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

Agencies: United States Navy
NOAA's National Marine Fisheries Service

Activities Considered: (1) The U.S. Navy's Training Exercises and Testing Activities in the Hawaii-Southern California Training and Testing Study Area from December 2013 through December 2018

(2) National Marine Fisheries Services' promulgation of regulations pursuant to the Marine Mammal Protection Act for the U.S. Navy to "take" marine mammals incidental to training exercises and testing activities in the Hawaii-Southern California Training and Testing Study Area from December 2013 through December 2018

(3) National Marine Fisheries Services' issuance of two Letters of Authorization pursuant to regulations under the Marine Mammal Protection Act to "take" marine mammals incidental to training exercises and testing activities in the Hawaii-Southern California Training and Testing Study Area from December 2013 through December 2018

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

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1 INTRODUCTION

The Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq*.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. Section 7(a)(2) of the ESA requires Federal agencies to consult with the United States Fish and Wildlife Service (FWS), NMFS, or both, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Section 7(b)(3) requires that at the conclusion of consultation, the Service provide an opinion stating how the agencies' actions will affect listed species and their critical habitat. If an incidental take is expected, section 7(b)(4) requires the consulting agency to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

When a Federal agency's action "may affect" a protected species, that agency is required to consult formally with NMFS or the FWS, 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 FWS concurs with that conclusion (50 CFR § 402.14(b)).

Section 7(a)(4) of the ESA and NMFS/FWS regulations require Federal agencies to confer with us on actions likely to jeopardize the continued existence of species proposed for listing, or likely to result in the destruction or adverse modification of proposed critical habitat. If a proposed species is ultimately listed, Federal agencies must consult under section 7 on any action they authorize, fund, or carry out if those actions may affect the listed species or designated critical habitat.

For the actions described in this document, the action agencies are the United States Navy (U.S. Navy), which proposes to conduct military training exercises and testing activities and NMFS Office of Protected Resources - Permits and Conservation Division (Permits Division), which proposes to promulgate regulations pursuant to the Marine Mammal Protection Act of 1972, as amended (MMPA 16 U.S.C. 1361 *et seq*.) related to the U.S. Navy's proposed activities in the Hawaii-Southern California Training and Testing (HSTT) Study Area that may affect several ESA-listed species. The proposed regulations would authorize the issuance of two Letters of Authorization (LOAs) that would allow the U.S. Navy to "take" marine mammals incidental to its proposed action. The Federal action of issuing LOAs to the Navy is also considered in the biological opinion and conference report. The consulting agency for these proposals is NMFS Office of Protected Resources - Endangered Species Act Interagency Cooperation Division.

The U.S. Navy proposes to conduct training exercises and testing activities in the HSTT Study Area over a five year period following issuance of the MMPA Letters of Authorization in December 2013. This approach is consistent with Congress' intent that we coordinate and integrate the decision-making process under MMPA and ESA to the maximum extent practicable, so this opinion analyzes the training and testing activities during the time and in the geographic area covered by the MMPA regulations, which are limited to "periods of not more than five consecutive years." 16 U.S.C. 1371(a)(5)(A)(i). Further, NMFS has determined to structure this consultation in this way to ensure that the effects of reasonably anticipated training and testing activities may be analyzed close in time to their occurrence.

NMFS recognizes that while Navy training and testing requirements change over time in response to global or geopolitical events and other factors, the general types of activities addressed by this consultation are expected to continue into the reasonably foreseeable future, along with the associated impacts. Therefore, as part of our effects analysis, we assumed that the activities proposed for the next five years would continue into the reasonably foreseeable future at levels similar to that assessed in this opinion, and we considered the direct and indirect effects of those assumed future activities, together with the effects of all interrelated and interdependent actions. This approach addresses the recent court decision in Intertribal Sinkyone Wilderness Council v. National Marine Fisheries Service et al., No. 1:12-cv-00420-NJV (N.D. Cal. Sept. 25, 2013), although we may consider a different approach in future actions.

Notwithstanding this analysis, however, NMFS would fully take into account all of the best available science and any change in the status of the species when and if the Navy applies for a new MMPA incidental take authorization upon expiration of the five-year regulations considered in this opinion. The Navy would also need to initiate a new ESA consultation at that time.

The biological opinion (opinion) and incidental take statement portions of this consultation were prepared by NMFS Endangered Species Act Interagency Cooperation Division in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, *et seq.*), and implementing regulations at 50 CFR § 402. This document represents NMFS' final opinion on the effects of these actions on endangered and threatened species and critical habitat that has been designated for those species.

1.1 Background

This biological opinion is based on information provided in the 24 September 2012 U.S. Navy's request for ESA consultation package which included the *Hawaii-Southern California Training and Testing Draft Environmental Impact Statement/Overseas Environmental Impact Statement* (DEIS/OEIS dated November 2011), the *Hawaii-Southern California Training and Testing Endangered Species Act Section 7 Consultation Supplemental Information* (Navy 2012b), and NMFS Permits Division's 26 February 2013 request for Section 7 consultation under the ESA, the proposed Federal regulations under the MMPA specific to the proposed activities (78 FR

6977). The DEIS/OEIS was subsequently updated and replaced with the *Hawaii-Southern California Training and Testing Final Environmental Impact Statement/Overseas Environmental Impact Statement* (FEIS/OEIS dated August 2013) (Navy 2013c). Also considered were draft or final recovery plans for the endangered or threatened species that are considered in this document, and publications that we identified, gathered, and examined from the public scientific literature.

The Navy proposes to conduct training exercises and testing activities within the HSTT Study Area. Navy training exercises and testing activities have been ongoing in the same general geographic area since the 1940s. Most of the activities occurring in recent years (2008-present) were analyzed in three separate environmental impact statements (EISs) completed between 2008 and 2011; the *Hawaii Range Complex (HRC) EIS/OEIS* (Navy 2008a), the *Southern California (SOCAL) Range Complex EIS/OEIS* (Navy 2008d), and the *Silver Strand Training Complex (SSTC) EIS* (Navy 2011b).

1.2 Consultation History

On 24 September 2012, NMFS received a request for consultation pursuant to section 7 of the ESA on proposed training exercises and testing activities (i.e., training exercises and testing activities) to be conducted in the HSTT Study Area over five years.

On 5 November 2012, we responded to the Navy's request for consultation indicating that we had received sufficient information to initiate formal consultation with the Navy. At this time we also determined that NMFS Permits Division's proposed action of promulgating a rule under the Marine Mammal Protection Act (MMPA) regulating the take of marine mammals and subsequent letters of authorization (LOAs) pursuant to those MMPA regulations authorizing "take" of marine mammals incidental to Navy proposed action in the HSTT Study Area was inter-dependent and interrelated therefore should be included in the consultation. At that time we did not have sufficient information on the MMPA regulations or LOAs to initiate consultation on those actions. Further, due to the complexity of the proposed action and extent of species potentially affected, we proposed an extended consultation timeline with a final opinion issued no later than 24 October 2013.

On 26 February 2013, we received a request for consultation from NMFS Permits Division on its proposed issuance of regulations under the MMPA to take marine mammals during training exercises and testing activities in the HSTT Study Area.

Between September 2012 and September 2013 the ESA Interagency Cooperation Division of NMFS Office of Protected Resources had numerous meetings, phone calls, and exchanges of information that comprise the ESA section 7 consultation process. This included the pre-decision review of information and draft versions of this final biological opinion. Comments were received from the U.S. Navy on two draft biological opinions. NMFS Permits Division did not

provide comments on the draft biological opinions. Comments were considered and addressed in this final document.

On 31 January 2013, NMFS' Permits Division published a notice of proposed rulemaking and request for comments for Takes of Marine Mammals Incidental to Specified Activities; U.S. Navy Training and Testing Study Area; Proposed Rule.

On 7 July 2013, NMFS' Permits Division provided a draft Final Rule for Takes of Marine Mammals Incidental to Specified Activities; U.S. Navy Training and Testing Activities in the Hawaii-Southern California Training and Testing Study Area. The Navy provided comments on the draft final rule on 16 July 2013.

On 26 September 2013, NMFS' Permits Division provided a revised Final Rule for Takes of Marine Mammals Incidental to Specified Activities; U.S. Navy Training and Testing Activities in the Hawaii-Southern California Training and Testing Study Area.

On 30 September 2013, U.S. Navy Commander, Pacific Fleet provided a Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for Hawaii-Southern California Training and Testing Study Area.

On 29 May 2013, NMFS' ESA Interagency Cooperation Division provided a copy of the preliminary draft biological opinion to the U.S. Navy per agreed upon milestones. The Navy provided comments on the preliminary draft on 4 June 2013. On 16 August 2013, NMFS' ESA Interagency Cooperation Division provided a copy of the revised draft biological opinion to the U.S. Navy per agreed upon milestones. The Navy provided comments on the revised draft biological opinion draft on 24 August 2013.

On 14 August 2013, NMFS' Permits Division provided a revised Final Rule for Takes of Marine Mammals Incidental to Specified Activities; U.S. Navy Training and Testing Activities in Hawaii-Southern California Training and Testing Study Area. The Navy provided comments on the revised Final Rule on 21 August 2013.

On 6 November 2013, NMFS' ESA Interagency Cooperation Division provided a copy of the draft final biological opinion to the U.S. Navy, upon their request. The Navy provided comments on the draft biological opinion on 14 November 2013.

2 DESCRIPTION OF THE PROPOSED ACTION

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration.

The Navy proposes to conduct training exercises and testing activities in the HSTT Study Area over a five year period beginning in December 2013. The HSTT Study Area includes three existing range complexes (Southern California (SOCAL) Range Complex, Hawaii Range Complex (HRC), and Silver Strand Training Complex (SSTC)) plus pierside locations and areas on the high seas where maintenance, training, or testing may occur. The proposed activities are classified as training exercises and testing activities.

2.1 Navy Training Exercises

The Navy has categorized training exercises into eight functional warfare areas (anti-air warfare; amphibious warfare; strike warfare; anti-surface warfare; anti-submarine warfare; electronic warfare; mine warfare; and naval special warfare) which are briefly described below. Details regarding each warfare area can be found in the *Hawaii-Southern California Training and Testing Final Environmental Impact Statement/Overseas Environmental Impact Statement (FEIS/OEIS)* (Navy 2013d).

2.1.1 Anti-Air Warfare

The mission of anti-air warfare (AAW) is to destroy or reduce enemy air and missile threats (including unmanned airborne threats) and serves two purposes: to protect U.S. forces from attacks from the air and to gain air superiority. Anti-air warfare also includes providing U.S. forces with adequate attack warnings, while denying hostile forces the ability to gather intelligence about U.S. forces.

Aircraft conduct anti-air warfare through radar search, detection, identification, and engagement of airborne threats—generally by firing anti-air missiles or cannon fire. Surface ships conduct anti-air warfare through an array of modern anti-aircraft weapon systems such as aircraft detecting radar, naval guns linked to radar-directed fire-control systems, surface-to-air missile systems, and radar-controlled cannons for close-in point defense (Table 1).

Table 1. Typical Anti-Air Warfare Training Exercises proposed to occur in the Hawaii-Southern California Training and Testing Study Area.

Activity Name	Activity Description
Air Combat Maneuver (ACM)	Aircrews engage in flight maneuvers designed to gain a tactical advantage during combat.
Air Defense Exercises (ADEX)	Aircrew and ship crews conduct defensive measures against threat aircraft or missiles.
Gunnery Exercise (Air-to-Air) (GUNEX [A-A])	Aircrews defend against threat aircraft with cannons (machine gun).
Missile Exercise (Air-to-Air) (MISSILEX [A-A])	Aircrews defend against threat aircraft with missiles.
Gunnery Exercise (Surface-to-Air) (GUNEX [S-A])	Surface ship crews defend against threat missiles and aircraft with guns.
Missile Exercise (Surface-to-Air) (MISSILEX [S-A])	Surface ship crews defend against threat missiles and aircraft with missiles.

2.1.2 Amphibious Warfare

The mission of amphibious warfare (AMW) is to project military power from the sea to the shore through the use of naval firepower and Marine Corps landing forces. It is used to attack a threat located on land by a military force embarked on ships. Amphibious warfare operations include small unit reconnaissance or raid missions to large-scale amphibious operations involving multiple ships and aircraft combined into a strike group.

Amphibious warfare training ranges from individual, crew, and small unit events to large task force exercises. Individual and crew training include amphibious vehicles and naval gunfire support training. Small-unit training operations include shore assaults, boat raids, airfield or port seizures, and reconnaissance. Large-scale amphibious exercises involve ship-to-shore maneuver, naval fire support, such as shore bombardment, and air strike and close air support training.

The Navy conducts other amphibious warfare support activities that could affect ESA-listed species (such as pile driving and removal) in the near shore region from the beach to about 914 m from shore (Table 2).

Table 2. Typical Amphibious Warfare Training Exercises proposed to occur in the Hawaii-Southern California Training and Testing Study Area.

Activity Name	Activity Description
Naval Surface Fire Support Exercise–Land-based target (FIREX [Land])	Surface ship crews use large-caliber guns to fire on land-based targets in support of forces ashore.
Naval Surface Fire Support Exercise-At Sea (FIREX [At Sea])	Surface ship crews use large-caliber guns to support forces ashore; however, the land target is simulated at sea. Rounds impact the water and are scored by passive acoustic hydrophones located at or near the target area.
Amphibious Assault	Forces move ashore from ships at sea for the immediate execution of inland objectives.
Amphibious Raid/Humanitarian Assistance Operations	Small unit forces move ashore swiftly from ships at sea for a specific short-term mission. These operations with as few personnel as possible.

2.1.3 Strike Warfare

The mission of strike warfare (STW) is to conduct offensive attacks on land-based targets, such as refineries, power plants, bridges, major roadways, and ground forces to reduce the enemy's ability to wage war. Strike warfare employs weapons by manned and unmanned air, surface, submarine, and naval special warfare assets in support of extending dominance over enemy territory (power projection).

Strike warfare includes training of fixed wing attack aircraft pilots and aircrews in the delivery of precision-guided munitions, non-guided munitions, rockets, and other ordnance, including the high-speed anti-radiation missile, against land-based targets in all conditions. Not all strike mission training events involve dropping ordnance and instead the event is simulated with video footage obtained by onboard sensors (Table 3).

Table 3. Typical Strike Warfare Training Exercises proposed to occur in the Hawaii-Southern California Training and Testing Study Area.

Activity Name	Activity Description
Bombing Exercise Air-to-Ground (BOMBEX A-G)	Fixed-wing aircraft drop non-explosive bombs against a land target.

2.1.4 Anti-surface Warfare

The mission of anti-surface warfare (ASUW) is to defend against enemy ships or boats. In the conduct of anti-surface warfare, aircraft use cannons, air-launched cruise missiles or other precision guided munitions; ships employ torpedoes, naval guns, and surface-to-surface missiles; and submarines attack surface ships using torpedoes or submarine-launched, anti-ship cruise missiles. Anti-surface warfare training includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, and submarine missile or torpedo launch events (Table 4).

Table 4. Typical Anti-Surface Warfare Training Exercises proposed to occur in the Hawaii-Southern California Training and Testing Study Area.

Activity Name	Activity Description
Maritime Security Operations (MSO)	Helicopter and surface ship crews conduct a suite of maritime security operations (e.g., visit, board, search, and seizure; maritime interdiction operations; force protection; and anti-piracy operation).
Gunnery Exercise (Surface-to-Surface) (Ship) (GUNEX [S-S] – Ship)	Ship crews engage surface targets with ship's small, medium, and large caliber guns.
Gunnery Exercise (Surface-to-Surface) (Boat) (GUNEX [S-S] – Boat)	Small boat crews engage surface targets with small and medium-caliber guns.
Missile Exercise (Surface-to-Surface) (MISSILEX [S-S])	Surface ship crews defend against threat missiles and other surface ships with missiles.
Gunnery Exercise (Air-to-Surface) (GUNEX [A-S])	Fixed-wing and helicopter aircrews, including embarked personnel, use small and medium-caliber guns to engage surface targets.
Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	Fixed-wing and helicopter aircrews fire both precision-guided missiles and unguided rockets against surface targets.
Bombing Exercise (Air-to-Surface)	Fixed-wing aircrews deliver bombs against surface targets.

(BOMBEX [A-S])	
Laser Targeting	Fixed-winged, helicopter, and ship crews use single or multi-beam lasers to illuminate enemy targets or to defend against approaching hostile forces.
Sinking Exercise (SINKEX)	Aircraft, ship, and submarine crews deliver ordnance on a seaborne target, usually a deactivated ship, which is deliberately sunk using multiple weapon systems.

2.1.5 Anti-submarine Warfare

The mission of anti-submarine warfare (ASW) is to locate, neutralize, and defeat hostile submarine threats to surface forces. Anti-submarine warfare is based on the principle of a layered defense of surveillance and attack aircraft, ships, and submarines all searching for hostile submarines. These forces operate together or independently to gain early warning and detection, and to localize, track, target, and attack hostile submarine threats.

Anti-submarine warfare training addresses basic skills such as detection and classification of submarines, and distinguishing between sounds made by enemy submarines and those of friendly submarines, ships, and marine life. More advanced, integrated anti-submarine warfare training exercises are conducted in coordinated, at-sea training events involving submarines, ships, fixed wing aircraft, and helicopters. This training integrates the full spectrum of anti-submarine warfare from detecting and tracking a submarine to attacking a target using either exercise torpedoes or simulated weapons (Table 5).

Table 5. Typical Anti-Submarine Warfare Training Exercises proposed to occur in the Hawaii-Southern California Training and Testing Study Area.

Activity Name	Activity Description
Tracking Exercise/ Torpedo Exercise –Submarine (TRACKEX/TORPEX-Sub)	Submarine crews search, track, and detect submarines. Exercise torpedoes may be used during this event.
Tracking Exercise/ Torpedo Exercise –Surface (TRACKEX/TORPEX-Surface)	Surface ship crews search, track and detect submarines. Exercise torpedoes may be used during this event.
Tracking Exercise/ Torpedo Exercise –Helicopter (TRACKEX/TORPEX-Helo)	Helicopter crews search, detect and track submarines. Recoverable air launched torpedoes may be employed against submarine targets.
Tracking Exercise/ Torpedo Exercise - Maritime Patrol Aircraft (TRACKEX/TORPEX - MPA)	Maritime patrol aircraft crews search, detect, and track submarines. Recoverable air launched torpedoes may be employed against submarine targets.
Tracking Exercise-Maritime Patrol Aircraft Extended Echo Ranging Sonobuoy (TRACKEX–MPA sonobuoy)	Maritime patrol aircraft crews search, detect, and track submarines with extended echo ranging sonobuoys. Recoverable air launched torpedoes may be employed against submarine targets.

2.1.6 Electronic Warfare

The mission of electronic warfare (EW) is to degrade the enemy's ability to use their electronic systems, such as communication systems and radar, in order to confuse or deny them the ability to defend their forces and assets. Electronic warfare is also used to recognize an emerging threat and counter an enemy’s attempt to degrade the electronic capabilities of the Navy.

Typical electronic warfare activities include threat avoidance training, signals analysis for intelligence purposes, and use of airborne and surface electronic jamming devices to defeat tracking and communications systems (Table 6).

Table 6. Typical Electronic Warfare Training Exercises proposed to occur in the Hawaii-Southern California Training and Testing Study Area.

Activity Name	Activity Description
Electronic Warfare Operations (EW OPS)	Aircraft, surface ship and submarine crews attempt to control portions of the electromagnetic spectrum used by enemy systems to degrade or deny the enemy's ability to take defensive actions.
Counter Targeting - Flare Exercise (FLAREX)	Fixed-winged aircraft and helicopters crews defend against an attack by deploying flares to disrupt threat infrared missile guidance systems.
Counter Targeting - Chaff Exercise (CHAFFEX)	Surface ships, fixed-winged aircraft and helicopter crews defend against an attack by deploying chaff, a radar reflective material, which disrupt threat targeting and missile guidance radars.

2.1.7 Mine Warfare

The mission of mine warfare (MIW) is to detect, and avoid or neutralize mines to protect Navy ships and submarines and to maintain free access to ports and shipping lanes. Mine warfare also includes offensive mine laying to gain control of, or deny the enemy access to sea space. Naval mines can be laid by ships (including purpose-built minelayers), submarines, or aircraft.

Mine warfare neutralization (destruction) training includes exercises in which ships, aircraft, submarines, or underwater vehicles search for mines (Table 7). Personnel train to destroy or disable mines by attaching and detonating underwater explosives to the mine. Other neutralization techniques involve impacting the mine with a bullet-like projectile or intentionally triggering the mine to detonate.

Finally, the Navy deploys California sea lions and Atlantic bottlenose dolphins in the HSTT Study Area for integrated training involving two primary missions areas: to find objects such as inert mine shapes, and to detect swimmers or other intruders around Navy facilities such as piers. When deployed, the animals are part of what the Navy refers to as marine mammal systems. These systems include one or more motorized small boats, several crew members, and a trained marine mammal. Each trained animal is deployed under behavioral control to find the intruding swimmer or submerged object.

Table 7. Typical Mine Warfare Training Exercises proposed to occur in the Hawaii-Southern California Training and Testing Study Area.

