some fin whales more likely to avoid activities associated with the military readiness activities while other whales would be less likely to avoid those activities. 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.

The 850 instances in which fin whales might be exposed to received levels between 150 and 160 dB between May and October 2011 (the warm season), might engage in low-level avoidance behavior (slight changes in their direction of travel) or short-term vigilance behavior that are not likely to result in adverse consequences for that animals exhibiting the behavior. These changes in behavior are more likely if the whales are migrating and less likely if the whales are actively foraging.

Of the fin whales that might be exposed to received levels between 160 and 180 dB during the 190 exposure events that are likely to occur between May and October 2011, some whales are likely to reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming angle or direction to avoid U.S. Navy vessels, change their respiration rates, increase dive times, or reduce feeding behavior, and social interactions. We assume that these responses are more likely to occur when fin whales are aware of multiple vessels in their acoustic scene or when particular vessels are engaged in course changes that are unpredictable from the perspective of the whale.

PROBABLE RESPONSES OF FIN WHALES TO UNDERWATER DETONATIONS. We would expect two instances in which fin whales might be exposed to underwater detonations on the Southern California Range Complex at received levels that would result in "behavioral harassment." We would expect another two 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. We would not expect any fin whales to be exposed to received levels of 205 dB re 1µPa^2-s (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 RISK. As we discussed in the narrative for blue whales, our consideration of probable exposures and responses of fin whales to stressors associated with the military readiness activities on the Southern California Range Complex are designed to help us answer the question of whether those activities are likely to increase the extinction risks facing fin whales. Although the military readiness activities the U.S. Navy plans to conduct on the Southern California Range Complex January 2011 through January 2012 are likely to cause some individual fin whales to experience changes in their behavioral states that, in some circumstances, might have adverse consequences for free-ranging animals (Frid 2001, Frid and Dill 2002, Papouchis *et al*. 2001), these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual fin whales in ways or to a degree that would reduce their fitness because the whales are actively foraging in waters on and around the range complex or migrating through the range complex.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Whales have an ability to store substantial amounts of energy, which allows them to survive for months on stored energy during migration and while in their wintering areas, and their feeding patterns allow them to acquire energy at high rates. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like fin whales. As a result, the fin whales' probable responses to close approaches by Navy vessels and their probable exposure to active sonar and underwater detonations are not likely to reduce the current or expected future reproductive success of fin whales or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

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). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the species is the fin whale. As a result, the activities the U.S. Navy plans to conduct on the Southern California Range Complex from January 2011 through January 2012 are not likely to appreciably reduce the fin whales' likelihood of surviving and recovering in the wild.

Humpback whale

PROBABLE EXPOSURE. We assume that the humpback whales that occur on the Southern California Range Complex would be individuals from the eastern North Pacific population or "stock" which inhabits waters from Costa Rica to southern British Columbia. These whales are most abundant in coastal waters off California during spring and summer, and off Mexico during autumn and winter. As a result, we believe the estimates for the warm season are more reliable than the estimates for the cold season. Further, because humpback whales forage in waters off southern California and reproduce elsewhere, we assume the humpback whales that occur in the action area would be adults, juveniles, or calves, but would not consist of cows accompanied by neonate calves.

Our analyses led us to reach the following conclusions about the potential stressors humpback whales might be exposed to on the Southern California Range Complex and the number of instances in which humpback whales might be exposed:

1. As we discussed in the *Approach to the Assessment* chapter of this Opinion and in the preceding narrative for blue whales, we did not estimate the number of 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 develop exposure models and run simulations 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.

   Based on these assumptions, we identified four instances in which humpback whales might occur close enough to a Navy vessel that is underway to have some risk of being struck by the vessel. One instance would occur during the cold season and three during the warm season.

2. The mid-frequency active sonar training the U.S. Navy proposes to conduct on the Southern California Range Complex was likely to result in about 300 instances in which humpback whales would be exposed to sound fields produced by this sonar at received levels greater than 140 dB, which corresponds to distances closer than 140 or 40 kilometers in the cold or warm seasons, respectively. Slightly more than half of these exposure events would occur during major training exercises, with the balance occurring during unit-level training activities. About 229 of these exposure events would occur during the cold season (November to April), with the balance occurring during the warm season (72 exposure events).

   Because of the size of the humpback whale population in waters of the Southern California Range Complex, these 300 exposure events almost certainly mean that a smaller number of whales would each be exposed to the sound fields produced by U.S. Navy vessels multiple times. For example, humpback whales that occur on the Southern California Range Complex are likely to be exposed to energy from active sonar several times during major training exercises (although separate exposure events would probably occur at different distances from ships, so they would involve different received levels). During unit-level training exercises, which involve fewer ships and fewer sonar pings, individual whales might be exposed to the sound field produced by the ships once or a smaller number of times than would occur during a major training exercise.

   Of the 229 exposure events that are likely to occur during the cold season, about 134 exposure events would occur at received levels between 140 and 150 dB or distances between 6.7 and 44 kilometers from the source of a sonar ping; about 60 exposure events would occur at received levels between 150 and 160 dB, when humpback whales would occur between 6.7 and 19 kilometers of the source of a sonar ping; about 30 exposure events would occur at received levels between 160 and 180 dB, when humpback whales would occur between 680 meters and 6.7 kilometers of the source of a sonar ping; and about 4 exposure events would occur at received levels between 180 and 200 dB, when humpback whales would occur between 210 and 680 meters of the source of a sonar ping. At received levels between 200 and 210 dB, humpback whales would occur between 20 and 60 meters and at received levels greater than 210 dB, humpback whales would occur between 0 and 20 meters; at these distances, we assume the risks of a ship strike would exceed any risks associated posed by active sonar transmissions.

Of the 72 exposure events that are likely to occur during the warm season, about 43 exposure events would occur at received levels between 140 and 150 dB or distances between 8.3 and 40 kilometers from the source of a sonar ping; about 17 exposure events would occur at received levels between 150 and 160 dB, when humpback whales would occur between 0.5 and 1.3 kilometers of the source of a sonar ping; and about 9 exposure events would occur at received levels between 160 and 180 dB, when humpback whales would occur between 200 and 1,300 meters of the source of a sonar ping. At received levels between 180 and 210 dB, humpback whales would occur between 0 and 200 meters of a Navy vessel; at these distances, we assume the risks of a ship strike would exceed any risks associated posed by active sonar transmissions.

3. We would not expect any instances in which humpback whales might be exposed to underwater detonations on the Southern California Range Complex at received levels that would result in "behavioral harassment" or in which humpback whales might be exposed to received levels of 205 dB re 1μPa^2-s (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 HUMPBACK WHALES TO CLOSE APPROACHES BY VESSELS. The most important question is whether the four instances in which humpback whales might occur within 210 meters (689 feet or the distance at which received levels would be about 190 dB) of a Navy vessel moving at speeds greater than 14 knots are likely to be struck rather than experience a close approach.