Activity Name	Activity Description
Mine Countermeasures Exercise (MCM) - Ship Sonar	Littoral combat ship crews detect and avoid mines while navigating restricted areas or channels using active sonar.
Explosive Ordnance Disposal (EOD)/Mine Neutralization	Personnel disable threat mines. Explosive charges may be used.
Mine Countermeasures -Towed	Ship crews and helicopter aircrews tow systems (e.g., Organic and

Mine Neutralization	Surface Influence Sweep, MK 104/105) through the water designed to disable and/or trigger mines.
Mine Countermeasures - Mine Detection	Ship crews and helicopter aircrews detect mines using towed and laser mine detection systems (e.g., AN/AQS-20, Airborne Laser Mine Detection System).
Mine Countermeasures – Mine Neutralization	Ship crews and helicopter aircrews disable mines by firing small and medium-caliber projectiles.
Mine Countermeasures - Mine Neutralization – Remotely Operated Vehicles	Ship crews and helicopter aircrews disable mines using remotely operated underwater vehicles.
Mine Laying	Fixed-winged aircraft and submarine crews drop/launch non explosive mine shapes.
Civilian Port Defense	Maritime security operations for military and civilian ports and harbors. Because other stressors associated with this activity were concluded by Navy to be “no effect”, only the sonar portion of this activity is analyzed in this document.

2.1.8 Naval Special Warfare

The mission of naval special warfare is to conduct unconventional warfare, direct action, combat terrorism, special reconnaissance, security assistance, counter-drug operations, and recovery of personnel from hostile situations. Naval special warfare operations are highly specialized and require continual and intense training.

Naval special warfare units utilize a combination of specialized training, equipment, and tactics, including insertion and extraction operations using parachutes, submerged vehicles, rubber boats, and helicopters; boat-to-shore and boat-to-boat gunnery; underwater demolition training; reconnaissance; and small arms training.

2.1.9 Major Training Exercises

Major training exercises are not included in the primary mission areas but comprise many smaller or "unit level" range exercises conducted by several units operating together while commanded and controlled by a single commander. These exercises typically employ an exercise scenario developed to train and evaluate the strike group in naval tactical tasks. In a major training event, most of the operations and activities being directed and coordinated by the strike group commander are identical in nature to the operations conducted during individual, crew, and smaller-unit training events. In a major training event, however, these disparate training tasks are conducted in concert, rather than in isolation. Typical major training exercises are described in Table 8.

Table 8. Typical Major Training Exercises proposed to occur in the Hawaii-Southern California Training and Testing Study Area.

Activity Name	Activity Description
Composite Training Unit Exercise (COMPTUEX)	Intermediate level exercise designed to create a cohesive Strike Group prior to deployment or joint task force exercise. Typically seven surface ships, helicopters, maritime patrol aircraft, two submarines, and various unmanned vehicles. Marine mammal systems may be used during the exercise.
Joint Task Force Exercise (JTFEX) / Sustainment Exercise (SUSTAINEX)	Final fleet exercise prior to deployment of the Strike Group. Serves as a ready-to-deploy certification for all units involved. Typically nine surface ships, helicopters, maritime patrol aircraft, two submarines, and various unmanned vehicles. Marine mammal systems may be used during the exercise.
Anti-Submarine Warfare-Composite Training Unit Exercise (COMPTUEX)	Anti-submarine warfare activities conducted during a composite training unit exercise.
Integrated Anti-Submarine Warfare Course (IAC)	Multiple ships, aircraft, and submarines coordinate use of sensors, including sonobuoys, to search, detect and track threat submarines. Integrated Anti-Submarine Warfare Course is an intermediate level training event and can occur in conjunction with other major exercises.
Group Sail	Multiple ships and helicopters integrate the use of sensors, including sonobuoys, to search, detect and track a threat submarine. Group sails are not dedicated anti-submarine warfare events and involve multiple warfare areas.

2.1.10 Other Training Exercises

Other training exercises that do not fall under a particular category as described in Table 9.

Table 9. Typical Other Training Exercises proposed to occur in the Hawaii-Southern California Training and Testing Study Area.

Activity Name	Activity Description
Precision Anchoring	Ship crews train in releasing of anchors in designated locations.
Submarine Navigational (SUB NAV)	Submarine crews locate underwater objects and ships while transiting in and out of port.
Submarine Navigation Under Ice Certification	Submarine crews train to operate under ice. During training and certification other submarines and ships simulate ice.
Surface Ship Sonar Maintenance	Pierside and at-sea maintenance of sonar systems.
Submarine Sonar Maintenance	Pierside and at-sea maintenance of sonar systems.

2.1.11 Proposed Training Activity Levels

The following table (Table 10, Table 11, and Table 12) provides a summary of training exercises (as described in Section 2.1 above) including tempo and quantities of inert and live munitions that the U.S. plans to expend during training that were analyzed by the U.S. Navy.

Table 10. Proposed Training exercises in the Hawaii-Southern California Training and Testing (HSTT) Study Area (adapted from Table 2.8-1, Alternative 2, U.S. Navy Final EIS/OEIS, August 2013).

Range Activity	No. of Events (per Year)	Ordnance (Number per Year)	Location
Anti-Air Warfare (AAW)			
Air Combat Maneuver (ACM)	814	n/a	HRC
	3,970	n/a	SOCAL
Air Defense Exercise (ADEX)	185	n/a	HRC
	550	n/a	SOCAL
Gunnery Exercise (Air-to-Air) – Medium-Caliber (GUNEX [A-A] – Medium-Caliber	3	3,000 rounds	SOCAL
Missile Exercise (Air-to-Air) (MISSILEX [A-A])	27	**105 missiles (53 HE)**	HRC
	25	**52 missiles (26HE)**	SOCAL
Gunnery Exercise (Surface-to-Air) – Large-Caliber (GUNEX [S-A]) – Large-Caliber	50	**400 HE rounds**	HRC
	160	1,300 rounds	SOCAL
Gunnery Exercise (Surface-to-Air) – Medium-Caliber (GUNEX [S-A]) – Medium-Caliber	70	140,000 rounds	HRC
	190	380,000 rounds	SOCAL
Missile Exercise (Surface-to-Air) (MISSILEX [S-A])	30	**30 HE missiles**	HRC
	20	**20 HE missiles**	SOCAL
Missile Exercise- Man-portable Air Defense System (MISSILEX–MANPADS)	4	**68 HE missiles**	SOCAL
Amphibious Warfare (AMW)			
Naval Surface Fire Support Exercise – Land-Based Target (FIREX [Land])[4]	52	8,500 rounds- all ashore	SOCAL
Naval Surface Fire Support Exercise – At Sea (FIREX [At Sea])	12	1,000 NEPM rounds; **840 HE rounds**	HRC
Amphibious Assault	12	n/a	HRC
	18	n/a	SSTC boat Lanes 11-14
Amphibious Raid – Battalion Landing	2	n/a	SOCAL
Amphibious Raid	2,342	n/a	SOCAL
	84	n/a	SSTC Boat Lanes 1-8

Range Activity	No. of Events (per Year)	Ordnance (Number per Year)	Location
Expeditionary Fires Exercise/ Supporting Arms Coordination Exercise (EFEX/SACEX)	8	1,045 rounds- all ashore	SOCAL
Humanitarian Assistance Operations	2	n/a	HRC
Strike Warfare (STW)			
Bombing Exercise (Air-to-Ground) (BOMBEX A-G)	60	275 bombs (**no HE**)	HRC
Gunnery Exercise (Air-to-Ground) (GUNEX A-G)	307	60,000 small and medium calibre rounds	HRC
Anti-Surface Warfare (ASUW)			
Maritime Security Operations (MSO)	70	n/a	Hawaii OPAREA
	150	n/a	SOCAL
	42	n/a	SSTC Boat Lanes 1-10
Gunnery Exercise (Surface-to-Surface) – Ship Small-Caliber (GUNEX [S-S] – Ship) Small-Caliber	60	318,000 rounds	HRC
	350	1,855,000 rounds	SOCAL
	16	84,000 rounds	HSTT Transit Corridor
Gunnery Exercise (Surface-to-Surface) – Ship Medium-Caliber (GUNEX [S-S] – Ship) Medium-Caliber	44	4,800 rounds (**440 HE**)	HRC
	164	20,800 rounds (**1,640 HE**)	SOCAL
	32	6,400 rounds (**320 HE**)	HSTT Transit Lane
Gunnery Exercise (Surface-to-Surface) - Ship Large-Caliber (GUNEX [S-S] - Ship) - Large-Caliber	60	1,000 rounds (**934 HE**)	HRC
	190	8,500 rounds (**4,204 HE**)	SOCAL
	16	400 rounds (**20 HE**)	HSTT Transit Lane
Gunnery Exercise (Surface-to-Surface) - Boat Small-Caliber (GUNEX [S-S] - Boat) - Small-Caliber	200	600,000	SOCAL
Gunnery Exercise (Surface-to-Surface) – Boat Medium-Caliber (GUNEX [S-S] - Boat) - Medium-Caliber	10	**100 HE rounds, 100 HE grenades**, 200 NEPM rounds	HRC
	14	**140 HE rounds, 140 HE grenades**, 240 NEPM rounds	SOCAL
Missile Exercise (Surface-to-Surface)	12	12 Missiles	HRC
	4	4 Missiles	SOCAL

Range Activity	No. of Events (per Year)	Ordnance (Number per Year)	Location
(MISSILEX [S-S])			
Gunnery Exercise (Air-to-Surface) – Small-Caliber (GUNEX [A-S]) – Small-Caliber	275	74,000 rounds	HRC
	131	104,800	SOCAL
Gunnery Exercise [Air-to-Surface] – Medium-Caliber (GUNEX [A-S]) – Medium-Caliber	130	27,000 (**6,000 HE**)	HRC
	100	48,000 rounds (**12,000 HE**)	SOCAL
Missile Exercise (Air-to-Surface) – Rocket (MISSILEX [A-S]) - Rocket	20	**760 HE rockets**	HRC
	130	**3,800 HE rockets**	SOCAL
Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	57	**57 HE missiles**	HRC
	214	**214 HE missiles**	SOCAL
Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	28	180 bombs (**56 HE**)	HRC
	120	1,280 bombs (**160 HE**)	SOCAL
Laser Targeting	50	n/a	HRC
	250	n/a	SOCAL
Sinking Exercise (SINKEX)	6	36 bombs (**18 HE**), 10 missiles (**6 HE**), 300 large-caliber rounds (**120 HE**), 6 **MK 48 HE torpedoes**, 12,000 medium-caliber NEPM	HRC
	2	12 bombs (**6 HE**), 4 missiles (**2 HE**), 100 large-caliber rounds (**40 HE**), **2 MK 48 HE torpedoes**, 4,000 medium-caliber NEPM	SOCAL
Anti-Submarine Warfare (ASW)			
Tracking Exercise/ Torpedo Exercise – Submarine (TRACKEX/ TORPEX – Sub)	127	244 MK 48 EXTORP	HRC
	63	76 MK 48 EXTORP	SOCAL
	7	n/a	HSTT Transit Lane
Tracking Exercise/ Torpedo	274	20 EXTORP, 30 REXTORP	HRC

Range Activity	No. of Events (per Year)	Ordnance (Number per Year)	Location
Exercise – Surface (TRACKEX/ TORPEX – Surface)	540	48 EXTORP, 69 REXTORP	SOCAL
Tracking Exercise/ Torpedo Exercise – Helicopter (TRACKEX/ TORPEX – Helo)	165	6 EXTORP, 110 REXTORP	HRC
	628	6 EXTORP, 200 REXTORP	SOCAL
	6	n/a	HSTT Transit Lane
Tracking Exercise/Torpedo Exercise - Maritime Patrol Aircraft (TRACKEX/TORPEX – MPA)	296	20 EXTORP, 210 REXTORP	HRC
	116	24 EXTORP, 17 REXTORP	SOCAL
Tracking Exercise - Maritime Patrol Advanced Extended Echo Ranging Sonsbuoys	96	480 IEER buoys, 1,440 MAC buoys	HRC
	48	120 IEER buoys, 360 MAC buoys	SOCAL
Kilo Dip-Helicopter	1,060	n/a	SOCAL
Submarine Command Course (SCC) Operations	2	30 MK 54, 72 MK 48, EXTORP	HRC
Electronic Warfare (EW)			
Electronic Warfare Operations (EW Ops)	33	n/a	Hawaii OPAREA
	350	n/a	SOCAL
Counter Targeting Flare Exercise (FLAREX)	8	n/a	Hawaii OPAREA
	25	n/a	SOCAL
Counter Targeting Chaff Exercise (CHAFFEX) - Ship	37	n/a	Hawaii OPAREA
	125	n/a	SOCAL
Counter Targeting Chaff Exercise (CHAFFEX) – Aircraft	30	n/a	Hawaii OPAREA
	250	n/a	SOCAL
Mine Warfare (MIW)			
Mine Countermeasures Exercise (MCM) – Ship Sonar	30	n/a	HRC
	92	n/a	SOCAL
Mine Countermeasure Exercise- Surface (SMCMEX)	266	n/a	SOCAL
Mine Neutralization – Explosive Ordnance Disposal (EOD)	22	**82 HE**	HRC
	75	**300 HE**	SOCAL
	279	**414 HE**	SSTC Boat Lanes 1-14

Range Activity	No. of Events (per Year)	Ordnance (Number per Year)	Location
Mine Countermeasure (MCM)- Towed Mine Neutralization	240	n/a	SOCAL
	100	n/a	SSTC Boat Lanes 1-14
Mine Countermeasure (MCM) – Mine Neutralization	36	360 rounds	SOCAL
Airborne Mine Countermeasure (AMCM) – Mine Detection	630	n/a	SOCAL
	372	n/a	SSTC Boat Lanes 1-14
Mine Countermeasure (MCM) - Mine Neutralization – Remotely Operated Vehicle	60	**8 HE**	SOCAL
	312	**20 HE**	SSTC Boat Lanes 1-14
Mine Laying	32	384 mine shapes	HRC
	18	750 mine shapes	SOCAL
Marine Mammal System	10	n/a	HRC
	175	**8 HE**	SSTC Boat Lanes 1-14
Shock Wave Action Generator	90	**90 HE**	SSTC Boat Lanes 1-14
Surf Zone Test Detachment/Equipment Test and Evaluation	200	n/a	SSTC Boat Lanes 1-14
Submarine Mine Exercise	34	n/a	HRC
	32	n/a	SOCAL
Civilian Port Defense	1	**4 HE**	Pearl Harbor
	1	**4 HE**	San Diego
Naval Special Warfare (NSW)			
Personnel Insertion/Extraction- Submarine	145	n/a	SSTC Boat Lanes 1-10
Personnel Insertion/Extraction- Non-Submarine	15	n/a	SOCAL
	394	n/a	SSTC Boat Lanes 1-14
Underwater Demolition Multiple Charge- Mat Weave and Obstacle Loading	18	18 HE	SOCAL
Underwater Demolition Qualification/Certification	24	30 HE	SSTC Boat Lanes 1-14
Major Training Events			

Range Activity	No. of Events (per Year)	Ordnance (Number per Year)	Location
Composite Training Unit Exercise (COMPTUEX)6	4	Exercise is comprised of various activities accounted for elsewhere within Table	SOCAL
Joint Task Force Exercise (JTFX)/ Sustainment Exercise (SUSTAINEX)	5	Exercise is comprised of various activities accounted for elsewhere within Table	SOCAL
Rim of the Pacific (RIMPAC) Exercise	1	Exercise is comprised of various activities accounted for elsewhere within Table	HRC/SOCAL
Multi-Strike Group Exercise	1	n/a	HRC
Integrated Anti-Submarine Warfare Course (IAC)	4	Exercise is comprised of various activities accounted for elsewhere within Table	SOCAL
Group Sail	2	Exercise is comprised of various activities accounted for elsewhere within Table	HRC
	8	Exercise is comprised of various activities accounted for elsewhere within Table	SOCAL
Undersea Warfare Exercise (USWEX)	5	Exercise is comprised of various activities accounted for elsewhere within Table	HRC
Ship ASW Readiness and Evaluation Measuring (SHAREM)	2	8 MK 48 EXTORP, 16 MK 46/54 EXTORP	SOCAL
Other			
Precision Anchoring	18	n/a	HRC
	72	n/a	SSTC Anchorages
Small Boat Attack	6	2,100 small-caliber rounds	Hawaii OPAREA
	36	10,500 blank rounds	SSTC Boat Lans 1-10
Offshore Petroleum Discharge System (OPDS)	6	n/a	SSTC Boat Lanes 1-10
Elevated Causeway System (ELCAS)	4	n/a	SSTC Boat Lanes 1-10
Submarine Navigation	216	n/a	Pearl Harbor

Range Activity	No. of Events (per Year)	Ordnance (Number per Year)	Location
Exercise	84	n/a	Subase Pt. Loma
Submarine Under Ice Certification	12	n/a	Hawaii OPAREA
	6	n/a	SOCAL
Savage Operations	3	n/a	HRC
Surface Ship Sonar Maintenance	148	n/a	HRC
	488	n/a	SOCAL
	4	n/a	HSTT Transit Lane
Submarine Sonar Maintenance	132	n/a	HRC
	68	n/a	SOCAL
	4	n/a	HSTT Transit Lane

** All major exercise munitions are distributed among the individual unit events.*

[1] Number of torpedoes represents total for entire HSTT Study Area for each activity.

Table 11. Proposed annual number of impulsive source detonations during training exercises in the Hawaii-Southern California Training and Testing Study Area.

Explosive Class	Net Explosive Weight (NEW)	Annual In-Water Detonations (Training)
E1	(0.1 lb. – 0.25 lb.)	19,840
E2	(0.26 lb. – 0.5 lb.)	1,044
E3	(>0.5 lb. – 2.5 lb.)	3,020
E4	(>2.5 lb.-5 lb.)	668
E5	(>5 lb.-10 lb.)	8,154
E6	(>10 lb.-20 lb.)	538
E7	(>20 lb.-60 lb.)	407
E8	(>60 lb.-100 lb.)	64
E9	(>100 lb. – 250 lb.)	16
E10	(>250 lb. – 500 lb.)	19
E11	(>500 lb. – 650 lb.)	8
E12	(>650 lb. – 1,000 lb.)	224
E13	(>1,000 lb. – 1,740 lb.)	9

Table 12. Annual hours and items of non-impulsive sources used during training exercises within the Hawaii-Southern California Training and Testing Study Area.

Source Class Category	Source Class	Annual Use
Mid-Frequency (MF) Active sources from 1 to 10 kHz	MF1	11,588 hours
	MF1K	88 hours
	MF2	3,060 hours
	MF2K	34 hours
	MF3	2,336 hours
	MF4	888 hours
	MF5	13,718 items
	MF11	1,120 hours
	MF12	1,094 hours
High-Frequency (HF) and Very High-Frequency (VHF) Tactical and non-tactical sources that produce signals greater than 10kHz but less than 200kHz	HF1	1,754 hours
	HF4	4,848 hours
Anti-Submarine Warfare (ASW)	ASW1	224 hours
Active ASW sources	ASW2	1,800 items
	ASW3	16,561 hours
	ASW4	1,540 items
Torpedoes (TORP)	TORP1	170 items
Active torpedo sonar	TORP2	400 items

2.2 Navy Testing Activities

The Navy's research and acquisition community engages in a broad spectrum of testing activities in support of the Pacific Fleet. These activities include, but are not limited to, basic and applied scientific research and technology development; testing, evaluation, and maintenance of systems (missiles, radar, and sonar), and platforms (surface ships, submarines, and aircraft); and acquisition of systems and platforms to support U.S. Navy missions and give a technological edge over adversaries.The individual commands within the research and acquisition community are the Naval Air Systems Command, the Naval Sea Systems Command, Space and Naval Warfare Systems Command, and the Office of Naval Research and Naval Research Laboratory. Some testing activities are similar to training exercises conducted by the Fleet. For example, both the Fleet and the research and acquisition community fire torpedoes. While the firing of a torpedo might look identical to an observer, the difference is in the purpose of the firing. The Fleet might fire the torpedo to practice the procedures for such a firing, whereas the research and acquisition community might be assessing a new torpedo guidance technology or to ensure the torpedo meets performance specifications and operational requirements. These differences may

result in different analysis and mitigations for the activity. While many of these systems will eventually be used by the Fleet during normal training exercises and are addressed in the HSTT FEIS/OEIS for those Fleet activities, testing and development activities involving the same or similar systems as will be used by operational Fleet units may be used in different locations and manners than when actually used by operational Fleet units. Hence, the analysis for testing events and training of Fleet units may differ.

The Navy's activities in anti-air warfare, strike warfare, and electronic warfare do not involve stressors that may affect ESA-listed species. Therefore, these activities are not discussed further.

2.2.1 Naval Air Systems Command Testing

Naval Air Systems Command testing activities generally fall in the primary mission areas used by the fleets. Naval Air Systems Command activities include, but are not limited to, the testing of new aircraft platforms, weapons, and systems before those platforms, weapons, and systems are integrated into the fleet. In addition to the testing of new platforms, weapons, and systems, Naval Air Systems Command also conducts lot acceptance testing of weapons and systems, such as sonobuoys (Table 13).

The majority of testing and development activities conducted by Naval Air Systems Command are similar to Pacific Fleet training events, and many platforms (e.g., the MH-60 helicopter) and systems (e.g., Airborne Towed Mine-hunting System (AN/AQS-20A)) currently being tested are already being used by the Fleet or will ultimately be integrated into Fleet training exercises. However, some testing and development may be conducted in different locations and in a different manner than the fleet and, therefore, though the environmental effects may be the same, the analysis for those events may differ.

Table 13. Typical Naval Air Systems Command Testing Activities proposed to occur in the Hawaii-Southern California Training and Testing Study Area.

Activity Name	Activity Description
Anti-Air Warfare (AAW)	
Air Combat Maneuver (ACM) Test	This event is identical to the air combat maneuver training event. Test events involve two or more aircraft, each engaged in continuous proactive and reactive changes in aircraft attitude, altitude, and airspeed. No weapons are fired during air combat maneuver test activities.
Air Platform/Vehicle Test	Testing performed to quantify the flying qualities, handling, airworthiness, stability, controllability, and integrity of an air platform or vehicle. No weapons are released during an air platform/vehicle test. In-flight refueling capabilities are tested.
Air Platform Weapons Integration Test	Testing performed to quantify the compatibility of weapons with the aircraft from which they would be launched or released. Mostly non-explosive weapons or shapes are used, but some tests may require the use of high-explosive weapons.
Air-to-Air (A-A) Weapons System Test	Test to evaluate the effectiveness of air-launched weapons against designated airborne targets. Fixed-wing or rotary-wing aircraft may be used. No testing of high-explosive weapons is planned.

Activity Name	Activity Description
Intelligence, Surveillance, and Reconnaissance Test	Test to evaluate communications capabilities of fixed wing and rotary-wing aircraft, including unmanned systems that can carry cameras, sensors, communications equipment, or other payloads. New systems are tested at sea to ensure proper communications between aircraft and ships.
Anti-Surface Warfare (ASUW)	
Air-to-Surface Missile Test	This event is similar to the training event missile exercise (air-to-surface). Test may involve both fixed-wing and rotary-wing aircraft launching missiles at surface maritime targets to evaluate the weapon system or as part of another systems integration test.
Air-to-Surface Gunnery Test	This event is similar to the training event gunnery exercise (air-to-surface). Strike fighter and helicopter aircrews evaluate new or enhanced aircraft guns against surface maritime targets to test that the gun, gun ammunition, or associated systems meet required specifications or to train aircrew in the operation of a new or enhanced weapon system.
Rocket Test	Rocket testing evaluates the integration, accuracy, performance, and safe separation of laser-guided and unguided 2.75-in. rockets fired from a hovering or forward flying helicopter or from a fixed-wing strike aircraft.
Laser Targeting Test	Aircrew use laser targeting devices integrated into aircraft or weapon systems to evaluate targeting accuracy and precision and to train aircrew in the use of newly developed or enhanced laser targeting devices. Lasers are designed to illuminate designated targets for engagement with laser-guided weapons.
Electronic Warfare (EW)	
Electronic Systems Evaluation	Test that evaluates the effectiveness of electronic systems to control, deny, or monitor critical portions of the electromagnetic spectrum. In general, electronic warfare testing will assess the performance of three types of electronic warfare systems: electronic attack, electronic protect, and electronic support.
Anti-Submarine Warfare (ASW)	
Anti-Submarine Warfare Torpedo Test	This event is similar to the training event torpedo exercise. The test evaluates antisubmarine warfare systems onboard rotary-wing and fixed-wing aircraft and the ability to search for, detect, classify, localize, and track a submarine or similar target.
Kilo Dip	A kilo dip is the operational term used to describe a functional check of a helicopter deployed dipping sonar system. The sonar system is briefly activated to ensure all systems are functional. A kilo dip is simply a precursor to more comprehensive testing.
Sonobuoy Lot Acceptance Test	Sonobuoys are deployed from surface vessels and aircraft to verify the integrity and performance of a lot, or group, of sonobuoys in advance of delivery to the fleet for operational use.
Anti-Submarine Warfare Tracking Test—Helicopter	This event is similar to the training event anti-submarine warfare tracking exercise/torpedo exercise - helicopter. The test evaluates the sensors and systems used to detect and track submarines and to ensure that helicopter systems used to deploy the tracking systems perform to specifications.
Anti-Submarine Warfare Tracking Test—Maritime Patrol Aircraft	This event is similar to the training event anti-submarine warfare tracking exercise/torpedo exercise -Maritime Patrol Aircraft extended echo ranging sonobuoy. The test evaluates the sensors and systems used by Maritime Patrol Aircraft to detect and track submarines and to ensure that aircraft systems used to deploy the tracking systems perform to

Activity Name	Activity Description
	specifications and meet operational requirements.
Mine Warfare (MIW)	
Airborne Mine Neutralization Test – AN/ASQ-235 (AMNS)	Airborne mine neutralization tests of the AN/ASQ-235 evaluate the system's ability to detect and destroy mines. The AN/ASQ-235 uses up to four unmanned underwater vehicles equipped with high-frequency sonar, video cameras, and explosive neutralizers.
Airborne Projectile-based Mine Clearance System	A helicopter uses a laser-based detection system to search for mines and to fix mine locations for neutralization with an airborne projectile-based mine clearance system. The system neutralizes mines by firing a small or medium-caliber inert, supercavitating projectile from a hovering helicopter.
Airborne Towed Minesweeping Test – AN/ALQ-220 (OASIS)	Tests of the Organic Airborne and Surface Influence Sweep (OASIS) would be conducted by a helicopter to evaluate the functionality of Organic Airborne and Surface Influence Sweep at sea. The Organic Airborne and Surface Influence Sweep is towed from a forward flying helicopter and works by emitting an electromagnetic field and mechanically generated underwater sound to simulate the presence of a ship. The sound and electromagnetic signature cause nearby mines to explode.
Airborne Towed Minehunting Sonar Test	Tests of the Airborne Towed Minehunting Sonar System to evaluate the search capabilities of this towed, mine hunting, detection, and classification system. The sonar on the Airborne Towed Minehunting Sonar System identifies mine-like objects in the deeper parts of the water column.
Airborne Laser-Based Mine Detection System Test (ALMDS)	An airborne mine hunting test of the AN/AES-1 Airborne Laser Mine Detection System, or "ALMDS" evaluates the system's ability to detect, classify, and fix the location of floating and near-surface, moored mines. The system uses a laser to locate mines and may operate in conjunction with an airborne projectile-based mine detection system to neutralize mines.
Other Testing Activities	
Test and Evaluation Catapult Launch	Tests evaluate the function of aircraft carrier catapults at sea following enhancements, modifications, or repairs to catapult launch systems. This includes aircraft catapult launch tests. No weapons or other expendable materials would be released.
Air Platform Shipboard Integrate Test	Tests evaluate the compatibility of aircraft and aircraft systems with ships and shipboard systems. Tests involve physical operations and verify and evaluate communications and tactical data links. This test function also includes an assessment of carrier-shipboard suitability and hazards of electromagnetic radiation to personnel, ordnance, and fuels.
Shipboard Electronic Systems Evaluation	Tests measure ship antenna radiation patterns and test communication systems with a variety of aircraft.

2.2.2 Proposed Testing Activity Levels / Naval Air Systems Command

Table 14 provides a summary of testing activities including tempo and quantities of inert and live munitions that the U.S. Navy proposes to expend during testing activities.

Table 14. Proposed Naval Air Systems Command Testing Activities in the Hawaii-Southern California Training and Testing (HSTT) Study Area (adapted from Table 2.8-2, Alternative 2, U.S. Navy Final EIS/OEIS, August 2013).

Event	No. of Events (per Year)	Ordnance (Number per Year)	Location
Anti-Air Warfare (AAW)			
Air Combat Maneuver	11	n/a	HRC
	110	n/a	SOCAL
Air Platform/Vehicle Test	50	n/a	HRC
	385	n/a	SOCAL
Air Platform Weapons Integration Test	44	n/a	HRC
	165	28 missiles, 22,000 small-and medium-caliber rounds, 330 rockets	SOCAL
Intelligence, Surveillance, and Reconnaissance Test	11	n/a	HRC
	50	n/a	SOCAL
Anti-Surface Warfare (ASUW)			
Air-to-Surface Missile Test	10	10 missiles (**5 HE**)	HRC
	100	156 missiles (**48 HE**)	SOCAL
Air-to-Surface Gunnery Test	55	44,000 medium caliber rounds (**11,000 HE**)	SOCAL
Rocket Test	66	748 rockets (**202 HE**)	SOCAL
Laser Targeting Test	6	n/a	SOCAL
Electronic Warfare (EW)			
Electronic Systems Evaluation	670	n/a	SOCAL
Anti-Submarine Warfare (ASW)			
Anti-submarine Warfare Torpedo Test	12	22 torpedoes	HRC
	36	70 torpedoes	SOCAL
Kilo Dip	5	n/a	HRC
	5	n/a	SOCAL
Sonobuoy Lot Acceptance Test	36	**744 HE sonobuoys**	SOCAL
Anti-submarine Warfare Tracking Test – Helicopter	122	**211 HE sonobuoys**	HRC
	188	**1,267 HE sonobuoys**	SOCAL
Anti-submarine Warfare Tracking Test – Maritime Patrol Aircraft	14	**308 HE sonobuoys**	HRC
	33	**1,004 HE sonobuoys**	SOCAL
Mine Warafare (MIW)			
Airborne Mine Neutralization System Test (AMNS)	17	**53 HE neutralizers**	SOCAL
Airborne Towed Minehunting Sonar System Test	17	n/a	SOCAL
Airborne Towed Minesweeping System Test	17	n/a	SOCAL
Airborne Laser- Based Mine Detection	17	n/a	SOCAL

Event	No. of Events (per Year)	Ordnance (Number per Year)	Location
System Test – ALMDS			
Airborne Projectile-based Mine Clearance System Test	17	330 medium caliber rounds, **6 HE mines**	SOCAL
Other Testing			
Test and Evaluation – Catapult Launch	9,570	n/a	HSTT
Air Platform Shipboard Integration Test	136	n/a	HSTT
Shipboard Electronic Systems Evaluation	136	n/a	HSTT

2.2.3 Naval Sea Systems Command Testing

Naval Sea Systems Command Testing (NAVSEA) testing activities are aligned with its mission of new ship construction, life cycle support, and other weapon systems development and testing **Error! Reference source not found.**.

New Ship Construction Activities – Ship construction activities include pierside testing of ship systems, tests to determine how the ship performs at sea (sea trials), and developmental and operational test and evaluation programs for new technologies and systems. Pierside and at-sea testing of systems aboard a ship may include sonar, acoustic countermeasures, radars, and radio equipment. During sea trials, each new ship propulsion engine is operated at full power and subjected to high-speed runs and steering tests. At-sea test firing of shipboard weapon systems, including guns, torpedoes, and missiles, are also conducted.

Life Cycle Activities – Testing activities are conducted throughout the life of a Navy ship to verify performance and mission capabilities. Sonar system testing occurs pierside during maintenance, repair, and overhaul availabilities, and at sea immediately following most major overhaul periods. A Combat System Ship Qualification Trial is conducted for new ships and for ships that have undergone modification or overhaul of their combat systems. Radar cross signature testing of surface ships is conducted on new vessels and periodically throughout a ship's life to measure how detectable the ship is by radar. Electromagnetic measurements of off-board electromagnetic signature are also conducted for submarines, ships, and surface craft periodically.

Other Weapon Systems Development and Testing – Numerous test activities and technical evaluations, in support of NAVSEA's systems development mission, often occur with Fleet activities within the Study Area. Tests within this category include, but are not limited to, anti-surface, anti-submarine, and mine warfare, using torpedoes, sonobuoys, and mine detection and neutralization systems.

Table 15. Typical Naval Sea Systems Command Testing Activities proposed to occur in the Hawaii-Southern California Training and Testing Study Area.

Activity Name		Activity Description
New Ship Construction		
Surface Combatant Sea Trials	Pierside Sonar Testing	Tests ship's sonar systems pierside to ensure proper operation.
	Propulsion Testing	Ship is run at high speeds in various formations (e.g., straight-line and reciprocal paths).
	Gun Testing	Gun systems are tested using non-explosive rounds.
	Missile Testing	Explosive and non-explosive missiles are fired at target drones to test the launching system.
	Decoy Testing	Includes testing of the MK 36 Decoy Launching system
	Surface Warfare Testing	Ships defend against surface targets with large-caliber guns.
	Anti-Submarine Warfare Testing	Ships demonstrate capability of countermeasure systems and underwater surveillance and communications systems.
Other Ship Class Sea Trials	Propulsion Testing	Ship is run at high speeds in various formations (e.g., straight-line and reciprocal paths). ("Other Ship" indicates class of vessels without hull-mounted sonar. Example ship classes include LCS, MLP, and T-AKE.)
	Gun Testing – Small Caliber	Gun systems are tested using non-explosive rounds.
Mission Package Testing	Anti-Submarine Warfare	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines.
	Surface Warfare	Ships defense against surface targets with small-, medium-, and large-caliber guns and medium range missiles.
	Mine Countermeasures	Ships conduct mine countermeasure operations.
Post-Homeporting Testing (all classes)		Tests all ship systems, including navigation and propulsion systems.
Ship Signature Testing		Tests ship and submarine radars and electromagnetic signatures.
Surface Ship Sonar Testing/ Maintenance (in OPAREAs and Ports)		Pierside and at-sea testing of surface ship systems occurs periodically following major maintenance periods and for routine maintenance.
Submarine Sonar Testing/ Maintenance (in OPAREAs and Ports)		Pierside and at-sea testing of submarine systems occurs periodically following major maintenance periods and for routine maintenance.
Combat System Ship Qualification Trial (CSSQT)	In-port Maintenance Period	Each combat system is tested to ensure they are functioning in a technically acceptable manner and are operationally ready to support at-sea Combat System Ship Qualification Trials.

Activity Name		Activity Description
	Air Defense (AD)	Tests the ship's capability to detect, identify, track, and successfully engage live and simulated targets.
	Surface Warfare (SUW)	Tests shipboard sensors capabilities to detect and track surface targets, relay the data to the gun weapon system, and engage targets.
	Undersea Warfare (USW)	Tests ships ability to track and engage undersea targets.
Anti-Surface Warfare (ASUW)/Anti-Submarine Warfare (ASW) Testing		
Missile Testing		Missile testing includes various missiles fired from submarines and surface combatants.
Kinetic Energy Weapon Testing		A kinetic energy weapon uses stored energy released in a burst to accelerate a non-explosive projectile.
Electronic Warfare Testing		Testing will include radiation of military and commercial radar and communication systems (or simulators).
Torpedo (Non-explosive) Testing		Air, surface, or submarine crews employ non-explosive torpedoes against submarines or surface vessels. All torpedoes are recovered.
Torpedo (Explosive) Testing		Air, surface, or submarine crews employ high-explosive torpedoes against artificial targets or deactivated ships.
Countermeasure Testing		Various acoustic systems (e.g., towed arrays and surface ship torpedo defense systems) are employed to detect, localize, track, and neutralize incoming weapons.
Pierside Sonar Testing		Pierside testing to ensure systems are fully functional in a controlled pierside environment prior to at-sea test activities.
At-sea Sonar Testing		At-sea testing to ensure systems are fully functional in an open ocean environment.
Mine Warfare (MIW) Testing		
Mine Detection and Classification Testing		Air, surface, and subsurface vessels detect and classify mines and mine-like objects.
Pierside Systems Health Checks		Mine warfare systems are tested in pierside locations to ensure acoustic and electromagnetic sensors are fully functional prior to at-sea test activities.
Shipboard Protection Systems and Swimmer Defense Testing		
Pierside Integrated Swimmer Defense		Swimmer defense testing ensures that systems can effectively detect, characterize, verify, and engage swimmer/diver threats in harbor environments.
Shipboard Protection Systems Testing		Loudhailers and small caliber munitions are used to protect a ship against small boat threats.
Chemical/Biological Simulant Testing		Chemical/biological agent simulants are deployed against surface ships.
Unmanned Vehicle Testing		
Underwater Deployed Unmanned Aerial System Testing		Unmanned aerial systems are launched by submarines and special operations forces while submerged.

Activity Name	Activity Description
Unmanned Vehicle Development and Payload Testing	Vehicle development involves the production and upgrade of new unmanned platforms on which to attach various payloads used for different purposes.
Other Testing Activities	
Special Warfare	Special warfare includes testing of submersibles capable of inserting and extracting personnel or payloads into denied areas from strategic distances.
Acoustic Communications Testing	Acoustic modems, submarines, and surface vessels transmit signals to communicate.
Mine Countermeasure/Neutralization Testing	Air, surface, and subsurface vessels neutralize threat mines that would otherwise restrict passage through an area.

2.2.4 Proposed Testing Activity Levels/Naval Sea Systems Command

Table 15**Error! Reference source not found.** provides a summary of testing activities including tempo and quantities of inert and live munitions that the U.S. Navy proposes to expend during testing activities.

Table 15. Proposed Naval Sea Systems Command Testing Activities in the Hawaii-Southern California Training and Testing Study Area (adapted from Table 2.8-2, Alternative 2, U.S. Navy Final EIS/OEIS, August 2013).

Event		No. of Events (per Year)	Ordnance (Number per Year)	Location
Ship Construction and Maintenance				
New Ship Construction				
Surface Combatant Sea Trials	Pierside Sonar Testing	2	n/a	Pearl Harbor
		2	n/a	San Diego
	Propulsion Testing	2	n/a	HRC
		2	n/a	SOCAL
	Gun Testing	2	52 large-calber rounds, 1,400 medium-caliber rounds	HRC
		2	52 large-calber rounds, 1,400 medium-caliber rounds	SOCAL
	Missile Testing	2	**4 High Explosives (HE) missiles**	HRC
		2	**4 HE missiles**	SOCAL
	Decoy Testing	2	n/a	HRC
		2	n/a	SOCAL
	Surface Warfare Testing	2	96 large-caliber rounds	HRC
		2	96 large-caliber rounds	SOCAL
	Anti-Submarine	2	n/a	HRC

Event		No. of Events (per Year)	Ordnance (Number per Year)	Location
	Warfare Testing	2	n/a	SOCAL
Other Class Ship Sea Trials	Propulsion Testing	21	n/a	SOCAL
	Gun Testing - Small Caliber	6	6,000 rounds	SOCAL
ASW Mission Package Testing		40	40 Torpedoes	SOCAL
		16	16 Torpedoes	HRC
Surface Warfare Mission Package Testing	Gun Testing – Small Caliber	5	2,500 rounds	HRC/SOCAL
	Gun Testing - Medium Caliber	5	7,000 rounds (**3,500 HE**)	HRC/SOCAL
	Gun Testing – Large Caliber	5	7,000 rounds (**4,900 HE**)	HRC/SOCAL
	Missile/Rocket Testing	15	30 missilies/rockets (**15 HE**)	HRC/SOCAL
MCM Mission Package Testing		4	n/a	SOCAL / CPAAA
		8	128 neutralizers (**64 HE**)	SOCAL
		4	n/a	SOCAL / Tanner Bank Minefield
		4	128 neutralizers (**64 HE**)	HRC
Life Cycle Activities				
Post Homeporting Testing (All Classes)		22	n/a	HRC
		22	n/a	SOCAL
Ship Signature Testing		3	n/a	HRC
		6	n/a	Pearl Harbor
		39	n/a	SOCAL
Surface Ship Sonar Testing/Maintenance (in OPAREAs and Ports)		17	n/a	HRC
		10	n/a	SOCAL
Submarine Sonar Testing/Maintenance (in OPAREAs and Ports)		18	n/a	HRC
		9	n/a	SOCAL
Combat System Ship Qualification Trial (CSSQT) In Port Maintenance Period		2	n/a	Pearl Harbor
		2	n/a	San Diego
Combat System Ship Qualification Trial (CSSQT) – Air Defense (AD)		6	12,000 medium-caliber rounds, 120 large rounds (**48 HE**), 84 missiles (**42 HE**)	HRC
		2	**2 HE missiles**	SOCAL
Combat System Ship Qualification Trial (CSSQT) – Anti-Surface Warfare (ASUW)		6	12,000 medium-caliber rounds, 1,800 large rounds (**678 HE**), 6 missiles	HRC
		13	14,000 medium-caliber rounds, 3,420 large rounds (**1,511 HE**), 9	SOCAL

Event	No. of Events (per Year)	Ordnance (Number per Year)	Location
		missiles	
Combat System Ship Qualification Trial (CSSQT) – Undersea Warfare (USW)	10	80 torpedoes	HRC
	11	88 torpedoes	SOCAL
Anti-Surface Warfare (ASUW) / Anti-Submarine Warfare (ASW) Testing			
Missile Testing	24	24 missiles	HRC/SOCAL
Kinetic Energy Weapon Testing	55	2,200	HRC
	1 in 5 years	5,000	HRC
Electronic Warfare Testing	106	n/a	Pearl Harbor
	16	n/a	HRC
	54	n/a	SOCAL
Torpedo (Non-Explosive) Testing	9	140 torpedoes	HRC
	10	250 torpedoes	HRC
	2	16 torpedoes	HRC
	17	391 torpedoes	SOCAL
Torpedo (Explosive) Testing	2	28 torpedoes (**8 HE**)	HRC
	2	28 torpedoes (**8 HE**)	SOCAL
Countermeasure Testing	1	n/a	HSTT Transit Corridor
	5	105 torpedoes (**21 HE**)	HRC
	2	84 torpedoes	SOCAL
Pierside Sonar Testing	10	n/a	Pearl Harbor/San Diego
At-Sea Sonar Testing	20	n/a	HRC/SOCAL
Mine Warfare (MIW) Testing			
Mine Detection and Classification Testing	2	n/a	HRC
	3	n/a	HRC: Kahoolawe Training Minefield
	5	n/a	SOCAL
	3	n/a	SOCAL: Mission Bay Training Minefield
Mine Countermeasures / Neutralization Testing	14	**28 HE charges**	SOCAL
	4	n/a	San Diego
Pierside Systems Health Checks	4	n/a	San Diego
Shipboard Protection Systems and Swimmer Defense Testing			
Pierside Integrated Swimmer Defense	5	n/a	San Diego
Shipboard Protection Systems Testing	4	n/a	San Diego
	4	1,300 small caliber rounds	SOCAL
Chemical / Biological Simulant Testing	440	n/a	HRC/SOCAL
Unmanned Vehicle Testing			
Underwater Deployed Unmanned Aerial System Testing	30	n/a	HRC/SOCAL
Unmanned Vehicle Development and Payload Testing	17	n/a	HRC
	26	n/a	SOCAL
Other Testing			
Special Warfare	4	n/a	HRC/SOCAL
Acoustic Communications Testing	2	n/a	HRC/SOCAL

The Navy proposes to conduct various testing activities in the HSTT Study Area. Detailed information about each proposed activity (stressor, testing event, description, sound source, duration, and geographic location) can be found in Appendix A of the HSTT FEIS/OEIS. NMFS used the detailed information in Appendix A to analyze the impacts from testing activities on ESA-listed species. Table 16 provides the annual number of impulsive source detonations during testing activities within the HSTT Study Area, and Table 17 shows the annual number of hours or items of non-impulsive sources used during testing within the HSTT Study Area.