Applying the approach we discussed in the preceding narrative for blue whales, the number of incidents are too limited for us to estimate a humpback whale's probability of being struck, injured, or killed in a collision with a U.S. Navy vessel between January 2011 and January 2012 (or over the five-year duration of the MMPA permit). However, the data available suggest that gray whales are more likely to be struck, injured, or killed by a U.S. Navy vessel than any other species of whale (allowing that we could not identify the species in more than half of the collisions that have been reported).

Regardless of their probability of being struck by a ship, we assume that humpback whales that find themselves this close to U.S. Navy vessels are likely to suddenly change their behavioral state to avoid an approaching vessel. We also assume that these whales will experience physiological stress responses before and after the avoidance response.

PROBABLE RESPONSES OF HUMPBACK WHALES TO ACTIVE SONAR. We have already discussed the purpose and structure of our response analyses in the *Approach to the Assessment* section of this Opinion and the preceding narrative for blue whales. Employing the same approach, we reached the following conclusions about the probable responses of humpback whales exposed to active sonar.

Acoustic Resonance. For the reasons we discussed in the preceding narrative for blue whales, based on the information available (which we review in greater detail in our 2009 Programmatic Opinion), humpback whales and the other species considered in this Opinion are not likely to experience acoustic resonance. The evidence available suggests that this phenomenon poses potential risks to smaller cetaceans such as some beaked whales rather than larger cetaceans such as humpback whales.

Noise-Induced Loss of Hearing Sensitivity. For the reasons we discussed in the preceding narrative for blue whales, the limited information available would not lead us to expect temporary losses in hearing sensitivity to reduce the longevity or reproductive success of individual humpback whales or of the other species considered in this Opinion.

Behavioral Responses. Unlike blue and fin whales, humpback whales have previously been reported to have hearing sensitivities ranging from 0.7 kHz to 10 kHz, with a maximum sensitivity between 2 and 6 kHz (Helwig *et al.* 2000), which overlaps with the frequency ranges of the mid-frequency active sonar the U.S. Navy proposes to employ on the Southern California Range Complex. However, like blue and fin whales, humpback whales are not likely to respond to high-frequency sound sources associated with the military readiness activities the U.S. Navy proposes to conduct on the Southern California Range Complex because of their hearing sensitivities.

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 the information available, we assume that humpback whales are likely to ignore sonar transmissions at received levels lower than about 150 dB, ignore received levels greater than these when they were engaged in some kinds of feeding behavior, and engage in short, avoidance movements when engaged in other kinds of feeding behavior. Because of their distance from the source of active sonar, we also would not expect humpback whales to change their behavior or experience losses in hearing sensitivity or physiological stress responses in the 180 instances in which humpback whales might be exposed to received levels ranging from 140 and 150 dB during the cold season (at these received levels, whales exposed to mid-frequency active sonar would occur between 19 and 44 kilometers, or 11.8 and 27 miles, from Navy vessels).

The 80 instances in which humpback whales might be exposed to received levels between 150 and 160 dB between January-April 2011 and October 2011-January 2012 (the cold season), might cause the whales to engage in low-level avoidance behavior (slight changes in their direction of travel) or short-term vigilance behavior that are not likely to result in adverse consequences for that animals exhibiting the behavior. These changes in behavior are more likely if the whales are migrating and less likely if the whales are actively foraging.

Of the humpback whales that might be exposed to received levels between 160 and 180 dB during the 40 exposure events that are likely to occur between January-April 2011 and October 2011-January 2012, some whales are likely to reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming angle or direction to avoid U.S. Navy vessels, change their respiration rates, increase dive times, or reduce 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). We assume that these responses are more likely to occur when humpback whales are aware of multiple vessels in their acoustic scene or when particular vessels are engaged in course changes that are unpredictable from the perspective of the whale.

Some humpback whales may be less likely to engage in these responses on the Southern California Range Complex because they occur on the Southern California Range Complex to feed; while they forage, they are less likely to devote attentional resources to the periodic activities the U.S. Navy proposes to conduct on the range complex. The humpback whales that are likely to be exposed on the Southern California Range Complex would have had prior experience with similar stressors resulting from their exposure on the Northwest Training Range Complex earlier in the year; that experience will make some humpback whales more likely to avoid activities associated with the military readiness activities while other whales would be less likely to avoid those activities. 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.

The 60 instances in which humpback whales might be exposed to received levels between 150 and 160 dB between May and October 2011 (the warm season), might engage in low-level avoidance behavior (slight changes in their direction of travel), short-term vigilance behavior, acoustic masking, impairment of acoustic communication, behavioural disturbance, and physiological stress responses as a result of that exposure. However, these responses are not likely to result in adverse consequences for animals exhibiting the behavior. These changes in behavior are more likely if the whales are migrating and less likely if the whales are actively foraging.

Of the humpback whales that might be exposed to received levels between 160 and 180 dB during the 15 exposure events that are likely to occur between May and October 2011, some whales are likely to reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming angle or direction to avoid U.S. Navy vessels, change their respiration rates, increase dive times, or reduce feeding behavior, and social interactions. We assume that these responses are more likely to occur when humpback whales are aware of multiple vessels in their acoustic scene or when particular vessels are engaged in course changes that are unpredictable from the perspective of the whale.

PROBABLE RISK. As we discussed in the narrative for blue whales, our consideration of probable exposures and responses of humpback whales to stressors associated with the military readiness activities on the Southern California Range Complex are designed to help us answer the question of the whether those activities are likely to increase the extinction risks facing humpback whales. Although the military readiness activities the U.S. Navy plans to conduct on the Southern California Range Complex January 2011 through January 2012 are likely to cause some individual humpback whales to experience changes in their behavioral states that, in some circumstances, might have adverse consequences for free-ranging animals (Frid 2001, Frid and Dill 2002, Papouchis *et al*. 2001), these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual humpback whales in ways or to a degree that would reduce their fitness because the whales are actively foraging in waters on and around the range complex or migrating through the range complex.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Whales have an ability to store substantial amounts of energy, which allows them to survive for months on stored energy during migration and while in their wintering areas, and their feeding patterns allow them to acquire energy at high rates. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like humpback whales. As a result, the humpback whales' probable responses to close approaches by Navy vessels and their probable exposure to active sonar and underwater detonations are not likely to reduce the current or expected future reproductive success of humpback whales or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

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). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the species is the humpback whale. As a result, the activities the U.S. Navy plans to conduct on the Southern California Range Complex from January 2011 through January 2012 are not likely to appreciably reduce the humpback whales' likelihood of surviving and recovering in the wild.