Table 16. Proposed annual number of impulsive source detonations during testing activities within the Hawaii-Southern California Training and Testing Study Area.

Explosive Class	Net Explosive Weight (NEW)	Annual In-Water Detonations
E1	(0.1 lb. – 0.25 lb.)	14,501
E2	(0.26 lb. – 0.5 lb.)	0
E3	(>0.5 lb. – 2.5 lb.)	2,990
E4	(>2.5 lb.-5 lb.)	753
E5	(>5 lb.-10 lb.)	202
E6	(>10 lb.-20 lb.)	37
E7	(>20 lb.-60 lb.)	21
E8	(>60 lb.-100 lb.)	12
E9	(>100 lb. – 250 lb.)	0
E10	(>250 lb. – 500 lb.)	31
E11	(>500 lb. – 650 lb.)	14
E12	(>650 lb. – 1,000 lb.)	0
E13	(>1,000 lb. – 1,740 lb.)	0

Table 17. Annual hours and items of non-impulsive sources used during testing activities proposed to occur in the Hawaii-Southern California Training and Testing Study Area.

Source Class Category	Source Class	Annual Use
Low-Frequency (LF) Sources that produce signals less than 1 kHz	LF4	52 hours
	LF5	2,160 hours
	LF6	192 hours
Mid-Frequency (MF) Tactical and non-tactical sources that produce signals from 1 to 10 kHz	MF1	180 hours
	MF1K	18 hours
	MF2	84 hours
	MF3	392 hours
	MF4	693 hours

Source Class Category	Source Class	Annual Use
	MF5	5,024 items
	MF6	540 items
	MF8	2 hours
	MF9	3,039 hours
	MF10	35 hours
	MF12	336 hours
High-Frequency (HF) and Very High-Frequency (VHF): Tactical and non-tactical sources that produce signals greater than 10kHz but less than 200kHz	HF1	1,025 hours
	HF3	273 hours
	HF4	1,336 hours
	HF5	1,094 hours
	HF6	3,460 hours
Anti-Submarine Warfare (ASW) Tactical sources used during anti-submarine warfare	ASW1	224 hours
	ASW2	2,260 items
	ASW2	255 hours
	ASW3	1,278 hours
	ASW4	477 items
Torpedoes (TORP) Source classes associated with active acoustic signals produced by torpedoes	TORP1	701 items
	TORP2	732 items
Acoustic Modems (M) Transmit data acoustically through the water	M3	4,995 hours
Swimmer Detection Sonar (SD) Used to detect divers and submerged swimmers	SD1	38 hours
Airguns (AG) Used during swimmer defense and diver deterrent	AG	5 uses
Synthetic Aperture Sonar (SAS): Sonar in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS1	2,700 hours
	SAS2	4,956 hours
	SAS3	3,360 hours

2.2.5 Space and Naval Warfare Systems Command Testing

The mission of Space and Naval Warfare Systems Command Testing (SPAWAR) is to acquire, develop, deliver, and sustain decision superiority for the warfighter at the right time and for the right cost. SPAWAR Systems Center Pacific is the research and development part of SPAWAR focused on developing and transitioning technologies in the area of command, control, communications, computers, intelligence, surveillance, and reconnaissance. SPAWAR Systems Center Pacific conducts research, development, test, and evaluation projects to support emerging technologies for intelligence, surveillance, and reconnaissance; anti-terrorism and force protection; mine countermeasures; anti-submarine warfare; oceanographic research; remote sensing; and communications. These activities include, but are not limited to, the testing of unmanned undersea and surface vehicles, a wide variety of intelligence, surveillance, and

reconnaissance sensor systems, underwater surveillance technologies, and underwater communications (Table 18).

Table 18. Typical Space and Naval Warfare Systems Command Testing Activities in the Hawaii-Southern California Training and Testing Study Area.

Activity Name	Activity Description
Autonomous Undersea Vehicle (AUV) Anti-Terrorism/Force Protection (AT/FP) Mine Countermeasures	Autonomous undersea vehicle shallow water mine countermeasure testing is focused on the testing of unmanned undersea vehicles with mine hunting sensors in marine environments in and around rocky outcroppings. Anti-terrorism/force protection mine countermeasures testing is focused on mine countermeasure missions in confined areas between piers and pilings
Autonomous Undersea Vehicle (AUV) Underwater Communications	This testing is focused on providing two-way networked communications below the ocean surface while maintaining mission profile.
Fixed System Underwater Communications	Fixed underwater communications systems testing is focused on testing stationary or free floating equipment that provides two-way networked communications below the ocean surface while maintaining mission profile
Autonomous Undersea Vehicle (AUV) Autonomous Oceanographic Research and Meteorology and Oceanography (METOC)	The research is comprised of ocean gliders and autonomous undersea vehicles. Gliders are portable, long-endurance buoyancy driven vehicles that provide a means to sample and characterize ocean water properties. Autonomous undersea vehicles are larger, shorter endurance vehicles.
Fixed Autonomous Oceanographic Research and Meteorology and Oceanography (METOC)	The goal of these systems is to develop, integrate, and demonstrate deployable autonomous undersea technologies that improve the Navy's capability to conduct effective anti-submarine warfare and intelligence, surveillance, and reconnaissance operations in littoral waters
Passive Mobile Intelligence, Surveillance, and Reconnaissance Sensor Systems	These systems use passive arrays hosted by surface and subsurface vehicles and vessels for conducting submarine detection and tracking experiments and demonstrations
Fixed Intelligence, Surveillance, and Reconnaissance Sensor Systems	These systems use stationary fixed arrays for conducting submarine detection and tracking experiments and demonstrations.
Anti-Terrorism/Force Protection (AT/FP) Fixed Sensor Systems	These systems use stationary fixed arrays for providing protection of Navy assets from underwater threats.

2.2.6 Proposed Testing Activity Levels/Space and Naval Warfare Systems Command

Table 19 provides a summary of testing activities including tempo and location where the U.S. Navy proposes to conduct during testing.

Table 19. Proposed Space and Naval Warfare Systems Command Testing Activities proposed to occur in the Hawaii-Southern California Training and Testing Study Area (adapted from Table 2.8-4, Alternative 2, U.S. Navy Final EIS/OEIS, August 2013).

Event	No. of Events (per Year)	Ordnance (Number per Year)	Location
Autonomous Undersea Vehicle (AUV) Anti-Terrorism/Force Protection (AT/FP) Mine Countermeasures	92	n/a	SOCAL
	20	n/a	HRC
AUV Underwater Communications	92	n/a	SOCAL
	20	n/a	HRC
Fixed System Underwater Communications	37	n/a	SOCAL
AUV Autonomous Oceanographic Research and Meteorology and Oceanography (METOC)	92	n/a	SOCAL
	20	n/a	HRC
Fixed Autonomous Oceanographic Research and METOC	26	n/a	SOCAL
Passive Mobile Intelligence, Surveillance, and Reconnaissance Sensor Systems	27	n/a	SOCAL
Fixed Intelligence, Surveillance, and Reconnaissance Sensor Systems	39	n/a	SOCAL
	4	n/a	HRC
Anti-Terrorism/Force Protection (AT/FP) Fixed Sensor Systems	11	n/a	SOCAL

2.2.7 Office of Naval Research Testing

As the Navy's science and technology provider, Office of Naval Research and Naval Research Laboratory Testing (ONR and NRL) provide technology solutions for Navy and Marine Corps needs. ONR's mission is to plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security. Further, ONR manages the Navy's basic, applied, and advanced research to foster transition from science and technology to higher levels of research, development, test, and evaluation. The Ocean Battlespace Sensing Department explores science and technology in the areas of oceanographic and meteorological observations, modeling, and prediction in the battlespace environment; submarine detection and classification (anti-submarine warfare); and mine warfare applications for detecting and neutralizing mines in both the ocean and littoral environment. ONR events include research, development, test, and evaluation activities; surface processes acoustic communications experiments; shallow water acoustic communications experiments; sediment acoustics experiments; shallow water acoustic propagation experiments; and long range acoustic propagation experiments Table 20.

Table 20. Typical Office of Naval Research Testing Activity in the Hawaii-Southern California Training and Testing Study Area.

Activity Name	Activity Description
Kauai Acoustic Communications Experiment (Coastal)	The primary purpose of the Kauai Acoustic Communications Experiment is to collect acoustic and environmental data appropriate for studying the coupling of oceanography, acoustics, and underwater communications.

2.2.8 Proposed Testing Activity Levels/ Office of Naval Research

Table 21 provides a summary of testing activities including tempo and location where the U.S. Navy proposes to conduct during testing.

Table 21. Proposed Office of Naval Reasearch Testing Activities in the Hawaii-Southern California Training and Testing Study Area (adapted from Table 2.8-5, Alternative 2, U.S. Navy Final EIS/OEIS, August 2013).

Event	No. of Events (per Year)	Ordnance (Number per Year)	Location
Kauai Acoustic Communications Experiment	2	n/a	HRC

2.2.9 Sonar, Ordnance, Targets, and Other Systems

The Navy uses a variety of sensors, platforms, weapons, and other devices to meet its mission. Training and testing with these systems may introduce acoustic (sound) energy into the environment. This section describes and organizes sonar systems, ordnance, munitions, targets, and other systems to facilitate understanding of the activities in which these systems are used. Underwater sound is described as one of two types for the purposes of the Navy's proposed action: impulsive and non-impulsive. Underwater detonations of explosives and other percussive events are impulsive sounds. Sonar and similar sound producing systems are categorized as non-impulsive sound sources.

Sonar and Other Non-impulsive Sources – Modern sonar technology includes a variety of sonar sensor and processing systems. The simplest active sonar emits sound waves, or "pings," sent out in multiple directions and the sound waves then reflect off of the target object in multiple directions. The sonar source calculates the time it takes for the reflected sound waves to return; this calculation determines the distance to the target object. More sophisticated active sonar systems emit a ping and then rapidly scan or listen to the sound waves in a specific area. This provides both distance to the target and directional information. Even more advanced sonar systems use multiple receivers to listen to echoes from several directions simultaneously and provide efficient detection of both direction and distance. The Navy rarely uses active sonar continuously throughout activities. When sonar is in use, the pings occur at intervals, referred to as a duty cycle, and the signals themselves are very short in duration. For example, sonar that

emits a 1-second ping every 10 seconds has a 10-percent duty cycle. The Navy utilizes sonar systems and other acoustic sensors in support of a variety of mission requirements. Primary uses include the detection of and defense against submarines (anti-submarine warfare) and mines (mine warfare); safe navigation and effective communications; use of unmanned undersea vehicles; and oceanographic surveys.

Ordnance and Munitions – Most ordnance and munitions used during training exercises and testing events fall into three basic categories: projectiles (such as gun rounds), missiles (including rockets), and bombs. Ordnance can be further defined by their net explosive weight, which considers the type and quantity of the explosive substance without the packaging, casings, bullets, etc. Net explosive weight (NEW) is the trinitrotoluene (TNT) equivalent of energetic material, which is the standard measure of strength of bombs and other explosives. For example, a 12.7-centimeter (cm) shell fired from a Navy gun is analyzed at about 9.5 pounds (lb) (4.3 kilograms (kg)) of NEW. The Navy also uses non-explosive ordnance in place of high explosive ordnance in many training exercises and testing events. Non-explosive ordnance and munitions look and perform similarly to high explosive ordnance, but lack the main explosive charge.

Defensive Countermeasures – Naval forces depend on effective defensive countermeasures to protect themselves against missile and torpedo attack. Defensive countermeasures are devices designed to confuse, distract, and confound precision guided munitions. Defensive countermeasures analyzed in this biological opinion application include acoustic countermeasures, which are used by surface ships and submarines to defend against torpedo attack. Acoustic countermeasures are either released from ships and submarines, or towed at a distance behind the ship.

Mine Warfare Systems – The Navy divides mine warfare systems into two categories: mine detection and mine neutralization. Mine detection systems are used to locate, classify, and map suspected mines, on the surface, in the water column, or on the sea floor. The Navy analyzed the following mine detection systems for impacts to marine mammals:

- Towed or hull-mounted mine detection systems. These detection systems use acoustic and laser or video sensors to locate and classify suspect mines. Fixed and rotary wing platforms, ships, and unmanned vehicles are used for towed systems, which can rapidly assess large areas.
- Unmanned/remotely operated vehicles. These vehicles use acoustic and video or lasers to locate and classify mines and provide unique capabilities in nearshore littoral areas, surf zones, ports, and channels.
- Marine mammal systems. The Navy deploys trained Atlantic bottlenose dolphins (*Tursiops truncatus*) and California sea lions (*Zalophus californianus*) for integrated training involving two primary mission areas: to find objects such as inert mine shapes, and to detect swimmers or other intruders around Navy facilities such as

piers. These systems also include one or more motorized small boats and several crew members for each trained marine mammal. When not engaged in training, Navy marine mammals are housed in temporary enclosures either on land or aboard ships.

Mine Neutralization Systems – Mine neutralization systems disrupt, disable, or detonate mines to clear ports and shipping lanes, as well as littoral, surf, and beach areas in support of naval amphibious operations. The Navy analyzed the following mine neutralization systems for impacts to ESA-listed species:

- Towed influence mine sweep systems. These systems use towed equipment that mimic a particular ship's magnetic and acoustic signature triggering the mine and causing it to explode.
- Unmanned/remotely operated mine neutralization systems. Surface ships and helicopters operate these systems, which place explosive charges near or directly against mines to destroy the mine.
- Airborne projectile-based mine clearance systems. These systems neutralize mines by firing a small or medium-caliber non-explosive, supercavitating projectile from a hovering helicopter.
- Diver emplaced explosive charges. Operating from small craft, divers put explosive charges near or on mines to destroy the mine or disrupt its ability to function.

Classification of Non-impulsive and Impulsive Sources Analyzed

In order to better organize and facilitate the analysis of about 300 sources of underwater non-impulsive sound or impulsive energy, the Navy developed a series of source classifications, or source bins. This method of analysis provides the following benefits:

- Allows for new sources to be covered under existing authorizations, as long as those sources fall within the parameters of a "bin;"
- Simplifies the data collection and reporting requirements anticipated under the MMPA;
- Ensures a conservative approach to all impact analysis because all sources in a single bin are modeled as the loudest source (e.g., lowest frequency, highest source level, longest duty cycle, or largest net explosive weight within that bin);
- Allows analysis to be conducted more efficiently, without compromising the results;
- Provides a framework to support the reallocation of source usage (hours/explosives) between different source bins, as long as the total number and severity of marine mammal and sea turtle takes remain within the overall analyzed and authorized limits. This flexibility is required to support evolving Navy training exercises and testing requirements, which are linked to real world events.

Non-impulsive sources are grouped into bins based on the frequency, source level when warranted, and how the source would be used. Impulsive bins are based on the net explosive weight of the munitions or explosive devices. The following factors further describe how non-impulsive sources are divided:

- Frequency of the non-impulsive source:
    - Low-frequency sources operate below 1 kilohertz (kHz)
    - Mid-frequency sources operate at or above 1 kHz, up to and including 10 kHz
    - High-frequency sources operate above 10 kHz, up to and including 100 kHz
    - Very high-frequency sources operate above 100, but below 200 kHz
- Source level of the non-impulsive source:
    - Greater than 160 decibels (dB), but less than 180 dB
    - Equal to 180 dB and up to 200 dB
    - Greater than 200 dB

How a sensor is used determines how the sensor's acoustic emissions are analyzed. Factors to consider include pulse length (time source is on); beam pattern (whether sound is emitted as a narrow, focused beam, or, as with most explosives, in all directions); and duty cycle (how often a transmission occurs in a given time period during an event).

There are also non-impulsive sources with characteristics that are not anticipated to result in takes of marine mammals and sea turtles. These sources have low source levels, narrow beam widths, downward directed transmission, short pulse lengths, frequencies beyond known hearing ranges of marine mammals, or some combination of these factors. These sources were not modeled by the Navy.

2.3 Marine Mammal Protection Act Regulations

The regulations NMFS Permits Division proposes to promulgate would establish a framework under the MMPA whereby the Navy may obtain authorization to "take" marine mammals only if the "take" occurs within the HSTT Study Area. The framework includes the following: (1) specific activity and geographical region where "take" make occur, (2) dates when "take" may occur, (3) permissible methods of taking, (4) prohibitions on taking of marine mammals, (5) mitigation required, (6) monitoring and reporting requirements, (7) how LOAs may be applied for, (8) specifics of LOAs, and (9) renewals and modifications of LOAs and adaptive management processes.

In order to promulgate the proposed rule, NMFS must find that the incidental taking of marine mammals will have a negligible impact on the species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). NMFS has defined negligible impact in 50 CFR 216.103 as "an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably

likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival."

NMFS Permits Division has determined that the Navy's proposed action (summarized above in Sections 2.1 and 2.2) would result in the take of ESA-listed species and that such take would be in the form of exposure to sound or pressure waves in the water and interactions with vessels. The specific activity and geographic region where take may occur, the dates when take may occur, and permissible method of taking that will be set by the proposed regulations are all consistent with the Navy's proposed action described previously in this opinion so they will not be reiterated here. The prohibitions on taking of marine mammals specific to ESA-listed species are presented in Table 22 and Table 23.

Table 22. Proposed Level B harassment take of listed species pursuant to the Marine Mammal Protection Act proposed by NMFS Permits Division for training exercises within the Hawaii-Southern California Training and Testing Study Area.

Species	Up to annual takes	5-year total takes
Blue Whale	4,325	21,559
Fin Whale	1,719	8,531
Western North Pacific Gray Whale	10	50
Humpback Whale	9,273	46,365
Sei Whale	630	2,996
Main Hawaiian Islands Insular False Killer Whale	49	220
Sperm Whale	3,332	15,920
Guadalupe Fur Seal	2,603	13,015
Hawaiian Monk Seal	1,292	6,334

In addition, the NMFS' Permits Division is proposing no more than 35 mortalities (seven annually) for any non-listed small odontocete or pinniped species from an impulse source and no more than 12 large whale mortalities (up to four annually) from vessel strike during training exercises. No more than two of the annual takes from vessel strike can be from ESA-listed species.

Table 23. Proposed Level B harassment take pursuant to the Marine Mammal Protection Act proposed by NMFS' Permits Division for testing activities within the Hawaii-Southern California Training and Testing Study Area.

Species	Up to annual takes	5-year total takes
Blue whale	428	2,140
Fin whale	225	1,125
Western North Pacific Gray Whale	2	10
Humpback whale	921	4,605
Sei whale	51	255
Main Hawaiian Islands Insular False killer whale	4	20
Sperm whale	263	1,315
Guadalupe fur seal	269	1,345
Hawaiian monk seal	358	1,790

In addition, NMFS' Permits Division is proposing no more than 95 mortalities (19 annually) for any small odontocete or pinniped species from an impulse source and no more than three large whale mortalities (up to two annually) from vessel strike during testing activities. Only one of the mortalities can be an ESA-listed species of large whale.

NMFS' Permits Division must also set forth mitigation, monitoring, and reporting requirements. Here we provide a summary of those based on the draft Final Rule. Items 7-9 addressed in the MMPA regulations are related to the LOA application process, specific requirements that must be included in each LOA issued under this proposed rule, and renewal process and modification process of LOAs. We do not reiterate those sections here.

2.3.1 Mitigation Measures Proposed by the U.S. Navy

NMFS Permits Division, NMFS ESA Interagency Cooperation Division, and the Navy have reached agreement regarding mitigation measures that will be implemented by the Navy. These measures satisfy the requirements of the MMPA and many were carried over as requirements in previous section 7 consultations. The Navy proposes to implement measures that would allow their training exercises 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 Permit Division's regulations and LOAs. Many of these measures would minimize the impacts to other ESA-listed species. Mitigation measures in the final rule are divided into four categories: (1) lookouts, (2) mitigation zones, (3) humpback whale cautionary area, and (4) stranding response.

Lookouts

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

The Navy would have two types of lookouts for purposes of conducting visual observations: (1) those positioned on surface ships, and (2) those positioned in aircraft or on boats. Lookouts positioned on surface ships would be dedicated solely to diligent observation of the air and surface of the water. They would have multiple observation objectives, which include but are not limited to detecting the presence of biological resources and recreational or fishing boats, observing mitigation zones, and monitoring for vessel and personnel safety concerns. Due to aircraft and boat manning and space restrictions, lookouts positioned in aircraft or on boats would consist of the aircraft crew, pilot, or boat crew.

Lookouts positioned in aircraft and boats may necessarily be responsible for tasks in addition to observing the air or surface of the water (for example, navigation of a helicopter or rigid hull inflatable boat). However, aircraft and boat lookouts would, to the maximum extent practicable and consistent with aircraft and boat safety and training and testing requirements, comply with the observation objectives described above for lookouts positioned on surface ships.

All divers placing the charges on mines will support the Lookouts while performing their regular duties. The divers will report all marine mammal and sea turtle sightings to their dive support vessel.

Mitigation Zones

The following are protective measures concerning the implementation of mitigation zones.

(i) Mitigation zones will be measured as the radius from a source and represent a distance to be monitored.

(ii) Visual detections of marine mammals within a mitigation zone will be communicated immediately to a watch station for information dissemination and appropriate action.

(iii) Mitigation zones for non-impulsive sound:

(A) When marine mammals are visually detected, the Navy shall ensure that low-frequency and hull-mounted mid-frequency active sonar transmission levels are limited to at least 6 dB below normal operating levels, for sources that can be powered down, if any detected marine mammals are within 1,000 yd (914 m) of the sonar dome (the bow).

(B) The Navy shall ensure that low-frequency and hull-mounted mid-frequency active sonar transmissions are limited to at least 10 dB below the equipment's normal operating level, for sources that can be powered down, if any detected marine mammals are within 500 yd (457 m) of the sonar dome.

(C) The Navy shall ensure that low-frequency sonar and hull-mounted mid-frequency active sonar transmissions are ceased, for sources that can be turned off during the activity, if any visually detected marine mammals are within 200 yd (183 m) of the sonar dome. Transmissions will not resume until one of the following conditions is met: the animal is observed exiting the mitigation zone; the animal is thought to have exited the mitigation zone based on a determination of its course and speed and the relative motion between the animal and the source; the mitigation zone has been clear from any additional sightings for a period of 30 minutes; the ship has transited more than 2,000 yd (1.8 km) beyond the location of the last sighting; or the ship concludes that dolphins are deliberately closing in on the ship to ride the ship's bow wave (and there are no other marine mammal sightings within the mitigation zone). Active transmission may resume when dolphins are bow riding because they are out of the main transmission axis of the active sonar while in the shallow-wave area of the bow.

(D) The Navy shall ensure that low-frequency and hull-mounted mid-frequency active sonar transmissions are ceased for sources that cannot be powered down during the activity, if any visually detected marine mammals are within 200 yd (183 m) of the source. Transmissions will not resume until one of the following conditions is met: the animal is observed exiting the mitigation zone; the animal is thought to have exited the mitigation zone based on a determination of its course and speed and the relative motion between the animal and the source; the mitigation zone has been clear from any additional sightings for a period of 30 minutes; the ship has transited more than 400 yd (366 m) beyond the location of the last sighting.

(E) When marine mammals are visually detected, the Navy shall ensure that high-frequency and non-hull-mounted mid-frequency active sonar transmission levels are ceased if any visually detected marine mammals are within 200 yd (183 m) of the source. Transmissions will not resume until one of the following conditions is met: the animals is observed exiting the mitigation zone; the animal is thought to have exited the mitigation zone based on a determination of its course and speed and the relative motion between the animal and the source; the mitigation zone has been clear from any additional sightings for a period of 10 minutes for an aircraft-deployed source; the mitigation zone has been clear from any additional sightings for a period of 30 minutes for a vessel-deployed source; the vessel or aircraft has repositioned itself more than 400 yd (366 m) away from the location of the last sighting; or the vessel concludes that dolphins are deliberately closing to ride the vessel's bow wave (and there are no other marine mammal sightings within the mitigation zone).

(iv) Mitigation zones for explosive and impulsive sound:

(A) A mitigation zone with a radius of 600 yd (549 m) shall be established for IEER sonobuoys (bin E4).

(B) A mitigation zone with a radius of 350 yd (320 m) shall be established for explosive sonobuoys using 0.6 to 2.5 lb net explosive weight (bin E3).

(C) A mitigation zone with a radius of 200 yd (183 m) shall be established for anti-swimmer grenades (bin E2).

(D) A mitigation zone ranging from 600 yd (549 m) to 2,100 yd (1.9 km), dependent on charge size, shall be established for general mine countermeasure and neutralization activities using positive control firing devices. Mitigation zone distances are specified for charge size in Table 11-2 of the Navy's application.

(E) A mitigation zone ranging from 350 yd (320 m) to 850 yd (777 m), dependent on charge size, shall be established for mine countermeasure and neutralization activities using diver-placed positive control firing devices. Mitigation zone distances are specified for charge size in Table 11-2 of the Navy's application.

(F) A mitigation zone with a radius of 1,000 yd (914 m) shall be established for mine neutralization diver placed mines using time-delay firing devices (bin E7).

(G) A mitigation zone with a radius of 200 yd (183 m) shall be established for small- and medium-caliber gunnery exercises with a surface target (bin E2).

(H) A mitigation zone with a radius of 600 yd (549 m) shall be established for large-caliber gunnery exercises with a surface target (bin E5).

(I) A mitigation zone with a radius of 900 yd (823 m) shall be established for missile exercises (including rockets) with up to 250 lb net explosive weight and a surface target (bin E9).

(J) A mitigation zone with a radius of 2,000 yd (1.8 km) shall be established for missile exercises with 251 to 500 lb net explosive weight and a surface target (E10)

(K) A mitigation zone with a radius of 2,500 yd (2.3 km) shall be established for bombing exercises (bin E12).

(L) A mitigation zone with a radius of 2,100 yd (1.9 km) shall be established for torpedo (explosive) testing (bin E11).

(M) A mitigation zone with a radius of 2.5 nautical miles shall be established for sinking exercises (bin E12).

(N) A mitigation zone with a radius of 1,600 yd (1.4 km) shall be established for at-sea explosive testing (bin E5).

(O) A mitigation zone with a radius of 60 yd (55 m) shall be established for elevated causeway system pile driving.

(P) A mitigation zone with a radius of 70 yd (64 m) within 30 degrees on either side of the gun target line on the firing side of the vessel for explosive and non-explosive large-caliber gunnery exercises.

(v) Mitigation zones for vessels and in-water devices:

(A) A mitigation zone of 500 yd (457 m) for observed whales and 200 yd (183 m) for all other marine mammals (except bow riding dolphins) shall be established for all vessel movement, providing it is safe to do so.

(B) A mitigation zone of 250 yd (229 m) for any observed marine mammal shall be established for all towed in-water devices that are towed from a manned platform, providing it is safe to do so.

(vi) Mitigation zones for non-explosive practice munitions:

(A) A mitigation zone of 200 yd (183 m) shall be established for small, medium, and large caliber gunnery exercises using a surface target with non-explosive practice munitions.

(B) A mitigation zone of 1,000 yd (914 m) shall be established for bombing exercises with non-explosive practice munitions.

(C) A mitigation zone of 900 yd (823 m) shall be established for missile exercises (including rockets) using a surface target.

(vii) Mitigation zones for the use of Navy sea lions:

(A) If a monk seal is seen approaching or within 100 m of a Navy sea lion, the handler will hold the Navy sea lion in the boat or recall the Navy sea lion immediately if it has already been released.

Humpback Whale Cautionary Area

The Navy will maintain a 5-km (3.1-mi) buffer zone between December 15 and April 15 where conducting mid-frequency active sonar exercises will require authorization by the Commander, U.S. Pacific Fleet (CPF). If authorized, the CPF will provide specific direction on required mitigation prior to operational units transiting to and training in the area. The Navy will provide NMFS with advance notification of any mid-frequency active sonar training and testing activities in the humpback whale cautionary area between December 15 and April 15.

Stranding Response

The proposed MMPA regulations include a stranding response plan as follows (78 FR 6978).

(4) Stranding Response Plan

(i) The Navy shall abide by the letter of the "Stranding Response Plan for Major Navy Training Exercises in the HSTT Study Area," to include the following measures:

(A) Shutdown Procedures - When an Uncommon Stranding Event (USE - defined in § 218.71 (b)(1)) occurs during a Major Training Exercise (MTE) in the HSTT Study Area, the Navy shall implement the procedures described below.

(1) The Navy shall implement a shutdown (as defined § 218.71 (b)(2)) when advised by a NMFS Office of Protected Resources Headquarters Senior Official designated in the HSTT Study Area Stranding Communication Protocol that a USE involving live animals has been identified and that at least one live animal is located in the water. NMFS and the Navy will maintain a dialogue, as needed, regarding the identification of the USE and the potential need to implement shutdown procedures.

(2) 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).

(3) If the Navy finds an injured or dead animal 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 behavior (if alive), and photo or video (if available). Based on the information provided, NFMS will determine if, and advise the Navy whether a modified shutdown is appropriate on a case-by-case basis.

(4) In the event, following a USE, that qualified individuals are attempting to herd animals back out to the open ocean and animals are not willing to leave, or 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 mid-frequency active sonar training activities or explosive detonations, though farther than 14 nautical miles from the distressed animal(s), is likely contributing to the animals' refusal to return to the open water. If so, NMFS and the Navy will further coordinate to determine what measures are necessary to improve the probability that the animals will return to open water and implement those measures as appropriate.

(B) Within 72 hours of NMFS notifying the Navy of the presence of a USE, the Navy shall provide available information to NMFS (per the HSTT Study Area Communication Protocol) regarding the location, number and types of acoustic/explosive sources, direction and speed of units using mid-frequency active sonar, and marine mammal sightings information associated with training activities occurring within 80 nautical miles (148 km) and 72 hours prior to the USE event. Information not initially available regarding the 80-nautical miles (148-km), 72-hour period prior to the event will be provided as soon as it

becomes available. The Navy will provide NMFS investigative teams with additional relevant unclassified information as requested, if available.

2.3.2 Monitoring and Reporting Requirements

Monitoring and reporting would be required by the MMPA regulations as described in the final MMPA rule. These requirements are generally consistent with monitoring and reporting required of and undertaken by the Navy in the past for the Southern California and Hawaii Range Complexes under prior biological opinions, rules, and permits. These data have helped to inform subsequent analyses, informing assumptions we have made in the past and better informing our new analyses. As such, we continue to require these components with occassional modification to reflect revised assumptions and analyses.

§ 218.75 Requirements for monitoring and reporting.

(a) As outlined in the HSTT Study Area Stranding Communication Plan, the Holder of the Authorization must notify NMFS immediately (or as soon as operational security considerations allow) if the specified activity identified in § 218.70 is thought to have resulted in the mortality or injury of any marine mammals, or in any take of marine mammals not identified in § 218.71.

(b) The Holder of the LOA must conduct all monitoring and required reporting under the LOA, including abiding by the HSTT Monitoring Plan.

(c) General Notification of Injured or Dead Marine Mammals - Navy personnel shall ensure that NMFS (regional stranding coordinator) is notified immediately (or as soon as operational security considerations allow) if an injured or dead marine mammal is found during or shortly after, and in the vicinity of, an Navy training or testing activity utilizing mid- or high-frequency active sonar, 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.

(d) Vessel Strike – In the event that a Navy vessel strikes a whale, the Navy shall do the following:

(1) Immediately report to NMFS (pursuant to the established Communication Protocol) the:

(i) Species identification if known;

(ii) Location (latitude/longitude) of the animal (or location of the strike if the animal has disappeared);

(iii) Whether the animal is alive or dead (or unknown); and

(iv) The time of the strike.

(2) As soon as feasible, the Navy shall report to or provide to NMFS, the:

(i) Size, length, and description (critical if species is not known) of animal;

(ii) An estimate of the injury status (e.g., dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared, etc.);

(iii) Description of the behavior of the whale during event, immediately after the strike, and following the strike (until the report is made or the animal is no long sighted);

(iv) Vessel class/type and operation status;

(v) Vessel length

(vi) Vessel speed and heading; and

(vii) To the best extent possible, obtain

(3) Within 2 weeks of the strike, provide NMFS:

(i) A detailed description of the specific actions of the vessel in the 30-minute timeframe immediately preceding the strike, during the event, and immediately after the strike (e.g., the speed and changes in speed, the direction and changes in the direction, other maneuvers, sonar use, etc., if not classified); and

(ii) A narrative description of marine mammal sightings during the event and immediately after, and any information as to sightings prior to the strike, if available; and

(iii) Use established Navy shipboard procedures to make a camera available to attempt to capture photographs following a ship strike.

(e) Annual HSTT Monitoring Plan Report - (1) The Navy shall submit an annual report for the HSTT Monitoring Plan in April of each year, describing the implementation and results from the previous calendar year. Data collection methods will be standardized across range complexes and study areas to allow for comparison in different geographic locations. Although additional information will be gathered, the protected species observers collecting marine mammal data pursuant to the HSTT Monitoring Plan shall, at a minimum, provide the same marine mammal observation data required in § 218.75. (2) As an alternative, the Navy may submit a multi-Range Complex annual Monitoring Plan report to fulfill this requirement. Such a report would describe progress of knowledge made with respect to monitoring plan study questions across all Navy ranges associated with the ICMP. Similar study questions shall be treated together so that progress on each topic shall be summarized across all Navy ranges. The report need not include analyses and content that does not provide direct assessment of cumulative progress on the monitoring plan study questions.

(f) Annual HSTT Exercise and Testing Reports - The Navy shall submit preliminary reports detailing the status of authorized sound sources within 21 days after the end of the annual authorization cycle. The Navy shall submit detailed reports 3 months after the anniversary of the date of issuance of the LOA. The detailed annual reports shall contain information on Major Training Exercises (MTE), Sinking Exercise (SINKEX) events, and a summary of sound sources used, as described below. The analysis in the detailed reports will be based on the accumulation of data from the current year's report and data collected from previous reports. The detailed reports shall contain information identified in paragraphs (e)(1) through (e)(5) of this section.

(1) Major Training Exercises/SINKEX:

(i) This section shall contain the reporting requirements for Coordinated and Strike Group exercises and SINKEX. Coordinated and Strike Group Major Training Exercises include:

(A) Sustainment Exercise (SUSTAINEX).

(B) Integrated ASW Course (IAC).

(C) Composite Training Unit Exercises (COMPTUEX).

(D) Joint Task Force Exercises (JTFEX).

(E) Undersea Warfare Exercise (USWEX).

(ii) Exercise information for each MTE:

(A) Exercise designator.

(B) Date that exercise began and ended.

(C) Location (operating area).

(D) Number of items or hours (per the LOA) of each sound source bin (impulsive and non-impulsive) used in the exercise.

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

(F) Individual marine mammal sighting info for each sighting for each MTE:

(1) Date/time/location of sighting.

(2) Species (if not possible, indication of whale/dolphin/pinniped).

(3) Number of individuals.

(4) Initial detection sensor.

(5) Indication of specific type of platform the observation was made from (including, for example, what type of surface vessel or testing platform).

(6) Length of time observers maintained visual contact with marine mammal(s).

(7) Sea state.

(8) Visibility.

(9) Sound source in use at the time of sighting.

(10) Indication of whether animal is <200 yd, 200-500 yd, 500-1,000 yd, 1,000-2,000 yd, or >2,000 yd from sound source.

(11) Mitigation implementation – whether operation of sonar sensor was delayed, or sonar was powered or shut down, and how long the delay was; or whether navigation was changed or delayed.

(12) If source in use is a hull-mounted sonar, relative bearing of animal from ship and estimation of anima's motion relative to ship (opening, closing, parallel).

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

(G) An evaluation (based on data gathered during all of the MTEs) of the effectiveness of mitigation measures designed to minimize the received level to which marine mammals may be exposed. This evaluation shall identify the specific observations that support any conclusions the Navy reaches about the effectiveness of the mitigation.

(iii) Exercise information for each SINKEX:

(A) List of the vessels and aircraft involved in the SINKEX.

(B) Location (operating area).

(C) Chronological list of events with times, including time of sunrise and sunset, start and stop time of all marine species surveys that occur before, during, and after the SINKEX, and ordnance used.

(D) Visibility and/or weather conditions, wind speed, cloud cover, etc. throughout exercise if it changes.

(E) Aircraft used in the surveys, flight altitude, and flight speed and the area covered by each of the surveys, given in coordinates, map, or square miles.

(F) Passive acoustic monitoring details (number of sonobuoys, area and depth that was heard, detections of biologic activity, etc.).

(G) Individual marine mammal sighting info for each sighting that required mitigation to be implemented:

(1) Date/time/location of sighting.

(2) Species (if not possible, indication of whale/dolphin/pinniped).

(3) Number of individuals.

(4) Initial detection sensor.

(5) Indication of specific type of platform the observation was made from (including, for example what type of surface vessel or platform).

(6) Length of time observers maintained visual contact with marine mammal(s).

(7) Sea state.

(8) Visibility.

(9) Indication of whether animal is <200 yd, 200-500 yd, 500-1,000 yd, 1,000-2,000 yd, or >2,000 yd from the target.

(10) Mitigation implementation – whether the SINKEX was stopped or delayed and length of delay.

(11) 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.), and if any calves present.

(H) List of the ordnance used throughout the SINKEX and net explosive weight (NEW) of each weapon and the combined ordnance NEW.

(2) Summary of Sources Used.

(i) This section shall include the following information summarized from the authorized sound sources used in all training and testing events:

(A) Total annual hours or quantity (per the LOA) of each bin of sonar or other non-impulsive source;

(B) Total annual expended/detonated rounds (missiles, bombs, etc.) for each explosive bin;

(C) Total annual airgun use; and

(D) Improved Extended Echo-Ranging System (IEER)/sonobuoy summary, including:

(1) Total expended/detonated rounds (buoys).

(2) Total number of self-scuttled IEER rounds.

(3) Sonar Exercise Notification – The Navy shall submit to NMFS (specific contact information to be provided in LOA) either an electronic (preferably) or verbal report within fifteen calendar days after the completion of any major exercise (RIMPAC, USWEX, or Multi Strike Group) indicating:

(i) Location of the exercise.

(ii) Beginning and end dates of the exercise.

(iii) Type of exercise (e.g., RIMPAC, USWEX, or Multi Strike Group).

(4) Geographic Information Presentation – The reports shall present an annual (and seasonal, where practical) depiction of training exercises and testing bin usage geographically across the Study Area.

(5) Special Reporting Requirements – To the extent practicable, and as it applies to the specific Study Area, these reports will also include:

(i) The total hours (from 15 December through 15 April) of hull-mounted active sonar operation occurring in the dense humpback areas generally shown on the Mobley map (73 FR 35510, 35520) plus a 5-km buffer, but not including the Pacific Missile Range Facility (as illustrated in the HSTT FEIS/OEIS).

(ii) The total estimated annual hours of hull-mounted active sonar operation conducted in the Humpback Whale Cautionary Area between 15 December and 15 April.

(6) 5-year Close-out Exercise and Testing Report – This report will be included as part of the 2019 annual exercise or testing report. This report will provide the annual totals for each sound source bin with a comparison to the annual allowance and the 5-year total for each sound source

bin with a comparison to the 5-year allowance. Additionally, if there were any changes to the sound source allowance, this report will include a discussion of why the change was made and include the analysis to support how the change did or did not result in a change in the FEIS and final rule determinations. The report will be submitted 3 months after the expiration of the rule. NMFS will submit comments on the draft close-out report, if any, within 3 months of receipt. The report will be considered final after the Navy has addressed NMFS' comments, or 3 months after the submittal of the draft if NMFS does not provide comments.

2.4 Letters of Authorization

NMFS Permits Division proposes to issue two LOAs to the Navy authorizing "take" of marine mammals from (1) the Navy's training exercises in the HSTT Study Area and (2) the Navy's testing activities in the HSTT Study Area in accordance with the final rule as described above and consistent with the conditions listed below. Each LOA would be valid from December 2013 through December 2018.

(a) An LOA, unless suspended or revoked, will be valid for a period of time not to exceed the period of validity of this subpart.

(b) Each LOA will set forth:

(1) Permissible methods of incidental taking;

(2) Means of effecting the least practicable adverse impact on the species, its habitat, and on the availability of the species for subsistence uses (i.e., mitigation); and

(3) Requirements for mitigation, monitoring and reporting.

(c) Issuance and renewal of the LOA will be based on a determination that the total number of marine mammals taken by the activity as a whole will have no more than a negligible impact on the affected species or stock of marine mammal(s).

2.5 Action Area

The HSTT Study Area is comprised of established operating and warning areas across the north-central Pacific Ocean, from Southern California to Hawaii and the International Date Line (Figure 1). The defined Study Area has expanded beyond the areas included in previous Navy authorizations to include transit routes and pierside locations. The Navy proposes to conduct military readiness training exercises and testing activities throughout the in-water areas around the Hawaiian Islands and off the coast of Southern California, primarily in established operating and military warning areas of the Study Area.

The Hawaii Range Complex consists of ocean areas located around the major islands of the Hawaiian Islands chain. The offshore areas form an area approximately 1,700 nautical miles (nm) by 1,600 nm. The component areas of the Hawaii Range Complex include the Hawaii operating area which consists of 235,000 square nautical miles (nm^2) of surface and subsurface ocean areas and special use airspace as well as various Navy land ranges and other services' land used for military training exercises and testing activities.

The Southern California Range Complex is situated between Dana Point and San Diego, and extends more than 600 nm southwest into the Pacific Ocean, encompassing 120,000 nm^2 of sea space, 113,000 nm^2 of special use airspace, and over 56 square miles (m^2) of land area.

The Silver Strand Training Complex is composed of oceanside beach and boat training lanes, ocean anchorage areas, bayside water training areas in the San Diego Bay and its bayside beaches.