Sperm whale

PROBABLE EXPOSURE. Sperm whales are reported to be rare over the continental shelf of the Southern California Bight, but abundant directly offshore of the Southern California Bight (Bonnell and Dailey 1993). During the 1991 and 1993 ship-based surveys conducted by NMFS, sperm whales were more abundant farther offshore and farther south than they were on the Southern California Bight. There are widely scattered sightings of sperm whales in deep waters of the Southern California Range Complex in the warm-water period, and few sightings in the cold-water period. No sperm whales were sighted during the 1998–1999 NMFS' aerial surveys of the San Clemente Island range complex (Carretta *et al*. 2000). Vessel surveys conducted in 2001 and 2005 both yielded sightings of sperm whales (Forney 2007, Appler *et al*. 2004). However, sperm whales are found on the Southern California Range Complex throughout the year (Carretta *et al*. 2000).

We assume that any sperm whales exposed to active sonar during Navy training activities on the Southern California Range Complex will represent individuals from the California-Oregon-Washington population or "stock." Although the distribution of these sperm whales varies seasonally, the abundance of these sperm whales reaches two peaks during the year: from April through mid-June and from late August through mid-November (NMFS 2006).

Our analyses led us to reach the following conclusions about the potential stressors sperm whales might be exposed to on the Southern California Range Complex and the number of instances in which sperm whales might be exposed:

1. As we discussed in the *Approach to the Assessment* chapter of this Opinion and in the preceding narratives for endangered whales, we did not estimate the number of endangered or threatened 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 develop exposure models and run simulations 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.

   Based on these assumptions, we identified 34 instances in which sperm whales might occur close enough to a Navy vessel that is underway to have some risk of being struck by the vessel.

2. The mid-frequency active sonar training the U.S. Navy proposes to conduct on the Southern California Range Complex was likely to result in about 4,865 instances in which sperm whales would be exposed to sound fields produced by this sonar at received levels greater than 140 dB, which corresponds to distances closer than 140 or 40 kilometers in the cold or warm seasons, respectively. Slightly more than half of these exposure events would occur during major training exercises, with the balance occurring during unit-level training activities. About 4,330 of these exposure events would occur during the cold season (November to April), with the balance occurring during the warm season (about 535 exposure events).

   We do not know the size of the sperm whale population in waters of the Southern California Range Complex, however, these 4,865 exposure events would almost certainly involve the same individuals who are exposed multiple times.

   Of the 4,330 exposure events that are likely to occur during the cold season, about 2,535 exposure events would occur at received levels between 140 and 150 dB or distances between 6.7 and 44 kilometers from the source of a sonar ping; about 1,160 exposure events would occur at received levels between 150 and 160 dB, when sperm whales would occur between 6.7 and 19 kilometers of the source of a sonar ping; and 565 exposure event would occur at received levels between 160 and 180 dB, when sperm whales would occur between 680 meters and 6.7 kilometers of the source of a sonar ping. and about 60 exposure events would occur at received levels between 180 and 190 dB, when sperm whales would occur between 210 and

680 meters of the source of a sonar ping. At received levels between 190 and 210 dB, sperm whales would occur between 20 and 60 meters and at received levels greater than 210 dB, sperm whales would occur between 0 and 20 meters; at these distances, we assume the risks of a ship strike would exceed any risks associated posed by active sonar transmissions.

Of the 535 exposure events that are likely to occur during the warm season, about 320 exposure events would occur at received levels between 140 and 150 dB or distances between 8.3 and 40 kilometers from the source of a sonar ping; about 130 exposure events would occur at received levels between 150 and 160 dB, when sperm whales would occur between 0.5 and 1.3 kilometers of the source of a sonar ping; and about 70 exposure events would occur at received levels between 160 and 180 dB, when sperm whales would occur between 200 and 1,300 meters of the source of a sonar ping. At received levels between 180 and 210 dB, sperm whales would occur between 0 and 200 meters of a Navy vessel; at these distances, we assume the risks of a ship strike would exceed any risks associated posed by active sonar transmissions.

3. We would expect about 201 instances in which sperm whales might be exposed to underwater detonations on the Southern California Range Complex at received levels that would result in "behavioral harassment." We would expect another eight instances in which sperm 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 expect two instances in which sperm whales might be exposed to received levels of 205 dB re 1μPa^2-s (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 and one instance in which temporary threshold shifts as a result of their exposure to an underwater detonation.

PROBABLE RESPONSES OF SPERM WHALES TO CLOSE APPROACHES BY VESSELS. The most important question is whether the 34 instances in which sperm whales might occur within 210 meters (689 feet or the distance at which received levels would be about 190 dB) of a Navy vessel moving at speeds greater than 14 knots are likely to be struck rather than experience a close approach.

Applying the approach we discussed in the preceding narrative for blue whales, the number of incidents are too limited for us to estimate a sperm whale's probability of being struck, injured, or killed in a collision with a U.S. Navy vessel between January 2011 and January 2012 (or over the five-year duration of the MMPA permit). However, the data available suggest that gray whales are more likely to be struck, injured, or killed by a U.S. Navy vessel than any other species of whale (allowing that we could not identify the species in more than half of the collisions that have been reported).

Regardless of their probability of being struck by a ship, we assume that sperm whales that find themselves this close to U.S. Navy vessels are likely to suddenly change their behavioral state to avoid an approaching vessel. We also assume that these whales will experience physiological stress responses before and after the avoidance response.

PROBABLE RESPONSES OF SPERM WHALES TO ACTIVE SONAR. We have already discussed the purpose and structure of our response analyses in the *Approach to the Assessment* section of this Opinion and the preceding narrative for blue whales. Employing the same approach, we reached the following conclusions about the probable responses of sperm whales exposed to active sonar.

Acoustic Resonance. For the reasons we discussed in the preceding narrative for blue and fin whales, based on the information available (which we review in greater detail in our 2009 Programmatic Opinion), sperm whales and the other species considered in this Opinion are not likely to experience acoustic resonance. The evidence available suggests that this phenomenon poses potential risks to smaller cetaceans such as some beaked whales rather than larger cetaceans such as sperm whales.

Noise-Induced Loss of Hearing Sensitivity. For the reasons we discussed in the preceding narrative for blue and fin whales, the limited information available would not lead us to expect temporary losses in hearing sensitivity to reduce the longevity or reproductive success of individual sperm whales or of the other species considered in this Opinion.

Behavioral Responses. 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 sometimes avoid sound sources well before they are exposed to the levels listed above, and reactions in the wild may be more subtle than those described by Ridgway *et al.* (1997) and Schlundt *et al.* (2000).

Other studies identify instances in which sperm whales did not respond to anthropogenic sounds. Sperm whales did not alter their vocal activity when exposed to levels of 173 dB re 1 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 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). 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 studies suggest 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.