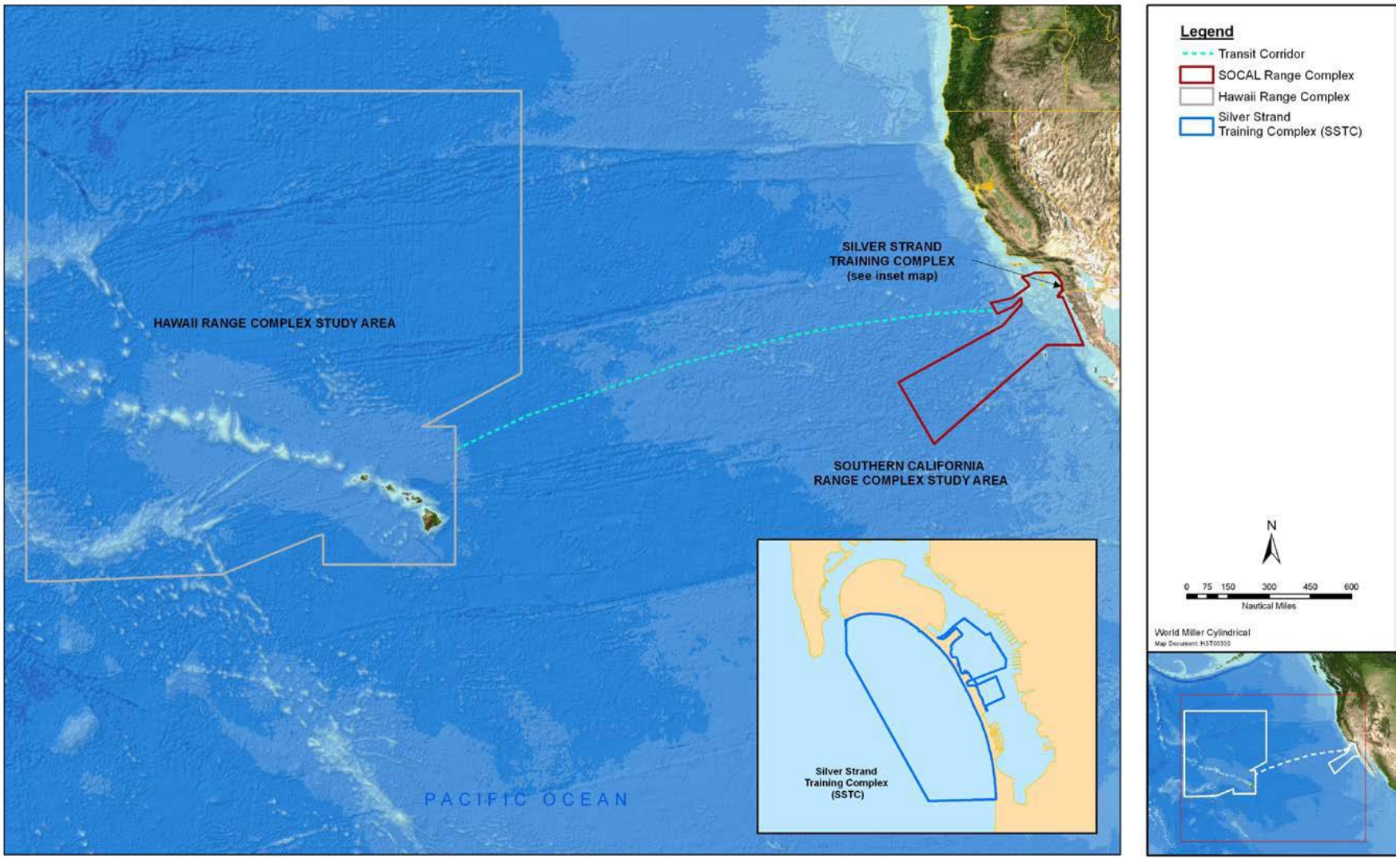

Figure 1. Hawaii-Southern California Training and Testing Study Area.

3 APPROACH TO THE ASSESSMENT

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

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

This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 C.F.R. §402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.[1]

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

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area. The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities *in the action area*. It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process.
- Analyze the effects of the proposed action on both species and their habitat. In this step, we consider how the proposed action would affect the species' reproduction, numbers, and distribution or, in the case of salmon and steelhead, their viable salmonid population (VSP) parameters. We also evaluate the proposed action's effects on critical habitat features.
- Describe any cumulative effects in the action area. Cumulative effects, as defined in our implementing regulations (50 C.F.R. §402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur

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

within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation.

- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat. In this step, we add the effects of the action (Section 6) to the environmental baseline (Section 5) and the cumulative effects (Section 6.7) to assess whether the action could reasonably be expected to: (1) reduce appreciably the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the conservation value of designated or proposed critical habitat. These assessments are made in full consideration of the status of the species and critical habitat (Section 4).
- Reach jeopardy and adverse modification conclusions. In this step we state our conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 8. These conclusions flow from the logic and rationale presented in Section 7 (Integration and Synthesis).
- If necessary, define a reasonable and prudent alternative to the proposed action. If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative (RPA) to the action in Section 8. The RPA must not be likely to jeopardize the continued existence of listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

3.1 Application of this Approach in this Consultation

In their consultation request, the U.S. Navy provided the list of stressors they evaluated in their FEIS/OEIS (Navy 2013c). The Navy categorized the stressors as listed in Table 24.

Table 24. List of stressors the U.S. Navy analyzed for impacts to biological resources in the Hawaii-Southern California Training and Testing Study Area.

Components and Stressors for Biological Resources
Acoustic Stressors
Sonar and other active acoustic sources
Explosives
Pile driving
Swimmer defense airguns
Weapons firing, launch, and impact noise
Vessel noise
Aircraft noise
Energy Stressors
Electromagnetic devices
Physical Disturbance and Strike Stressors
Vessels
In-water devices
Military expended materials
Seafloor devices
Entanglement Stressors
Fiber optic cables and guidance wires
Parachutes
Ingestion Stressors
Munitions
Military expended materials other than munitions
Secondary Stressors

We considered stressors based on the following categories:

1. Disturbance of threatened and endangered species from presence and movements of surface vessels, underwater vehicles, torpedoes, targets, and aircraft that would be used during the proposed training exercises and testing activities.

2. Risk of death or injury from collisions with surface vessels, underwater vehicles, and torpedoes that would be used during the proposed training exercises and testing activities.

3. Risks from expended materials that are used during the proposed training exercises and testing activities.

4. Stressors from electromagnetic devices that would be used during the proposed training exercises and testing activities.

5. Acoustic sources such as sonar and explosives associated with the proposed training exercises and testing activities.

The first step of our analysis evaluates the available evidence to determine the likelihood of listed species or critical habitat being exposed to these stressors. Our analysis assumed that these stressors pose no risk to listed species or critical habitat if these stressors do not co-occur, in space or time, with (1) individuals of endangered or threatened species or units of critical habitat that have 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.

3.1.1 Exposure Analyses

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. This exposure analyses was designed to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations (or other sub-divisions of "populations," including demes, runs, or races) those individuals represent.

In this opinion, we relied on the Navy and NMFS Permits Division exposure estimates of the number of ESA-listed species that might interact with naval assests associated with training exercises and testing activities in the HSTT Study Area.

3.1.2 Response Analyses

Once we identified which listed resources were likely to be exposed to a stressor or stressors associated with the proposed training exercises and testing activities and the nature of that exposure, we examined the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure. Prior to this consultation, we made several major changes to the conceptual model that forms the foundation for our response analyses. First, we constructed our revised model on a model of animal behavior and behavioral decision-making, which incorporates the cognitive processes involved in behavioral decisions; earlier versions of this model ignored critical components of animal behavior and behavioral decision-making. As a result, our revised model assumes that Navy training exercises

and testing activities primarily affect endangered and threatened species by changing their behavior, although we continue to recognize the risks of physical trauma and noise-induced losses in hearing sensitivity (threshold shift). Second, we expanded our concept of "hearing" to include cognitive processing of auditory cues, rather than a focus solely on the mechanical processes of the ear and auditory nerve. Third, our revised model incorporates the primary mechanisms by which behavioral responses affect the longevity and reproductive success of animals: changing an animal's energy budget, changing an animal's time budget (which is related to changes in an animal's energy budget), forcing animals to make life history trade-offs (for example, engaging in evasive behavior such a deep dives that involve short-term risks while promoting long-term survival), or changes in social interactions among groups of animals (for example, interactions between a cow and her calf). For further description of the response analyses conceptual model please see the programmatic consultation on the Keyport Range Complex regulations (NMFS 2010a).

3.1.3 Risk Analysis

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 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 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 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 Sterns 1992). If we conclude that listed 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 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.

3.2 Evidence Available for the Consultation

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

To supplement that body of knowledge, we conducted electronic literature searches using the *Web of Science*, and Cambridge Abstract's *Aquatic Sciences and Fisheries Abstracts* (ASFA) database services. Our searches specifically focus on the ArticleFirst, BasicBiosis, Dissertation Abstracts, Conference Papers Index, Oceanic Abstracts, Water Resources Abstracts, Proceedings and ECO databases, which index the major journals dealing with issues of biology and ecological risk. In addition to these sources, we searched a NMFS Office of Protected Resources

electronic library consisting of information from these and many other sources that collectively provide a comprehensive collection of citations and documents on listed species as well as the anthropogenic and natural stressors they experience. To supplement our searches, we examined the literature that was cited in the submittal documents and any articles we collected through our electronic searches. We did not conduct hand searches of published journals for this consultation. We organized the results of these searches using commercial bibliographic software.

To comply with our obligation to use the best scientific and commercial data available, we conducted additional searches throughout the consultation and during drafting of the biological opinion to identify information that has become available since we issued the previous biological opinions on the training and testing conducted by the U.S. Navy's Pacific Fleet and System Commands (SYSCOMs). The U.S. Navy provided NMFS with a draft and final Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) on training and testing that are proposed in the Action Area. We also evaluated the Navy's annual and comprehensive major training exercise and monitoring reports to assess effectiveness of mitigation and actual take incidental to actual training and testing activity levels where feasible.

NMFS is currently in the process of re-evaluating the acoustic criteria as they apply to all activity types (not just the Navy). Although our current use of acoustic criteria and acoustic thresholds for Navy relies on the best available science at the time of this action, our continuedevaluation of all available science and that science's application in the context of developing guidance for acoustic thresholds for all activities could result in changes to the acoustic criteria to the extent they are relevant to Navy activities. However, it is important to note that while changes in acoustic criteria may affect the enumeration of "takes," they do not necessarily significantly change the evaluation of population level effects or the outcome of our jeopardy analysis. Further, while acoustic criteria may also inform mitigation and monitoring decisions, the Navy has a robust adaptive management program that actively and regularly addresses new information and allows for modification of mitigation and/or monitoring measures as appropriate." When new information is identified that would potentially change our conclusions on population-level effects or our jeopardy analysis, reinitiation of consultation would be prudent.

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

3.3 The U.S. Navy Acoustic Effects Model (NAEMO)

Since 1997, the U.S. Navy has modeled the potential acoustic effects on marine mammals and sea turtles from specific Navy training and test activities. Various models used "area density" approaches in which acoustic footprints were computed and then multiplied by animal densities to calculate effects. As a result of a review conducted by the Center for Independent Experts, as required by the National Marine Fisheries Service, the Navy refined its process. The new model—the Navy Acoustic Effects Model (NAEMO)—is the standard model now used by the Navy to estimate the potential acoustic effects of proposed Navy training and testing activities on marine mammals and sea turtles.

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

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

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

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

Scenario Simulator executes the simulation and records the sound received by each marine mammal and sea turtle in the area for every time step that sound is emitted; it incorporates the

scenario definition, sound propagation data, and marine species distribution data, ultimately providing raw data output for each simulation. Most scenarios are run in small, 4- to 12-hour segments based on representative training and testing activities. Some scenarios are evaluated by platform and single locations, while others are evaluated in multiple locations within a single range complex or testing range. Within each scenario, multiple ship track iterations are run to provide a statistical set of raw data results.

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

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

Modeled effects from NAEMO were used to support the U.S. Navy's analyses in the HSTT Environmental Impact Statement/Overseas Environmental Impact Statement, mitigation strategies, and documentation associated with Endangered Species Act Biological Evaluations and Marine Mammal Protection Act permit applications. We have verified methodology and data used in NAEMO for these analyses and thus accept the modeling conclusions on exposure of marine species. We have verified the methodology and data used in NAEMO for these analyses, accept the modeling conclusions on exposure of marine species, and have considered those exposures in our analysis. A full description of NAEMO can be accessed in the NUWCNPT Technical Report 12,071a, 23 August 2013 (updated from 12 March 2012).

Additionally, the Navy has produced a Technical Report to describe the post model quantitative analysis that was applied (Navy 2012b).

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

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.

We considered cumulative impacts as part of our consultation. Specifically, we considered (1) impacts or effects that accumulate in the environment in the form of stressors or reservoirs of stressors and (2) impacts or effects that represent either the response of individuals, populations, or species to that accumulation of stressors in the environment or the accumulated responses of individuals, populations, and species to sequences of exposure to stressors. Further, we considered the likely impacts of these accumulative phenomema on an annual basis, over the duration of the five-year MMPA regulations, and under the assumption that these activities would continue into the reasonably foreseeable future. Given the ongoing nature of the proposed activities, we assume that the type, amount, and extent of training and testing do not exceed maximum levels assessed in the proposed action.

In the sense of Item 1, which captures the normal usage of "cumulative impacts," we concluded that phenomena like sound do not accumulate (sound energy rapidly transforms into other forms of energy), although phenomena like the acreage of habitat destroyed and concentrations of toxic chemicals, sediment, and other pollutants accumulate. We conclude that the probability of a ship strike accumulated, in the sense that the probabilities of collisions associated with multiple transits are higher than the probabilities associated with a single transit. We factored those considerations into our estimation of the probability of a collision associated with multiple transits.

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

At the level of populations, phenomena that "accumulate" include population abundance; the number or percent of individuals in a population with lifetime reproductive success greater than 2.0; the number or percent of individuals in a population with lifetime reproductive success equal to 2.0; the number or percent of individuals in a population with lifetime reproductive success less than 2.0; the number or percent of individuals that emigrate from a population per unit time; the number or percent of individuals that immigrate into a population per unit time; mortality

within a particular age or stage over generation time; and the reservoir of juveniles in a population that have a high probability of surviving to the age of reproduction (population momentum or its absence).

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

Cummulative effects also include effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this 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.

4 STATUS OF LISTED RESOURCES

This section identifies the ESA-listed species that occur within the Action Area that may be affected by the proposed action. It then summarizes the biology and ecology of those species and what is known about their life histories in the Action Area. The species occurring within the action area that may be affected by the Proposed Action are listed in Table 25 along with their ESA listing status.

Table 25. Species listed under the Federal Endangered Species Act under NMFS jurisdiction that may occur in the Action Area for the Hawaii-Southern California Training and Testing Study Area.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus*)	E - 35 FR 18319	-- --	07/1998
Fin Whale (*Balaenoptera physalus*)	E - 35 FR 18319	-- --	75 FR 47538
Western North Pacific Gray Whale (*Eschrichtius robustus*)	E – 35 FR 18319	-- --	-- --
Humpback Whale (*Megaptera novaeangliae*)	E - 35 FR 18319	-- --	55 FR 29646
Sei Whale (*Balaenoptera borealis*)	E - 35 FR 18319	-- --	-- --
Sperm Whale (*Physeter macrocephalus*)	E - 35 FR 18619	-- --	75 FR 81584
Main Hawaiian Islands Insular False Killer Whale (*Pseudorca crassidens*)	E- 76 FR 70915	-- --	77 FR 71260 [1]
Marine Mammals - Pinnipeds			
Hawaiian Monk Seal (*Monachus schauinslandi*)	E – 41 FR 51611	53 FR 18988 Proposed revision - 76 FR 32026	72 FR 46966
Guadalupe Fur Seal (*Arctocephalus townsendi*)	T - 50 FR 51252	-- --	-- --
Sea Turtles			
Green Turtle (*Chelonia mydas*)	E - 43 FR 32800	63 FR 46693	63 FR 28359
Hawksbill Turtle (*Eretmochelys imbricate*)	E - 35 FR 8491	63 FR 46693	63 FR 28359
Loggerhead Turtle (*Caretta caretta*)	E - 76 FR 58868	Prop. 78 FR 43005	63 FR 28359
Olive Ridley Turtle (*Lepidochelys olivacea*)	E - 61 FR 17	-- --	63 FR 28359
Leatherback Turtle (*Dermochelys coriacea*)	E - 61 FR 17	77 FR 4170	63 FR 28359
Fish			
Steelhead Trout (*Oncorhynchus mykiss*) Southern California Distinct Population Segment (DPS)	E - 71 FR 834	70 FR 52488	01/2012

Species	ESA Status	Critical Habitat	Recovery Plan
Invertebrates			
Black Abalone (*Haliotis cracherodii*)	E - 74 FR 1937	76 FR 66806	-- --
White Abalone (*Haliotis sorenseni*)	E - 66 FR 29046	-- --	73 FR 62257
Proposed Corals [2]			
Acropora paniculata	77 FR 73219	-- --	-- --
Alveopora verrilliana	77 FR 73219	-- --	-- --
Pocillopora elegans - Indo Pacific	77 FR 73219	-- --	-- --
Euphyllia paraancora	77 FR 73219	-- --	-- --
Montipora dilatata, Montipora flabellata, and *Montipora turgescens*	77 FR 73219	-- --	-- --
Montipora patula (verrilli)	77 FR 73219	-- --	-- --

[1] *Final rule to implement the false killer whale take reduction plan*
[2] *Coral species distribution based on Brainard et al. 2011 (Brainard et al. 2011)*

4.1 Species and Critical Habitat Not Considered Further in this Opinion

As described in the Approach to the Assessment, we use two criteria to identify those endangered or threatened species or critical habitat that are not likely to be adversely affected by the various proposed activities. The first criterion was exposure or some reasonable expectation of a co-occurrence between one or more stressors associated with the Navy's activities and a particular listed species or designated critical habitat: if we conclude that a listed species or designated critical habitat is not likely to be exposed to the activities, we must also conclude that the 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 in Table 25; this subsection summarizes the results of those evaluations.

4.1.1 Southern California Steelhead Trout

Steelhead trout (*Oncorhynchus mykiss*) are usually dark-olive in color, shading to silvery-white on the underside with a heavily speckled body and a pink to red stripe running along their sides. They are a unique species; individuals develop differently depending on their environment. While all *O. mykiss* hatch in gravel-bottomed, fast-flowing, well-oxygenated rivers and streams, some stay in fresh water all their lives. These fish are called rainbow trout. The steelhead that migrate to the ocean develop a much more pointed head, become more silvery in color, and typically grow much larger than the rainbow trout that remain in fresh water.

Recent surveys show that out of the 46 drainages that historically contained Southern California steelhead, (both resident and steelhead) less than half are currently occupied (Boughton et al. 2005). Additionally, this distributional survey determined that *O. mykiss* was present in two systems, one of them being San Mateo Creek, where it was previously reported to be extinct (Nehlsen et al. 1991).

Steelhead tend to move immediately offshore on entering the marine environment although, in general, steelhead tend to remain closer to shore than other Pacific salmon species (Beamish et al. 2005). They generally remain within the coastal waters of the California Current (Beamish et al. 2005). The ocean distributions for listed steelhead are not known in detail, but steelhead are caught only rarely in ocean salmon fisheries. Studies suggest that steelhead do not generally congregate in large schools as do other Pacific salmon species (Burgner et al. 1992; Groot et al. 1991).

Although the information available did not allow us to estimate the number of times Southern California steelhead might be exposed to the activities the Navy plans to conduct in the HSTT Study Area, we assume that some individuals are likely to be exposed to training exercises and testing activities.

Popper (2003) and Hastings and Popper (2005) presented evidence that establishes that most fish only detect sounds within the 1-3 kHz range, which would make them sensitive to the lower end of the frequency range of mid-frequency active sonar. The U.S. Navy's Biological Evaluation for the Northwest Training Range Complex (Navy 2008b; Navy 2008c) provided a thorough review of the information available on the probable responses of endangered and threatened fish to active sonar. We have extracted most of the narratives that follow from that review, although we have made a few corrections and clarifications and supplemented the analyses with a few additional studies.

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

Jørgensen et al. (2005) exposed fish larvae and juveniles representing four species (of three families) to sounds that were designed to simulate mid-frequency sonar transmissions (1 to 6.5 kHz) to study the effects of the exposure on the survival, development, and behavior of the

larvae and juveniles (the study used larvae and juveniles of Atlantic herring (*Clupea harengus*) Atlantic cod (*Gadus morhua*), saithe (*Pollachius virens)*, and spotted wolffish (*Anarhichas minor*). Their experiments have often been reported to have concluded that the sonar exposures produced mortalities of 20 to 30 percent, but those reports appear to have been in error. Jørgensen and his co-workers conducted a total of 42 trials for six different experiments with each trial consisting of a control group and an experimental group with the experimental group exposed to active sonar at a specific received level over a specific time interval. They reported the size of the fish, source frequency (in kHz), received level (Sound Pressure Level in dB rms), number of pulses the fish were exposed to, total energy (SEL in Pascals squared per second), and outcome of the trial: number of animals alive versus number of animals dead.

Fish died in 11 of the 42 trials they conducted with Atlantic herring, but some of the fish that died were from the control group that was not exposed to active sonar. In the two trials that resulted in 20 to 30 percent mortalities, the fish died in both control and experimental groups, so it would be incorrect to conclude that the mortalities were caused by exposure to active sonar.

More importantly, Jørgensen and his co-workers (Jørgensen et al. 2005) did not report the frequency, received level, duration, or total energy associated with the four trials that resulted in the 20 to 30 percent mortality (they only report that the fish died 10 or 11 days after the trial), so these data do not support a conclusion that the deaths were caused by exposure to active sonar. Because Jørgensen and his co-workers did not report the frequency, received level, duration, or total energy associated with the four trials that resulted in the 20 to 30 percent mortality, those trials could not establish a causal relationship between sonar exposures and the death of the fish so the trials should have been censored from subsequent study.

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

Hastings et al. (1996) studied the effects of low frequency underwater sound on fish hearing. More recently, Popper et al. (2008; 2007; Popper and Hastings 2009) investigated the effects of exposing several fish species to the U.S. Navy's SURTASS LFA sonar, focusing on the hearing and on non-auditory tissues. Their study exposed the fish to LFA sonar pulses for time intervals that would be substantially longer than what would occur in nature, but the fish did not experience mortalities or damage to body tissues at the gross or histological level. Some fish

experienced temporary losses in their hearing sensitivity but they recovered within several days of exposure.