Based on the information available, we assume that sperm whales are likely to ignore sonar transmissions at received levels lower than about 150 dB, ignore received levels greater than these when they were engaged in some kinds of feeding behavior, and engage in short, avoidance movements when engaged in other kinds of feeding behavior. Because of their distance from the source of active sonar, we also would not expect sperm whales to change their behavior or experience losses in hearing sensitivity or physiological stress responses in the 2,335 nstances in which sperm whales might be exposed to received levels ranging from 140 and 150 dB during the cold season (at these received levels. whales exposed to mid-frequency active sonar at these received levels would occur between 19 and 44 kilometers, or 11.8 and 27 miles, from Navy vessels).

Of the 565 instances in which sperm whales might be exposed at received levels between 160 and 180 dB, when the whales would occur between about 600 meters and two kilometers during the cold season or the 55 instances in which sperm whales might be exposed at received levels between 160 and 170 dB (between 500 meters and 1.3 kilometers from a source) during the warm season, the whales are likely to avoid being exposed to vessel traffic associated with U.S. Navy training activities or change their behavioral state. Like the other large whales discussed earlier, most of these avoidance responses would consist of slow movements away from vessels the animals perceive are on an approaching course, perhaps accompanied by slightly longer dives (or longer intervals between blows). Most the changes in behavior would consist of a shift from behavioral states that have low energy requirements (resting or milling) to behavioral states with higher energy requirements (active swimming or traveling), particularly social groups that include neonates or calves. In the remaining exposure events, the sperm whales are either not likely to respond or are not likely to respond in ways that might be adverse to the whales (the responses might represent an approach or attentive movement, a small change in orientation in the waters, etc.).

The 200 instances in which sperm whales might be exposed to received levels between 150 and 180 dB between May and October 2011 (the warm season), might cause the whales to engage in low-level avoidance behavior (slight changes in their direction of travel), short-term vigilance behavior, acoustic masking, impairment of acoustic communication, behavioural disturbance, and physiological stress responses as a result of that exposure. However, these responses are not likely to result in adverse consequences for that animals exhibiting the behavior. These changes in behavior are more likely if the whales are migrating and less likely if the whales are actively foraging.

PROBABLE RESPONSES OF SPERM WHALES TO UNDERWATER DETONATIONS. Our summary of the conclusions of our exposure analyses identifies how we would expect sperm whales to respond to underwater detonations: we would expect about 201 instances in which sperm whales might be exposed to underwater detonations on the Southern California Range Complex at received levels that would result in “behavioral harassment.” We would expect another eight instances in which sperm 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 expect two instances in which sperm whales might be exposed to received levels of 205 dB re 1μPa^2-s (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 and one instance in which whales experience temporary threshold shifts as a result of their exposure to an underwater detonation.

PROBABLE RISK. As we discussed in narratives for the other endangered whales we consider in this Opinion, although the military readiness activities the U.S. Navy plans to conduct on the Southern California Range Complex January 2011 through January 2012 are likely to cause some individual sperm whales to experience changes in their behavioral states that, in some circumstances, might have adverse consequences for free-ranging animals (Frid 2001, Frid and Dill 2002, Papouchis *et al*. 2001), particularly animals that are endangered or threatened with extinction. For sperm whales on the Southern California Range Complex, however, these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual sperm whales in ways or to a degree that would reduce their fitness because the whales are actively foraging in waters on and around the range complex or migrating through the range complex.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Whales have an ability to store substantial amounts of energy, which allows them to survive for months on stored energy during migration and while in their wintering areas, and their feeding patterns allow them to acquire energy at high rates. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like sperm whales. As a result, the sperm whales' probable responses to close approaches by Navy vessels and their probable exposure to active sonar and underwater detonations are not likely to reduce the current or expected future reproductive success of sperm whales or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

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 such populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the species is the sperm whale. As a result, the activities the U.S. Navy plans to conduct on the Southern California Range Complex from January 2011 through January 2012 are not likely to appreciably reduce the sperm whales' likelihood of surviving and recovering in the wild.

Guadalupe fur seal

PROBABLE EXPOSURE. Guadalupe fur seals are found on Guadalupe Island (Mexico) in the eastern Pacific Ocean off Mexico; a few individuals have been known to range as far north as Sonoma County, California, south to Los Islotes

Islands in Baja California, Mexico. A few Guadalupe fur seals occupy California sea lion rookeries in the Channel Islands of California (Stewart *et al.* 1987 in Reeves *et al.* 1992).

For several reasons, the exposure analyses for Guadalupe fur seals are much more complicated than they are for the other endangered marine mammals considered in this Opinion. First, unlike the other mammals considered in this Opinion, Guadalupe fur seals are amphibious: they spend only a portion of their lives in the ocean and a portion of their lives on rookeries (which, unlike other fur seals and sea lions, tend to be located in caves and rocky recesses): from about May through July (Belcher and Lee, Jr. 2000, Nowack 2003, Peterson *et al*. 1968), adults and neonates would occur on rookeries where they are not likely to be exposed to U.S. Navy military readiness activities. Second, when they are in the ocean, Guadalupe fur seals are shallow divers that forage in the upper 20 to 30 meters of the water column. The mean depths of their dives are about 17 meters (for lactating females); modal depths are 3.1 meters (Gallo-Reynoso 1994). At these depths, they would spend substantial amounts of time in sounds fields that are dominated by sounds produced by wind and waves rather than sounds such as active sonar. Third, the mean duration of their dives was 2.6 minutes, so they spend more time with their heads (and ears) at or above the ocean surface where they would not be exposed to most of the energy contained in underwater sound fields.

The exposure models we developed to assess the effects of active sonar and other sounds produced by the U.S. Navy's military readiness activities cannot and do not account for these three behavioral traits that allow Guadalupe fur seals to avoid exposure to sound fields produced by active sonar and underwater detonations. Because the ecology of Guadalupe fur seals violate several of the critical assumptions of these models, the exposure estimates produced by our model not only substantially overestimate the number of exposure events that are likely to occur, we must assume that those exposure estimates are sufficiently wrong that they cannot inform our assessment. We believe the ecology of Guadalupe fur seals would also cause the U.S. Navy to substantially overestimate the number of Guadalupe fur seals that are likely to be exposed to military readiness activities and experience behavioral harassment (as that term is defined pursuant to the MMPA) or temporary threshold shifts as a result of that exposure; however, to conduct our assessment, we assumed those estimates are correct.

The U.S. Navy reached the following conclusions about the potential stressors Guadalupe fur seals might be "taken" on the Southern California Range Complex and the stressors responsible for that "take":

1. The mid-frequency active sonar training the U.S. Navy proposes to conduct on the Southern California Range Complex was likely to result in 911 instances in which Guadalupe fur seals would be exposed to sound fields produced by this sonar at received levels sufficiently high (or distances sufficiently close) to cause the fur seals to change their behavioral state that would represent "behavioral harassment" (as that term is defined pursuant to the MMPA).
2. The mid-frequency active sonar training the U.S. Navy proposes to conduct on the Southern California Range Complex was likely to result in 190 instances in which Guadalupe fur seals would be exposed to sound fields produced by this sonar at received levels sufficiently high (or distances sufficiently close) to cause the fur seals to experience temporary, noise-induced losses in their hearing sensitivity.
3. Underwater detonations on the Southern California Range Complex were likely to result in two instances in which Guadalupe fur seals would be exposed to pressure waves or sound fields produced by detonations at

pressures sufficiently high (or distances sufficiently close) to cause the fur seals to change their behavioral state that would represent "behavioral harassment" (as that term is defined pursuant to the MMPA).

4. Underwater detonations on the Southern California Range Complex were likely to result in two instances in which Guadalupe fur seals would be exposed to pressure waves or sound fields produced by detonations at pressures sufficiently high (or distances sufficiently close) to cause the fur seals to experience temporary, noise-induced losses in their hearing sensitivity.

PROBABLE RESPONSES OF GUADALUPE FUR SEALS TO ACTIVE SONAR. We have already discussed the purpose and structure of our response analyses in the *Approach to the Assessment* section of this Opinion and the preceding narrative for blue whales. Employing the same approach, we reached the following conclusions about the probable responses of Guadalupe fur seals exposed to active sonar.

Acoustic Resonance. For the reasons we discussed in the preceding narratives for blue and fin whales, based on the information available (which we review in greater detail in our 2009 Programmatic Opinion), Guadalupe fur seals and the other species considered in this Opinion are not likely to experience acoustic resonance. The evidence available suggests that this phenomenon poses potential risks to deep- or prolonged-diving cetaceans rather than shallow-diving species such as Guadalupe fur seals.

Noise-Induced Loss of Hearing Sensitivity. Although the U.S. Navy assumes that 192 Guadalupe fur seals are likely to experience temporary losses in hearing sensitivity, these outcomes do not seem likely given the short dive times, shallow dive depths, and the tendency of pinnipeds such as fur seals to raise their heads above water to avoid exposure to sounds fields. Even if we accept the Navy's conclusions at face value, we still cannot assess the potential consequences of any losses in hearing sensitivity because the Navy's estimates provide no information about the magnitude of losses in hearing sensitivity (a 3 dB loss in sensitivity versus a 10 dB loss in sensitivity), the duration of the impairment (for example, whether the "temporary" loss in hearing sensitivity persists for minutes, hours, days, or weeks), or the frequency range affected by the loss (that is, what environmental cues might the animal not detect given the loss in hearing sensitivity). Without this information, it would be difficult to conclude that exposure to the active sonar had any consequence for Guadalupe fur seals that might be clinically important.

Nevertheless, for the purposes of this Opinion, we assume that the 192 instances in which Guadalupe fur seals would experience temporary losses in hearing sensitivity would experience impaired hearing that would be of sufficient magnitude and duration and would occur in frequency ranges to cause the fur seals to change their behavioral state.

Behavioral Responses. There is no published information on the hearing range of Guadalupe fur seals, although it is most likely similar to other fur seals. Northern fur seals produce underwater clicks, and in-air barking, coughing, and roaring sounds (Schusterman 1978; Richardson et al. 1995). The underwater hearing range of the northern fur seal ranges from 0.5Hz to 40 kHz (Moore and Schusterman 1987; Babushina *et al.* 1991) and the threshold is 50 to 60 dB re 1 μPa-m (Moore and Schusterman 1987). The best underwater hearing occurs between 4 and 17 to 28 kHz (Moore and Schisterman 1987; Babushina *et al.* 1991). The maximum sensitivity in air is at 3 to 5 kHz for northern fur seals (Babushina *et al.* 1991), after which there is anomalous hearing loss at around 4 to 5 kHz (Moore and Schusterman 1987; Babushina 1999).

Pinnipeds appear to engage in a wide variety of responses when exposed to anthropogenic noise. 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 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 GUADALUPE FUR SEALS TO UNDERWATER DETONATIONS. Our summary of the conclusions of our exposure analyses identifies how we would expect Guadalupe fur seals to respond to underwater detonations: we would expect about 201 instances in which Guadalupe fur seals might be exposed to underwater detonations on the Southern California Range Complex at received levels that would result in “behavioral harassment.” We would expect another eight instances in which Guadalupe fur seals 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 expect two instances in which Guadalupe fur seals might be exposed to received levels of 205 dB re 1µPa^2-s (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 and one instance in which temporary threshold shifts as a result of their exposure to an underwater detonation.

PROBABLE RISK. As we discussed in narratives for the endangered whales we consider in this Opinion, although the military readiness activities the U.S. Navy plans to conduct on the Southern California Range Complex January 2011 through January 2012 are likely to cause some individual Guadalupe fur seals to experience changes in their behavioral states that, in some circumstances, might have adverse consequences for free-ranging animals (Frid 2001, Frid and Dill 2002, Papouchis *et al*. 2001), these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual Guadalupe fur seals in ways or to a degree that would reduce their fitness.

As we discussed in the *Environmental Baseline* section of this Opinion, Guadalupe fur seals have been exposed to U.S. Navy training activities on the Southern California Range Complex, including vessel traffic, aircraft traffic, active sonar, and underwater detonations, for more than a generation. Despite this exposure, the Guadalupe fur seal population has been estimated to be increasing at a rate of about 13.7 percent per year; at the rate of growth, the population should double every five years. Although we do not know if the Guadalupe fur seal population might have increased at a much higher rate if they had not been exposed to U.S. Navy military readiness activities on the Southern California Range Complex, this rate suggests that the number of Guadalupe fur seals would continue to increases despite being exposed to stressors associated with these military readiness activities. As a result, the Guadalupe fur seals' probable responses to exposure to active sonar and underwater detonations are not likely to reduce the current or expected future reproductive success of Guadalupe fur seals or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

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 animals would not be likely to reduce the viability of the populations those individuals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of such populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the species is the Guadalupe fur seal. As a result, the activities the U.S. Navy plans to conduct on the Southern California Range Complex from January 2011 through January 2012 are not likely to appreciably reduce the Guadalupe fur seals' likelihood of surviving and recovering in the wild.

SEA TURTLES. The information available has not allowed us to estimate the probability of the different sea turtles being exposed to mid-frequency active sonar, vessel traffic, or explosions associated with the activities the U.S. Navy plans to conduct on the Southern California Range Complex from January 2011 through January 2012.