Based on the evidence available, if steelhead are exposed to transmissions associated with active sonar, detonations, or pile driving during training exercises or testing activities in the HSTT Study Area, we would expect steelhead to be able to detect those sounds. If juvenile fish, larvae, or eggs occurred close to the sound source, we would expect some of those life-stages to be killed or injured (which, in those life stages, would probably result in individuals being eaten by predators); however, because this species is anadromous (eggs and larvae occur in fresh water habitats), the juveniles, larvae, and eggs of steelhead trout would not be exposed to the Navy's training exercises and testing activities.

If steelhead are exposed to disturbance from vessels, active sonar, detonations or pile driving associated with the training exercises and testing activities in the HSTT Study Area, they might experience a startle response or change in their behavioral state, but those responses are likely to be brief and have no immediate or cumulative consequence for the reproductive success of the fish that might be exposed. However, we believe that the low number of listed steelhead over the relatively large action area, that any exposure would be minimal and any effects small enough to be discountable.

NMFS designated critical habitat for Southern California steelhead on 2 September 2005 (70 FR 52488). A total of 708 miles of stream habitat was designated as critical habitat from the 32 watersheds within the range of this Distinct Population Segment (DPS). Critical habitat for the Southern California Steelhead DPS includes most, but not all, occupied habitat from the Santa Maria River in southern San Luis Obispo County to San Mateo Creek in northern San Diego County, but excludes some occupied habitat based on economic considerations and all military lands with occupied habitat. Critical habitat was not designated for most of the watersheds south of Malibu Creek with the exception of San Juan Creek and San Mateo Creek.

These areas are important for the species' overall conservation by protecting quality growth, reproduction, and feeding. The critical habitat designation for this species identifies primary constituent elements that include sites necessary to support one or more steelhead life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. The critical habitat designation (70 FR 52488) contains additional description of the watersheds that are included as part of this designation, and any areas specifically excluded from the designation.

The critical habitat designation specifically excluded military areas for Southern California steelhead and the proposed training exercises and testing activities would not occur in freshwater

areas or affect the primary constituent elements for steelhead. Therefore, the training exercises and testing activities the U.S. Navy proposes to conduct in the HSTT Study Area will not affect the designated critical habitat for Southern California steelhead.

In summary, we conclude that the training exercises and testing activities the U.S. Navy proposes to conduct in the HSTT Study Area on an annual basis and cumulatively over five years from December 2013 through December 2018 are not likely to adversely affect the Southern California Distinct Population Segment of Steelhead Trout or its designated critical habitat. As a result, we will not consider this species or its critical habitat in the remainder of this opinion.

4.1.2 Black Abalone

The black abalone (*Haliotis cracherodii*) is a large marine gastropod found in rocky intertidal and subtidal habitats. Both their "mantle" and "foot" are black. They have 5-9 open respiratory pores along the left sides of their shell and spiral growth lines on the rear. Black abalone are herbivores. During low tides, they can typically be found wedged into crevices, cracks, and holes of intertidal and shallow subtidal rocks, where they are fairly concealed (Leighton 2005). They generally occur in areas of moderate to high surf and range vertically from the high intertidal zone to a depth of about 20 ft (6 m) and are typically found in middle intertidal zones. However, variation in wave exposure and where drift kelp (an important food item for black abalone) accumulates may result in animals being distributed primarily in high or low intertidal zones depending on the local conditions at particular locations (see definition of intertidal zones in Ricketts et al. 1985). Black abalone can withstand extreme variation in temperature, salinity, moisture, and wave action. The species was listed as endangered on 14 February 2009 (74 FR 1937).

Black abalone historically occurred from Crescent City, California, USA, to southern Baja California, Mexico (Butler et al. 2009a), but today the species' constricted range occurs from Point Arena, California, USA, to Bahia Tortugas, Mexico, and it is rare north of San Francisco, California, USA (Butler et al. 2009a), and south of Punta Eugenia, Mexico (76 FR 66805).

Critical habitat was designated for black abalone on 27 October 2011 (76 FR 66805). Most of the designated critical habitat lies along the California coast north of the HSTT Study Area. Designated critical habitat includes rocky intertidal and subtidal habitats from the mean higher high water line to a depth of approximately 20 ft. (6 m), as well as the waters encompassed by these areas. Designated critical habitat extends from Del Mar Landing Ecological Reserve to the Palos Verdes Peninsula. Within the Study Area, critical habitat occurs on Santa Catalina and Santa Barbara Islands. The specific areas proposed for designation off San Nicolas and San Clemente Islands were determined to be ineligible for designation because the Navy’s Integrated Natural Resources Management Plans provide benefits to black abalone in those areas. The critical habitat designation also identifies primary constituent elements, which are habitat elements essential for the conservation of the species. The primary constituent elements for black

abalone are rocky substrate, food resources, juvenile settlement habitat, suitable water quality, and suitable nearshore circulation patterns.

The most important source of black abalone mortality is the disease known as withering syndrome caused by the bacterium *Candidatus Xenohaliotis californiensis*. Disease transmission and manifestation is intensified when local sea surface temperatures increase by as little as 2.5 °C above ambient sea surface temperatures and remain elevated over a prolonged period of time (i.e., a few months or more) (Ben-Horin et al. 2013; Friedman et al. 1997; Raimondi et al. 2002; Vilchis et al. 2005). Although there is no explicitly documented causal link between the persistence of withering syndrome and long-term climate change, patterns observed over the past three decades suggest that progression of ocean warming associated with large-scale climate change may facilitate further and more prolonged vulnerability of black abalone to the effects of withering syndrome.

Factors such as poaching, reduced genetic diversity, ocean acidification, non-anthropogenic predation (e.g., by octopuses, lobsters, sea stars, fishes, sea otters, and shorebirds) and competition (e.g., with sea urchins), food limitation, environmental pollutants and toxins, and substrate destruction may all impose mortality on black abalone at varying rates, but predicting the relative impacts of each of these factors on the long-term viability of black abalone is difficult without further study. In addition to the aforementioned present-day sources of mortality, commercial and recreational fisheries operating in California until 1993 likely contributed to the species' decline. For more information on historic and present-day factors leading to the decline of black abalone populations see Butler et al. (2009b).

Mmassive declines in black abalone began in 1986 that resulted in significant large-scale population reductions by the early 1990s (Lafferty and Kuris 1993). Evidence of population declines has also been observed in central California (Raimondi et al. 2002). The Black Abalone Status Review Team estimates that, unless effective measures are put in place to counter the population decline caused by withering syndrome and overfishing, the species will be extinct within 30 years (Butler et al. 2009b).

The black abalone population at one known location at San Nicolas Island may remain above a critical density threshold and is experiencing ongoing successful recruitment (VanBlaricom, unpublished data). The San Nicolas Island location is known to be characterized by small local sea surface temperature anomalies, with typical temperatures slightly lower (< 1º C on average) than at other monitored sites at the Island (VanBlaricom, unpublished data) (Butler et al. 2009b).

Black abalone could be exposed to underwater detonations associated with training exercies and testing activities; however, because the number of underwater detonations is small at 18 per year, 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 (Navy 2013d), 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 training exercises and testing activities activities the U.S. Navy proposes to conduct in the HSTT Study Area, 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. Similarly, we do not expect primary constituent elements associated with black abalone critical habitat to be adversely affected and do not consider black abalone critical habitat further in this opinion.

4.1.3 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 (Davis et al. 1996; Tutschulte 1976).

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. A similar study in 2012 found only five white abalone (Navy 2013d). 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 charges 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.

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 exercises is also sufficiently small to be discountable. Therefore, this species will not be considered in greater detail in the remainder of this opinion.

4.1.4 Proposed Corals

Several species of corals that are proposed for threatened or endangered status under the ESA occur in the Hawaii Range Complex, including *Acropora paniculata*, *Alveopora verrilliana*,

Pocillopora elegans - Indo Pacific, *Euphyllia paraancora*, *Montipora dilatata*, *Montipora flabellata*, *Montipora turgescens*, and *Montipora patula* (*verrilli*). These corals generally occur in waters a few to a few dozen meters deep in association with coral reefs. Their status of each of the coral species proposed for listing is generally uncertain, but each species has generally undergone significant decline. Some coral species show indications of rebounding from bleaching, predation, and disease events. The proposed listing of coral species is generally due to the potential for bleaching, acidification, and water quality stressors to worsen in the future due to urbanization and climate change.

We do not anticipate stressors associated with the proposed U.S. Navy activities to adversely affect proposed corals for several reasons. The Navy specifically identifies coral reefs as areas where they could actively avoid undertaking activities. Stressors that could propagate into coral reef areas (sound, chemical pollution or physical material) are expected to either not impact coral biology or would be so diluted or infrequent/small that no meaningful biological affect is anticipated. Although it is possible that naval vessels could inadvertently ground on coral reefs (the USS Port Royal ran aground in Hawaii near the Honolulu airport causing damage to coral which was then restored by the Navy), which can have a significant impact to species exposed to this event, we find the probability of such an incident to be discountable during this period or in the reasonably foreseeable future as activities continue. Therefore, we find the likelihood of the proposed actions affecting proposed corals discountable.

4.1.5 Critical Habitat for Leatherback Sea Turtle

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

In 2007, NMFS received a petition to revise the leatherback critical habitat designation to include waters off the U.S. West Coast. NMFS published a 90-day finding on the petition in December 2007. On 26 January, 2012 we published a final rule (77 FR 4170). The revised critical habitat designated additional areas within the Pacific Ocean. This designation includes approximately 16,910 square miles (43,798 square km) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour; and 25,004 square miles (64,760 square km) stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour. The designated areas comprise approximately 41,914 square miles (108,558 square km) of marine habitat and include waters from the ocean surface down to a maximum depth of 262 feet (80 m). Other Pacific waters within the U.S. Exclusive Economic Zone (EEZ) were evaluated based on the geographical area occupied by the species, but we determined that they were not eligible for designation, as they do not contain the feature identified as essential to the conservation of the species.

The Critical Habitat Review Team (CHRT) identified two primary constituent elements (PCEs) essential for the conservation of leatherbacks in marine waters off the U.S. West Coast:

(1) Occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (*Chrysaora*, *Aurelia*, *Phacellophora*, and *Cyanea*) of sufficient condition, distribution, diversity, and abundance to support individual as well as population growth, reproduction, and development; (2) Migratory pathway conditions to allow for safe and timely passage and access to/from/within high use foraging areas.

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

4.2 Species Considered Further in this Biological Opinion

The rest of this section of our opinion consists of narratives for each of the threatened and endangered species that occur in the action area and that may be adversely affected by the readiness activities the U.S. Navy proposes to conduct in the HSTT Study Area. In each narrative, we present a summary of information on the distribution and population structure of each species to provide a foundation for the exposure analyses that appear later in this opinion. Then we summarize information on the threats to the species and the species' status given those threats to provide points of reference for the jeopardy determinations we make later in this opinion. That is, we rely on a species' status and trend to determine whether or not an action's direct or indirect effects are likely to increase the species' probability of becoming extinct.

After the *Status* subsection of each narrative, we present information on the diving and social behavior of the different species because that behavior helps determine whether aerial and ship board surveys are likely to detect each species. We also summarize information on the vocalizations and hearing of the different species because that background information lays the foundation for our assessment of the how the different species are likely to respond to sounds produced by the Navy's training exercises and testing activities.

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 1998c), fin whales (NMFS 2010b), fin and sei whale (NMFS 1998b), humpback whale (NMFS 1991), right whale (NMFS 2004), sperm whale (NMFS 2010c), a status report on

large whales prepared by Perry et al. (1999a), the status review and recovery plan for the leatherback turtle (NMFS and USFWS 1998a; NMFS and USFWS 2007c), the green turtle 5-year review (NMFS and USFWS 2007a), the status review of hawksbill turtle(NMFS and USFWS 2013), the status review of loggerhead turtles (NMFS and USFWS 2007c), and the 5-year review of olive ridley turtles (NMFS and USFWS 2007d). Richardson et al. (1995b) and Tyack (2000b) provide detailed analyses of the functional aspects of cetacean communication and their responses to active sonar. Finally, Croll et al. (1999b), NRC (2000; 2003a; 2005), and Richardson and Wursig (1995) provide information on the potential and probable effects of active sonar on the marine animals considered in this opinion.

4.2.1 Blue Whale

The blue whale, *Balaenoptera musculus* (Linnæus 1758), is a cosmopolitan species of baleen whale. It is the largest animal ever known to have lived on Earth: adults in the Antarctic have reached a maximum body length of about 33 m (108 ft) and can weigh more than 150,000 kg (330,700 lbs). The largest blue whales reported from the North Pacific are a female that measured 26.8 m (88 ft) taken at Port Hobron in 1932 (Reeves et al. 1985) and a 27.1 m (89 ft) female taken by Japanese pelagic whaling operations in 1959 (NMFS 1998c).

As is true of other baleen whale species, female blue whales are somewhat larger than males. Blue whales are identified by the following characteristics: a long-body and comparatively slender shape; a broad, flat "rostrum" when viewed from above; a proportionately smaller dorsal fin than other baleen whales; and a mottled gray color pattern that appears light blue when seen through the water.

Distribution

Blue whales inhabit all oceans and typically occur near the coast, over the continental shelf, though they are also found in oceanic waters. Blue whales are highly mobile, and their migratory patterns are not well known (Perry et al. 1999a; Reeves et al. 2004). Blue whales migrate toward the warmer waters of the subtropics in the fall to reduce energy costs, avoid ice entrapment, and reproduce (NMFS 1998a).

In the North Pacific Ocean, blue whales have been recorded off the island of Oahu in the main Hawaiian Islands and off Midway Island in the western edge of the Hawaiian Archipelago (Barlow 2006; Northrop et al. 1971; Thompson and Friedl 1982b), although blue whales are rarely sighted in Hawaiian waters and have not been reported to strand in the Hawaiian Islands.

The west coast of North America is known to be a feeding area for this species during summer and fall (Carretta et al. 2010a). This species has frequently been observed in waters off Southern California (Carretta et al. 2010a; Navy 2011a). Photographs of blue whales in California have been matched to individuals photographed off the Queen Charlotte Islands in northern British Columbia and the northern Gulf of Alaska (Calambokidis et al. 2009a). In the Southern

California Bight, the highest densities of blue whales occurred along the 200-m isobath in waters with high surface chlorophyll concentrations (Redfern et al. 2013) although blue whale visual sightings and acoustic detections can occur across the entire Bight (Navy 2012c; Navy 2013a).

Blue whales observed in the spring, summer, and fall off California, Washington, and British Columbia are known to be part of a group that returns to feeding areas off British Columbia and Alaska (Calambokidis and Barlow 2004; Calambokidis et al. 2009b; Gregr et al. 2000; Mate et al. 1999; Moore et al. 2002; Stafford et al. 1999)). These animals have shown site fidelity, returning to their mother's feeding grounds on their first migration (Calambokidis and Barlow 2004). They are known to migrate to waters off Mexico and as far as the Costa Rica Dome (Calambokidis and Barlow 2004; Calambokidis et al. 2009b). Winter migration movements south along the Baja California, Mexico coast to the Costa Rica Dome indicate that the Costa Rica Dome may be a calving and breeding area (Mate et al. 1999). Blue whales belonging to the western Pacific stock may feed in summer, south of the Aleutians and in the Gulf of Alaska, and migrate to wintering grounds in lower latitudes in the western Pacific and central Pacific, including Hawaii (Stafford et al. 2004; Watkins et al. 2000a; Watkins et al. 2000b; Watkins et al. 2000c).

Blue whales in the eastern Pacific winter from California south (Carretta et al. 2013); in the western Pacific, they winter from the Sea of Japan, the East China and Yellow Seas, and the Philippine Sea. Blue whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska. Nishiwaki (1966) reported that blue whales occur in the Aleutian Islands and in the Gulf of Alaska. An array of hydrophones, deployed in October 1999, detected two blue whale call types in the Gulf of Alaska (Stafford 2003). Fifteen blue whale sightings off British Columbia and in the Gulf of Alaska have been made since 1997 (Calambokidis et al. 2009a). Three of these photographically verified sightings were in the northern Gulf of Alaska within 71 nm of each other and were less than 100 nm offshore (Calambokidis et al. 2009a).

Population Structure

For this and all subsequent species, the term "population" refers to groups of individuals whose patterns of increase or decrease in abundance over time are determined by internal dynamics (births resulting from sexual interactions between individuals in the group and deaths of those individuals) rather than external dynamics (immigration or emigration). This definition is a reformulation of definitions articulated by Futuymda (1986) and Wells and Richmond (1995) and is more restrictive than those uses of 'population' that refer to groups of individuals that co-occur in space and time but do not have internal dynamics that determine whether the size of the group increases or decreases over time (see review by Wells and Richmond 1995). The definition we apply is important to section 7 consultations because such concepts as 'population decline,' 'population collapse,' 'population extinction,' and 'population recovery' apply to the

restrictive definition of 'population' but do not explicitly apply to alternative definitions. As a result, we do not treat the different whale "stocks" recognized by the International Whaling Commission or other authorities as populations unless those distinctions were clearly based on demographic criteria. We do, however, acknowledge those "stock" distinctions in these narratives.

At least three subspecies of blue whales have been identified based on body size and geographic distribution (*B. musculus intermedia*, which occurs in the higher latitudes of the Southern Oceans, *B. m. musculus*, which occurs in the Northern Hemisphere, and *B. m. brevicauda* which occurs in the mid-latitude waters of the southern Indian Ocean and north of the Antarctic convergence), but this consultation will treat them as a single entity. Readers who are interested in these subspecies will find more information in Gilpatrick et al. (1997), Kato et al. (1995), Omura et al. (1970), and Ichihara (1966).

In addition to these subspecies, the International Whaling Commission's Scientific Committee has formally recognized one blue whale population in the North Pacific (Donovan 1991), although there is increasing evidence that there may be more than one blue whale population in the Pacific Ocean (Gilpatrick et al. (1997), Barlow et al. (1995), Mizroch et al. (1984), Ohsumi and Wada (1972)). For example, studies of the blue whales that winter off Baja California and in the Gulf of California suggest that these whales are morphologically distinct from blue whales of the western and central North Pacific (Gilpatrick et al. 1997), although these differences might result from differences in the productivity of their foraging areas more than genetic differences (Barlow et al. 1997b; Calambokidis et al. 1990; Sears 1987). A population of blue whales that has distinct vocalizations inhabits the northeast Pacific from the Gulf of Alaska to waters off Central America (Gregr et al. 2000; Mate et al. 1998; Stafford 2003).

Natural Threats

Natural causes of mortality in blue whales are largely unknown, but probably include predation and disease (not necessarily in their order of importance). Blue whales are known to become infected with the nematode *Carricauda boopis* (Baylis 1928), which are believed to have caused fin whales to die as a result of renal failure (Lambertsen 1986); (see additional discussion under Fin whales). Killer whales and sharks are also known to attack, injure, and kill very young or sick fin and humpback whales and probably hunt blue whales as well (Perry et al. 1999a).

Anthropogenic Threats

Two human activities are known to threaten blue whales; whaling and shipping. Historically, whaling represented the greatest threat to every population of blue whales and was ultimately responsible for listing blue whales as an endangered species. As early as the mid-seventeenth century, the Japanese were capturing blue, fin, and other large whales using a fairly primitive open-water netting technique (Tonnessen and Johnsen 1982). In 1864, explosive harpoons and

steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species.

From 1889 to 1965, whalers killed about 5,761 blue whales in the North Pacific Ocean (Hill et al. 1999). From 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). Evidence of a population decline was seen in the catch data from Japan. In 1912, whalers captured 236 blue whales; in 1913, 58 blue whales; in 1914, 123 blue whales; from 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). In the eastern North Pacific, whalers killed 239 blue whales off the California coast in 1926. And, in the late 1950s and early 1960s, Japanese whalers killed 70 blue whales per year off the Aleutian Islands (Mizroch et al. 1984).

Although the International Whaling Commission banned commercial whaling in the North Pacific in 1966, Soviet whaling fleets continued to hunt blue whales in the North Pacific for several years after the ban. Surveys conducted in these former-whaling areas in the 1980s and 1990s failed to find any blue whales (Forney and Brownell Jr. 1996). By 1967, Soviet scientists wrote that blue whales in the North Pacific Ocean (including the eastern Bering Sea and Prince William Sound) had been so overharvested by Soviet whaling Fleets that some scientists concluded that any additional harvests were certain to cause the species to become extinct in the North Pacific (Latishev 2007). As its legacy, whaling has reduced blue whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push blue whales closer to extinction. Otherwise, whaling currently does not threaten blue whale populations.

In 1980, 1986, 1987, and 1993, ship strikes have been implicated in the deaths of blue whales off California (Barlow 1997b). More recently, Berman-Kowalewski et al. (2010) reported that between 1988 and 2007, 21 blue whale deaths were reported along the California coast, typically one or two cases annually. In addition, several photo-identified blue whales from California waters were observed with large scars on their dorsal areas that may have been caused by ship strikes. Studies have shown that blue whales respond to approaching ships in a variety of ways, depending on the behavior of the animals at the time of approach, and speed and direction of the approaching vessel. While feeding, blue whales react less rapidly and with less obvious avoidance behavior than whales that are not feeding (Sears 1983a). Available data from NMFS indicate that in waters off California between 1991 and 2010, there were 14 ship strikes involving blue whales (National Marine Fisheries Service Southwest Region Stranding Database 2011). Of these, three occurred in the same waters as HSTT, of which two were from commercial/research ships and one from Navy. Of the 14 blue whale strikes in California, 79 percent were in water north of the HSTT Study Area.