Further, although the information on the hearing capabilities of sea turtles is limited, 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). Wood turtles have 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). We assume that these sensitivities to sound apply to the three hardshell turtles (i.e., green, loggerhead , and Olive ridley sea turtles). 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 more likely to be similar to other sea turtles than 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 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, 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” green, leatherback, loggerhead, or Olive ridley sea turtles.

Sea turtles on the Southern California Range Complex might encounter one or more parachutes after they have been jettisoned from these sonobuoys and could become entangled as a result. We cannot, however, determine whether such interactions are probable, given the relatively small number of sonobuoys that would be employed in each of the exercises, the relatively large geographic area involved, and the relatively low densities of sea turtles that are likely to occur in the Action Area. Given the large size of the Southern California Range Complex, the relatively small number of sonobuoys that would be employed in an exercise, and the relatively low densities of sea turtles, an interaction between sea turtles and parachutes seems to have a very small probability; however, despite a very small probability, an interaction could be fatal to the sea turtle if it was entangled and drowned or if it swallowed a parachute.

Nevertheless, we conclude that training exercises and other activities the U.S. Navy plans to conduct on the Southern California Range Complex from January 2011 through January 2012 are not likely to interact with sufficient number of adult or sub-adult sea turtles, if they interact with any sea turtles at all, to reduce the viability of the nesting aggregations those sea turtles 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). As a result, those activities would not be expected to appreciably reduce the likelihood of green, leatherback, loggerhead, or Olive ridley sea turtles surviving and recovering in the wild by reducing their reproduction, numbers, or distribution.

Effects Resulting from Interactions of the Potential Stressors

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 explained how biological opinions consider "cumulative impacts" (in the NEPA sense of the term; see Approach to the Assessment for a complete treatment of this issue). There is a nuance to the idea of "cumulative impacts," however, that we have chosen to address separately and explicitly in this Opinion: potential interactions between stressors associated with the activities the U.S. Navy plans to conduct on the Southern California Range Complex and other physical, chemical, and biotic stressors that pre-exist in the environment.

Exposing living organisms to individual stressors or a suite of stressors that are associated with a specific action may be insignificant or minor when considered in isolation, but may have significant adverse consequences when they are added to other stressors, operate synergistically in combination with other stressors, or magnify or multiply the effects of other stressors. Further, the effects of life events, natural phenomena, and anthropogenic phenomena on an individual's performance will depend on the individual's phenotypic state when the individual is exposed to these phenomena. Disease, dietary stress, body burden of toxic chemicals, energetic stress, percentage body fat, age, reproductive state, and social position, among many other phenomena can "accumulate" to have substantial influence on an organism's response to subsequent exposure to a stressor. That is, exposing animals to individual stressors associated with a specific action can interact with the animal's prior condition (can "accumulate" and have additive, synergistic, magnifying, and multiplicative effect) and produce significant, adverse consequences that would not occur if the animal's prior condition had been different.

An illustrative example of how a combination of stressors interact was provided by Relyea (2001, 2003, 2005) who demonstrated that exposing several different amphibians to a combination of pesticides and chemical cues of natural predators, which induced stress, increased the mortality rates of the amphibians (see also Sih *et al.* 2004). For some species, exposing the amphibians to the combination of stressors produced mortality rates that were twice as high as the mortality rates associated with each individual stressor. This section considers the evidence available to determine if interactions associated with mid-frequency active sonar are likely to produce responses we have not considered already or if interactions are likely to increase the severity — and, therefore, the potential consequences — of the responses we have already considered.

The activities the U.S. proposes to conduct on the Southern California Range Complex will continue to introduce a suite of potential stressors into the marine and coastal ecosystem off Southern California that include mid-frequency and high-frequency active sonar from surface vessels, torpedoes, and dipping sonar; shock waves and sound fields associated with underwater detonations, acoustic and visual cues from surface vessels as they move through the ocean's surface, and sounds transferred into the water column from fixed-wing aircraft, helicopters, and through the hulls of hulks that are the targets of sinking exercises. Exposing endangered and threatened marine animals on the Southern California Range Complex to each of these individual stressors could pose additional potential risks as the exposures accumulate over time. Exposing endangered and threatened marine animals to this suite of stressors could pose additional potential risks as the stressors interact with one another or with other stressors that already occur in these waters.

Although we recognize these potential interactions and that these interactions might have effects on endangered and threatened species that we have not considered thus far, the data available do not allow us to do more than acknowledge the possibility. Consider the potential stressor that has received the most attention thus far: mid-frequency active sonar. The proposed exercises would add mid-frequency sound to ambient oceanic noise levels, which, in turn, could have cumulative impacts on the ocean environment, including listed species. During transmissions, mid-frequency sonar will add to regional noise levels. However, there are no reliable methods for assessing potential interactions between these sound sources. The U.S. Navy conducted computer simulations to assess the potential cumulative impacts of mid-frequency active sonar associated with Rim of the Pacific training events in the Hawai'i Range Complex (Navy 2008). That assessment concluded that the “cumulative impacts” of mid-frequency sonar would be “extremely small” because the proposed RIMPAC exercise would occur for a relatively short period of time every other year, for relatively short periods of time in any given area; the system would not be stationary, and the information available suggests that the effects of any mid-frequency exposure would stop when transmissions stop.

A greater cumulative impact is likely to result from an interaction between the number of times endangered or threatened species might be exposed to active sonar and explosions in association with the activities considered in this Opinion and other activities the U.S. Navy plans to conduct in waters off Southern California during the same time interval. Over the twelve-month period beginning in January 2011, the U.S. Navy plans on conducting up to fifteen major training exercises on the Southern California Range Complex. Each of those exercises are expected to last for several days and produce tens to 100s of hours of mid-frequency active sonar. Blue, fin, humpback, sei, sperm whales, and Guadalupe fur seals are likely to be exposed to mid-frequency active sonar associated with those exercises as well as the active sonar associated with the activities considered in this Opinion.

As a result, over the twelve-month period beginning in January 2011 , individual blue, fin, humpback, and sperm whales, Guadalupe fur seals, and sea turtles are likely to be exposed to the activities associated with major training exercises on the Southern California Range Complex; including more than 1,000 anti-submarine warfare tracking exercises, 40 bombing exercises; about 900 anti-submarine warfare tracking exercises and two sinking exercises in addition to a stress regime that includes close approaches for research, exposure to whale watch vessels; exposure to fisheries and fishing gear; and other natural and anthropogenic stressors.

Richardson *et al.* (1995) provided extensive information and arguments about the potential cumulative effects of man-made noise on marine mammals. Those effects included masking, physiological effects and stress, habituation, and sensitization. Those concerns were echoed by Clark and Fristrup (2001), Michel *et al.* (2001), NRDC (2001), and others. Although all of these responses have been measured in terrestrial animals reacting to airborne, man-made noises, those studies are counterbalanced by studies of other terrestrial mammals that did not exhibit these responses to similar acoustic stimuli.

The evidence available does not allow us to reach any conclusions about potential cumulative effects of the activities considered in this Opinion and other activities that are occurring or are designed to occur on the Southern California Range Complex. We could point to the increasing abundance of humpback whales over the past 30 years and infer that the status of these whales has improved despite the combination of natural and anthropogenic stressors in those waters. As a result, the existing stress regime in waters off Southern California would not reduce the performance of the humpback whales that forage in those waters. That inference is certainly consistent with the evidence available and it might be appropriate to extend that inference to the other endangered and threatened species in waters off Southern California.

The information available does not allow us to determine whether or to what degree there are any interactions between the U.S. Navy activities considered in this Opinion, other activities the U.S. Navy is conducting or plans to conduct on the Southern California Range Complex, and other natural and anthropogenic stressors in the Action Area. The evidence available suggests that the population of at least humpback whales that forages in the Action Area has increased for the past 10 to 20 years, despite the stress regime in those waters and that this increase does not mask demographic phenomena that are likely to reverse this trend in the future (for example, biases in the percentage of males or females in the population; gaps in the age structure of the population; reduced recruitment into the adult population; or a shift in the percentage of females with high reproductive success relative to the rest of the adult female population). This evidence suggests that the activities considered in this Opinion are not likely to interact to produce interactive, synergistic, or multiplicative effects that are greater than the effects considered elsewhere in this Opinion.

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.

CONCLUSION

After reviewing the status of endangered or threatened blue whales, fin whales, humpback whales, sperm whales, Guadalupe fur seals, green sea turtles, leatherback sea turtles, loggerhead sea turtles, and Olive ridley sea turtles, the environmental baseline for the action area, the effects of the proposed research program, and the cumulative effects, it is NMFS' biological opinion that the Navy's proposal to conduct major training exercises, unit-level and intermediate-level training activities, and research, development, test and evaluation activities on the Southern California Range Complex over the twelve-month period beginning in January 2011 are likely to adversely affect but are not likely to jeopardize the continued existence of these threatened and endangered species under NMFS jurisdiction.

No critical habitat has been designated for endangered or threatened species in the action area, so the proposed actions are not likely to result in the destruction or adverse modification of designated critical habitat.

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 this Incidental Take Statement.

The measures described below, which are non-discretionary, must be implemented by NMFS' Permits, Conservation and Education Division so they become binding conditions of any permit issued to the U.S. Navy, as appropriate, in order for the exemption in section 7(o)(2) to apply. NMFS' Permits, Conservation, and Education Division has a continuing duty to regulate the activity covered by this Incidental Take Statement. If NMFS' Permits, Conservation and Education Division (1) fails to require the U.S. Navy to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the permit or grant document, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

Amount or Extent of Take Anticipated

The section 7 regulations require NMFS to estimate the number of individuals that may be taken by proposed actions or the extent of land or marine area that may be affected by an action, if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (Federal Register 51, June 3, 1986, page 19953). The amount of take resulting from active sonar transmissions was difficult to estimate because we have no empirical information on (a) the actual number of listed species that are likely to occur in the different site, (b) the actual number of individuals of those species that are likely to be exposed to active sonar transmissions, (c) the circumstances associated with any exposure, and (d) the range of responses we would expect different individuals of the different species to exhibit upon exposure.

As discussed in the *Approach to the Assessment* section of this Opinion, we used discrete-event Bayesian analyses to estimate the the number of animals in the exposed population that might respond with particular responses, we multiplied our exposure estimates (which provided us with the number of instances of exposure) by the posterior probabilities for these responses (which identify the probability of a particular response given an exposure). To estimate the number of animals that might be "taken" in this Opinion, we classified the suite of responses as one or more form of "take" and estimated the number of animals that might be "taken" by (1) multiplying the number of animals exposed by the probability of particular responses given an exposure; (2) classifying particular responses as one or more form of "take" (as that term is defined by the ESA and implementing regulations that further define "harm"); then (3) adding the number of exposure events that are expected to produce responses that we would consider "take." Specifically, we summed the number of instances in which we concluded that endangered or threatened marine animals were likely to be exposed at received levels greater than 160 dB, regardless of the season. These estimates include whales that are likely to be exposed and respond to close approaches by U.S. Navy vessels (exposures that would occur at received levels of 190-210 dB during the cold season and 180-200 dB during the warm season) and exposures to mid-frequency active sonar at received levels that are likely to result in behavioral changes that we would classify as "harassment." The results of our estimates are presented in Table 9.

Although we concluded that marine mammals, including endangered and threatened marine mammals, have a clinically-significant probability of being struck, injured, or killed in a collision with a U.S. Navy vessel between January 2011 and January 2012, our incidental take statement cannot exempt such "take" because such "take" is not authorized pursuant to the Marine Mammal Protection Act of 1972, as amended (16 U.S.C. 1371(a)(5)). Until such time as that "take" is authorized pursuant to the MMPA, we cannot exempt that "take" in an incidental take statement (16 U.S.C. 1536(b)(4)).

Table 9. Estimates of the number of instances in which endangered or threatened marine mammals that might be "taken," in the form of behavioral harassment as a result of exposure to the training exercises and other activities the U.S. Navy plans to conduct on the Southern California Range Complex from January 2011 through January 2012

Species	Number of Instances of Harassment Resulting From Exposure Events Involving			Totals
	Active Sonar or Other Environmental Cues from Surface Vessels[1]	Underwater Detonations		
		Harassment	Harm	
Blue whale	505	4	-	509
Fin whale	135	3	-	138
Humpback whale	13	0	-	13
Sperm whale	160	3	-	163
Guadalupe fur seal	1,101	201	2	1,304
Totals	**1,914**	**14**	**0**	

Notes 1 These estimates include animals that respond to vessels involved in major training exercises (rather than unit-level training or RDT&E activities) and that are between 600 meters and 2 kilometers of individual animals

The instances of harassment identified in Table 9 would generally represent changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures and, therefore, would represent significant disruptions of the normal behavioral patterns of the animals that have been exposed. We grouped responses to active sonar and responses to vessel traffic and other environmental cues associated with the surface vessels involved in major training exercises because we assume animals would respond to a suite of environmental cues that include sound fields produced by active sonar, sounds produced by the engines of surface vessels, sounds produced by displacement hulls, and other sounds associated with training exercises. That is, we assume endangered marine mammals will perceive and respond to all of the environmental cues associated with an exercise rather than the single stimulus represented by active sonar. Further, we assume endangered marine mammals would recognize cues that suggest that ships are moving away from them rather than approaching them and they would respond differently to both situations.

Because of their hearing sensitivities, we generally expect blue and fin whales to change their behavior in response to cues from the vessels rather than to the sound field produced by active sonar and the estimates in Table 9 reflect that expectation. However, we assume that humpback and sperm whales would changes their behavior in response to the sound field produced by active sonar and cues from the vessles involved in training exercises.

As we discussed in the Effects of the Action section of this Opinion, endangered and threatened sea turtles that might be exposed to sound fields produced by active sonar or underwater detonations associated with the military readiness activities the U.S. Navy proposes to conduct on the Southern California Range Complex are likely to be adversely affected by their exposure, but we do not expect those adverse effects to rise to the level of harassment, harm, wounding, or any other form of "take" (as that term is defined pursuant to the Endangered Species Act of 1973, as amended, and implementing regulations). Because we do not expect sea turtles to be "taken," we have not exempted the "take" of sea turtles in this Opinion.

Effect of the Take

In the accompanying biological opinion, NMFS determined that the number of individuals that might be exposed to mid-frequency active sonar associated with the training exercises and other activities the U.S. Navy plans to conduct on the Southern California Range Complex and are likely to respond to that exposure in ways that NMFS would classify as "take" as that term is defined pursuant to section 3 of the Endangered Species Act is not likely to jeopardize the continued existence of blue, fin, humpback, sei, or sperm whales, Guadalupe fur seals, or endangered or threatened sea turtles. Although the biological significance of the animal's behavioral responses remains unknown, exposure to active sonar transmissions could disrupt one or more behavioral patterns that are essential to an individual animal's life history or to the animal's contribution to a population. For the proposed action, behavioral responses that result from active sonar transmissions and any associated disruptions are expected to be temporary and would not affect the reproduction, survival, or recovery of these species.

Reasonable and Prudent Measures

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

1. The U.S. Navy shall submit reports that identify the general location, timing, number of sonar hours and other aspects of the training exercises and other activities they conduct on the Southern California Range Complex over the next twelve months.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Endangered Species Act of 1973, as amended, NMFS' Permits, Conservation and Education Division and the U.S. Navy must comply with the following terms and conditions, which implements the reasonable and prudent measures described above and outlines the reporting requirements required by the section 7 regulations (50 CFR 402.14(i)).

1. Annual SOCAL Range Complex Exercise Report – The Navy shall submit an Annual SOCAL Range Complex Exercise Report on October 1, 2011 (covering data gathered through August 1, 2011). This report shall contain information identified in 50 CFR § 216.275(f)(1) through (5).

(1) MFAS/HFAS Major Training Exercises – This section shall contain the following information for Integrated, Coordinated, and Major Training Exercises (MTEs), which include Ship ASW Readiness and Evaluation Measuring (SHAREM), Sustainment Exercises, Integrated ASW Course Phase II (IAC2), Composite Training Unit Exercises (COMPTUEX), and Joint Task Force Exercises (JTFEX) conducted in the SOCAL Range Complex:

(i) Exercise Information (for each MTE):

(A) Exercise designator

(B) Date that exercise began and ended

(C) Location

(D) Number and types of active sources used in the exercise

(E) Number and types of passive acoustic sources used in exercise

(F) Number and types of vessels, aircraft, etc., participating in exercise

(G) Total hours of observation by watchstanders

(H) Total hours of all active sonar source operation

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

(J) Wave height (high, low, and average during exercise)

(ii) Individual marine mammal sighting info (for each sighting in each MTE)

(A) Location of sighting

(B) Species (if not possible – indication of whale/dolphin/pinniped)

(C) Number of individuals

(D) Calves observed (y/n)

(E) Initial Detection Sensor

(F) Indication of specific type of platform observation made from (including, for example, what type of surface vessel, i.e., FFG, DDG, or CG)

(G) Length of time observers maintained visual contact with marine mammal

(H) Wave height (in feet)

(I) Visibility

(J) Sonar source in use (y/n).

(K) Indication of whether animal is <200yd, 200-500yd, 500-1,000yd, 1,000-2,000yd, or >2,000yd from sonar source in 4(a)(1) above.

(L) Mitigation Implementation – Whether operation of sonar sensor was delayed, or sonar was powered or shut down, and how long the delay was.

(M) If source in use (J) is hull-mounted, true bearing of animal from ship, true direction of ship's travel, and estimation of animal's motion relative to ship (opening, closing, parallel)

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

(iii) An evaluation (based on data gathered during all of the MTEs) of the effectiveness of mitigation measures designed to avoid exposing marine mammals to mid-frequency sonar. This evaluation shall identify the specific observations that support any conclusions the Navy reaches about the effectiveness of the mitigation.

(2) ASW Summary – This section shall include the following information as summarized from both MTEs and 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 SOCAL Range Complex. The Navy shall include (in the SOCAL Range Complex annual report) a brief annual progress update on the status of the development of an effective and unclassified method to report this information until an agreed-upon (with NMFS) method has been developed and implemented.

(3) 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 (738 m for SINKEX in the SOCAL Range Complex); 2) the required exclusion zone (1 nm for SINKEX in the SOCAL Range Complex); (3) the required observation distance (if different than the exclusion zone (2 nm (3.7 km) for SINKEX in the SOCAL Range Complex); and (4) greater than the required observed distance. For example, in this case, the observer would indicate if <738 m, from 738 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.

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

(i) Total number of IEER events conducted in the SOCAL Range Complex

(ii) Total expended/detonated rounds (buoys)

(iii) Total number of self-scuttled IEER rounds

(5) 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 SOCAL Range Complex.

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

2. Sonar Exercise Notification – The Navy shall submit to the NMFS Office of Protected Resources (specific contact information to be provided in LOA) either an electronic (preferably) or verbal report within fifteen calendar days after the completion of any MTE (Sustainment, IAC2, SHAREM, COMPTUEX, or JTFEX) indicating:

(1) Location of the exercise

(2) Beginning and end dates of the exercise

(3) Type of exercise (e.g., SHAREM, JTFEX, etc.)

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

4. 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 SOCAL Range Complex, the Atlantic Fleet Active Sonar Training, the HRC, the Marianas Range Complex, the Northwest Training Range, and the Gulf of Alaska.

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.

REINITIATION NOTICE

This concludes formal consultation on the U.S. Navy’s proposal to undertake training activities on the Southern California Range Complex over the twelve-month period beginning in January 2011 and the National Marine Fisheries Service’s Permits, Education, and Conservation Division’s proposal to issue a Letter of Authorization for “take” of marine mammals in association with the U.S. Navy’s activities. As provided in 50 CFR 402.16, reinitiation of formal consultation is 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, section 7 consultation must be reinitiated immediately.

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