Although commercial fisheries using large gill nets or other large set gears poses some entanglement risk to marine mammals, there is little direct evidence of blue whale mortality from

fishing gears. Therefore it is difficult to estimate the numbers of blue whales killed or injured by gear entanglements. The offshore drift gillnet fishery is the only fishery that is likely to take blue whales from this stock, but no fishery mortalities or serious injuries have been observed. In addition, the injury or mortality of large whales due to interactions or entanglements in fisheries may go unobserved because large whales swim away with a portion of the net or gear. Fishermen have reported that large whales tend to swim through their nets without becoming entangled and cause little damage to nets (Carretta et al. 2008).

Between 1988 and 2007, 21 blue whale deaths were reported along the California coast, and many of these showed evidence of ship strike (Berman-Kowalewski et al. 2010). In 2007, National Oceanic and Atmospheric Administration declared an Unusual Mortality Event for endangered blue whales in Southern California as a result of commercial vessel ship strikes in that year.

Status and Trends

Blue whales (including all subspecies) were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973. Blue whales are listed as endangered on the IUCN Red List of Threatened Animals (IUCN 2010). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for blue whales.

It is difficult to assess the current status of blue whales globally because (1) there is no general agreement on the size of the blue whale population prior to whaling and (2) estimates of the current size of the different blue whale populations vary widely. We may never know the size of the blue whale population in the North Pacific prior to whaling, although some authors have concluded that their population numbers about 200,000 animals before whaling. Similarly, estimates of the global abundance of blue whales are uncertain. Since the cessation of whaling, the global population of blue whales has been estimated to range from 11,200 to 13,000 animals (Maser et al. 1981). These estimates, however, are more than 20 years old.

The current best available abundance estimate for the Eastern North Pacific stock of blue whales that occur off California, Oregon, and Washington is 2,497 (coefficient of variation = 0.24) (Fallis et al. 1983). There was a documented increase in the blue whale population size between 1979 and 1994, but there has not been evidence to suggest an increase in the population since then (Barlow 1994; Barlow and Taylor 2001; Carretta et al. 2010b) . In 2008, Cascadia Research conducted photographic identification surveys to make abundance estimates of blue whales along the U.S. West Coast. The results reflect an upward trend in abundance of blue whales along the U.S. West Coast, although their numbers are highly variable off California, most likely due to the variability of its use as a feeding area (Calambokidis et al. 2009b).

There currently is no estimate of abundance for the Central North Pacific stock of blue whales due to a lack of sighting information (Fallis et al. 1983).

The information available on the status and trend of blue whales do not allow us to reach any conclusions about the extinction risks facing blue whales as a species, or particular populations of blue whales. With the limited data available on blue whales, we do not know whether these whales exist at population sizes large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself) or if blue whales are threatened more by exogenous threats such as anthropogenic activities (primarily whaling and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate).

Diving and Social Behavior

Blue whales spend more than 94 percent of their time underwater (Lagerquist et al. 2000). Generally, blue whales dive 5-20 times at 12-20 sec intervals before a deep dive of 3-30 min (Croll et al. 1999a; Leatherwood et al. 1976; Maser et al. 1981; Yochem and Leatherwood 1985). Average foraging dives are 140 m deep and last for 7.8 min (Croll et al. 2001a). Non-foraging dives are shallower and shorter, averaging 68 m and 4.9 min (Croll et al. 2001a). However, dives of up to 300 m are known (Calambokidis et al. 2003). Nighttime dives are generally shallower (50 m).

Blue whales occur singly or in groups of two or three (Aguayo 1974; Mackintosh 1965; Nemoto 1964; Pike and Macaskie 1969; Ruud 1956; Slijper 1962). However, larger foraging aggregations, even with other species such as fin whales, are regularly reported (Corkeron et al. 1999; Fiedler et al. 1998; Schoenherr 1991; Shirihai 2002). Little is known of the mating behavior of blue whales. The primary and preferred diet of blue whales is krill (euphausiids).

Satellite tagging indicates that, for blue whales tagged off Southern California, movement is more linear and faster (3.7 km/h) while traveling versus while foraging (1.7 km/h)(Bailey et al. 2009). Residency times in what are likely prey patches averages 21 days and constituted 29 percent of an individual's time overall, although foraging could apparently occur at any time of year for tagged individuals (Bailey et al. 2009). Broad scale movements also varied greatly, likely in response to oceanographic conditions influencing prey abundance and distribution (Bailey et al. 2009). Blue whales along Southern California were found to be traveling 85 percent of the time and milling 11 percent (Bacon et al. 2011). While feeding, blue whales show slowed and less obvious avoidance behavior then when not feeding (Sears et al. 1983 as cited in NMFS 2005). In review of a 24-year blue whale sighting history, Sears et al. (Sears et al. 2013) documented a link between female blue whales sighted in the Gulf of California and the

U.S. West Coast, although the authors suggest that only some of the U.S. West Coast blue whales migrate to the Gulf of California.

Vocalization and Hearing

Blue whales produce prolonged low-frequency vocalizations that include moans in the range from 12.5-400 Hz, with dominant frequencies from 16-25 Hz, and songs that span frequencies from 16-60 Hz that last up to 36 sec repeated every 1 to 2 min (see McDonald et al. 1995). Berchok et al. (2006a) examined vocalizations of St. Lawrence blue whales and found mean peak frequencies ranging from 17.0-78.7 Hz. Reported source levels are 180-188 dB re 1μPa, but may reach 195 dB re 1μPa (Aburto et al. 1997b; Clark and Gagnon 2004; Ketten 1998; McDonald et al. 2001a). Samaran et al. (2010) estimated Antarctic blue whale calls in the Indian Ocean at 179 ± 5 dB re 1 μPa_{rms} -1 m in the 17-30 Hz range and pygmy blue whale calls at 175± 1 dB re 1 μPa_{rms} -1 m in the 17-50 Hz range.

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources) (Edds-Walton 1997; Payne and Webb. 1971; Thompson et al. 1992). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while in summer high-latitude feeding areas. Short, rapid sequences of 30-90 Hz calls are associated with socialization and may be displays by males based upon call seasonality and structure. The low-frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long-distance communication occurs (Edds-Walton 1997; Payne and Webb. 1971). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999).

Cetaceans have an auditory anatomy that follows the basic mammalian pattern, with some modifications to adapt to the demands of hearing in the sea. The typical mammalian ear is divided into the outer ear, middle ear, and inner ear. The outer ear is separated from the inner ear by the tympanic membrane, or eardrum. In terrestrial mammals, the outer ear, eardrum, and middle ear function to transmit airborne sound to the inner ear, where the sound is detected in a fluid. Since cetaceans already live in a fluid medium, they do not require this matching, and thus do not have an air-filled external ear canal. The inner ear is where sound energy is converted into neural signals that are transmitted to the central nervous system via the auditory nerve. Acoustic energy causes the basilar membrane in the cochlea to vibrate. Sensory cells at different positions along the basilar membrane are excited by different frequencies of sound (Tyack 1999). Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

Blue whale vocalizations tend to be long (>20 s), low-frequency (<100 Hz) signals (Thomson and Richardson 1995), with a range of 12 to 400 Hz and dominant energy in the infrasonic range of 12 to 25 Hz (Ketten 1998; McDonald et al. 2001b; Mellinger and Clark 2003) . Vocalizations are predominantly of two types – songs and calls. Blue whale calls have high acoustic energy, with reports of 186–188 dB re 1 μPa-m (Cummings and Thompson 1971b; McDonald et al. 2001b) and 195 dB re 1 μPa-m (Aburto et al. 1997a) source levels. Calls are short-duration sounds (2–5 s) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweeping down in frequency (80 to 30Hz), with seasonally variable occurrence.

Blue whale songs consist of repetitively patterned sounds produced over time spans of minutes to hours, or even days (Cummings and Thompson 1971b; McDonald et al. 2001b) . The songs are divided into two components – pulsed/tonal units, which are continuous segments of sound, and phrases, which are repeated combinations of 1 to 5 units (Mellinger and Clark 2003; Payne and McVay 1971). A song is composed of many repeated phrases. Songs can be detected for hundreds, and even thousands of kilometers (Stafford et al. 1998), and have only been attributed to males (McDonald et al. 2001b; Oleson et al. 2007a). Worldwide, songs are showing a downward shift in frequency (Mcdonald et al. 2009). For example, a comparison of recordings from November 2003 and November 1964–65 reveals a long-term shift in the frequency of blue whale calling near San Nicolas Island. In 2003, the spectral energy peak was 16 Hz compared to ~22.5 Hz in 1964–65, illustrating a more than 30 percent shift in call frequency over four decades (McDonald et al. 2006). McDonald et al. (2009) observed a 31 percent downward frequency shift in blue whale calls off the coast of California, and also noted lower frequencies in 7 of the world's 10 known blue whale songs originating in the Atlantic, Pacific, Southern, and Indian Oceans. Many possible explanations for the shifts exist, but none have emerged as the probable cause.

Although general characteristics of blue whale calls are shared in distinct regions (McDonald et al. 2001b; Mellinger and Clark 2003; Rankin et al. 2005; Thompson et al. 1996) (, some variability appears to exist among different geographic areas (Rivers 1997). Sounds in the North Atlantic have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Berchok et al. 2006b; Mellinger and Clark 2003) . Clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific have also been reported (Stafford et al. 2001); however, some overlap in calls from these geographically distinct regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford and Moore 2005).

In Southern Califronia, blues whales produce two predominant call types: Type B and D. B-calls are stereotypic of the blue whale population found in the eastern North Pacific (McDonald et al. 2006) and are produced exclusively by males and associated with mating behavior (Oleson et al.

2007a). These calls have long durations (20 sec) and low frequencies (10-100 Hz); they are produced either as repetitive sequences (song) or as singular calls. The B call has a set of harmonic tonals, and may be paired with a pulsed type A call. Blue whale D calls are down-swept in frequency (100-40 Hz) with duration of several seconds. These calls are similar worldwide and are associated with feeding animals; they may be produced as call- counter call between multiple animals (Oleson et al. 2007b). In the Southern California Range Complex region, D calls are produced in highest numbers during the late spring and early summer, and in diminished numbers during the fall, when A-B song dominates blue whale calling (Hildebrand et al. 2011; Hildebrand et al. 2012; Oleson et al. 2007c).

Calling rates of blue whales tend to vary based on feeding behavior. Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. Wiggins et al. (2005) reported the same trend of reduced vocalization during daytime foraging followed by an increase at dusk as prey moved up into the water column and dispersed. Blue whales make seasonal migrations to areas of high productivity to feed, and vocalize less at the feeding grounds than during migration (Burtenshaw et al. 2004). Oleson et al. (2007c) reported higher calling rates in shallow diving (<100 ft) whales, while deeper diving whales (>165 ft) were likely feeding and calling less.

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low-frequency) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995b). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hz (Croll et al. 2001b; Oleson et al. 2007c; Stafford and Moore 2005). In terms of functional hearing capability blue whales belong to the low-frequency group, which have the best hearing ranging from 7 Hz to 22 kHz (Southall et al. 2007a).

Blue whales have not been observed during monitoring surveys in the Hawaii Range Complex, but have been observed during aerial monitoring in Southern California (Navy 2013a). Additionally, nineteen controlled exposure experiments were conducted on blue whales during the Southern California 10 behavoiral response study (Southall et al. 2011b) and 13 in the Southern California 11 behavoiral response study (Southall 2012). Behavioral response was observed in some blue whales and consisted primarily of small changes in dive behavior and general avoidance of the sound source. Preliminary assessments show behavior appearing to return to baseline shortly after the transmissions ended, however, it is possible that the changes observed were a direct response to the transmission or some other unknown or un-analyzed factors (Southall 2012). Blue whales responded to a mid-frequency sound source, with a source level between 160-210 dB re 1 µPa at 1 m and a received sound level up to 160 dB re 1 µPa, by exhibiting generalized avoidance responses and changes to dive behavior during controlled exposure experiments (CCE) (Goldbogen et al. 2013b). However, reactions were not consistent

across individuals based on received sound levels alone, and likely were the result of a complex interaction between sound exposure factors such as proximity to sound source and sound type (mid-frequency sonar simulation vs. pseudo-random noise), environmental conditions, and behavioral state. Surface feeding whales did not show a change in behavior during controlled exposure experiments, but deep feeding and non-feeding whales showed temporary reactions that quickly abated after sound exposure. Distances of the sound source from the whales during controlled exposure experiments were sometimes less than a mile.

Critical Habitat

Blue whale critical habitat has not been designated.

4.2.2 Fin Whale

The fin whale, *Balaenoptera physalus* (Linnæus 1758), is a cosmopolitan species of baleen whale (Gambell 1985b). Fin whales are the second-largest whale species by length. Fin whales are long-bodied and slender, with a prominent dorsal fin set about two-thirds of the way back on the body. The streamlined appearance can change during feeding when the pleated throat and chest area becomes distended by the influx of prey and seawater, giving the animal a tadpole-like appearance. The basic body color of the fin whale is dark gray dorsally and white ventrally, but the pigmentation pattern is complex. The lower jaw is gray or black on the left side and creamy white on the right side. This asymmetrical coloration extends to the baleen plates as well, and is reversed on the tongue. Individually distinctive features of pigmentation, along with dorsal fin shapes and body scars, have been used in photo-identification studies (Agler et al. 1990). Fin whales live 70-80 years (Kjeld 1982). Fin whales can be found in social groups of 2-7 whales.

Distribution

Fin whales are distributed widely in every ocean except the Arctic Ocean. In the North Atlantic Ocean, fin whales occur in summer foraging areas from the coast of North America to the Arctic, around Greenland, Iceland, northern Norway, Jan Meyen, 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 1985b).

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 1985b).

Fin whales undertake migrations from low-latitude winter grounds to high-latitude summer grounds and extensive longitudinal movements both within and between years (Mizroch et al. 1999a). Fin whales are sparsely distributed during November-April, from 60° N, south to the northern edge of the tropics, where mating and calving may take place (Mizroch et al. 1999a).

However, fin whales have been sighted as far as 60° N throughout winter (Mizroch et al. 1999b). A resident fin whale population may exist in the Gulf of California (Tershy et al. 1993b).

Fin whales are observed year-round off central and southern California with peak numbers in the summer and fall (Barlow 1997a; Dohl et al. 1983a; Forney et al. 1995a). Peak numbers are seen during the summer off Oregon, and in summer and fall in the Gulf of Alaska and southeastern Bering Sea (Moore et al. 2000; Perry et al. 1999a). Fin whales are observed feeding in Hawaiian waters during mid-May, and their sounds have been recorded there during the autumn and winter (Balcomb 1987; Northrop et al. 1968b; Shallenberger 1981b; Thompson and Friedl 1982a). Fin whales in the western Pacific winter in the Sea of Japan, the East China, Yellow, and Philippine seas (Gambell 1985a).

November 2008 surveys by the Marine Mammal Research Consultants within the Southern California portion of the Study Area resulted in the sighting of 22 fin whales. Navy sponsored monitoring in the Southern California Range Complex in recent years also recorded the presence of fin whales (Navy 2011a; Navy 2012c; Navy 2013a). Moore and Barlow (Moore and Barlow 2011) indicate that, since 1991, there is strong evidence of increasing fin whale abundance in the California Current area; they predict continued increases in fin whale numbers over the next decade, and that perhaps fin whale densities are reaching "current ecosystem limits."

Open Ocean. The distribution of fin whales in the Pacific during the summer includes the northern area of the Hawaii portion of the Study Area to 32° N off the coast of California (Barlow 1995; Forney et al. 1995b) . Fin whales are relatively abundant in north Pacific offshore waters, including the Hawaii portion of the Study Area (Berzin and Vladimirov 1981; MIZROCH et al. 2009) . Acoustic signals that may be attributed to the fin whale have also been detected in the Transit Corridor portion of the Study Area (Northrop et al. 1968a; Watkins et al. 2000b) . Fin whales have been recorded in the eastern tropical Pacific (Ferguson 2005) and are frequently sighted there during offshore ship surveys. Fin whales were detected acoustically and visually sighted year-round within the Southern California Range Complex from 2008-2013 (Navy 2011a; Navy 2012c; Navy 2013a). It is unclear if this represents a distinct fin whale sub-population with semi-permenant status in the region, or reflective of frequent transit by fin whales in general through and within Southern California (Navy SOCAL annual monitoring reports).

Fin whales were observed twice during a NMFS survey of waters within the Hawaiian Exclusive Economic Zone in 2010 (Bradford et al. 2013), five sightings were made in offshore waters during a NMFS 2002 survey in the same region, and a single sighting was made during aerial surveys conducted between 1993 to 1998 (Barlow 2006; Carretta et al. 2010a; Mobley Jr. et al. 2000). There are other known sightings from Kaua'i and Oahu, Hawaii and a single stranding record from Maui, Hawaii Mobley Jr. et al. 1996(Shallenberger 1981a); the most recent sighting was a single juvenile fin whale incidentally reported off Kaua'i in 2011 (Navy 2011a). Based on

sighting data and acoustic recordings, fin whales are likely to occur in Hawaiian waters mainly in fall and winter (Barlow 2006). No fin whales were sighted in the HRC during monitoring efforts 2009-2012 (HDR 2012).

Locations of breeding and calving grounds for the fin whale are unknown, but it is known that the whales typically migrate seasonally to higher latitudes every year to feed and migrate to lower latitudes to breed (Kjeld et al. 2006; Macleod et al. 2006). The fin whale's ability to adapt to areas of high productivity controls migratory patterns (Canese et al. 2006; Reeves et al. 2002). Fin whales are one of the fastest cetaceans, capable of attaining speeds of 25 mi. (40.2 km) per hour (Jefferson et al. 2008; Marini et al. 1996).

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 1985b). The overall distribution may be based on prey availability. Fin whales are larger and faster than humpback and right whales and are less concentrated in nearshore environments.

Population Structure

Fin whales have two recognized subspecies: *Balaoptera physalus physalus* occurs in the North Atlantic Ocean while *B. p. quoyi* (Fischer 1829) occurs in the Southern Ocean. A third possible subspecies occurs off South America (Gray 1865; Van Waerebeek and Engblom 2007) (Archer et al. 2013). Globally, fin whales are sub-divided into three major groups: Atlantic, Pacific, and Antarctic. Within these major areas, different organizations use different population structure.

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

In the North Pacific Ocean, the International Whaling Commission recognizes two "stocks": (1) East China Sea and (2) rest of the North Pacific (Donovan 1991). However, Mizroch et al. (1984) concluded that there were five possible "stocks" of fin whales within the North Pacific based on histological analyses and tagging experiments: (1) East and West Pacific that intermingle around the Aleutian Islands; (2) East China Sea; (3) British Columbia; (4) Southern-Central California to Gulf of Alaska; and (5) Gulf of California. Based on genetic analyses, Berube et al. (1998) concluded that fin whales in the Sea of Cortez represent an isolated population that has very little genetic exchange with other populations in the North Pacific Ocean

(although the geographic distribution of this population and other populations can overlap seasonally). They also concluded that fin whales in the Gulf of St. Lawrence and Gulf of Maine are distinct from fin whales found off Spain and in the Mediterranean Sea.

Regardless of how different authors structure the fin whale population, mark-recapture studies have demonstrated that individual fin whales migrate between management units (Mitchell 1974; Sigurjonsson et al. 1989), which suggests that these management units are not geographically isolated populations.

Mizroch et al. (1984) identified five fin whale "feeding aggregations" in the Pacific Ocean: (1) an eastern group that move along the Aleutians, (2) a western group that move along the Aleutians (Berzin and Rovnin 1966; Nasu 1974); (3) an East China Sea group; (4) a group that moves north and south along the west coast of North America between California and the Gulf of Alaska (Rice 1974); and (5) a group centered in the Sea of Cortez (Gulf of California).

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

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

Fin whales also appear to migrate to waters offshore of Washington, Oregon, and northern California to forage. Most fin whales that occur in the action area for this consultation appear to migrate between summer, foraging areas and winter rearing areas along the Pacific Coast of the United States, although Moore et al. (1998) recorded fin whale vocalizations in waters off Washington and Oregon throughout the year, with concentrations between September and February, which demonstrates that fin whales are likely to occur in the action area throughout the year. Naval-sponsored passive acoustic monitoring along Southern California found year-round vocalization detections from 2009-2012 (Navy 2013a). Fin whales along Southern California were found to be traveling 87 percent of the time and milling 5 percent in groups that averaged 1.7 individuals (Bacon et al. 2011).

Natural Threats

Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggested annual natural mortality rates might range from 0.04 to 0.06 for northeast Atlantic fin

whales. The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure and may be preventing some fin whale populations from recovering (Lambertsen 1983). Adult fin whales engage in flight responses (up to 40 km/h) to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Killer whale or shark attacks may also result in serious injury or death in very young and sick individuals (Perry et al. 1999a).

Anthropogenic Threats

Fin whales have undergone significant exploitation, but are currently protected under the IWC. Fin whales are still hunted in subsistence fisheries off West Greenland. In 2004, five males and six females were killed, and two other fin whales were struck and lost. In 2003, two males and four females were landed and two others were struck and lost (IWC 2005). Between 2003 and 2007, the IWC set a catch limit of up to 19 fin whales in this subsistence fishery. However, the scientific recommendation was to limit the number killed to four individuals until accurate populations could be produced (IWC 2005). The Japanese whalers planned to kill 50 whales per year starting in the 2007-2008 season and continuing for the next 12 years (IWC 2006; Nishiwaki et al. 2006).

Fin whales experience significant injury and mortality from fishing gear and ship strikes (Carretta et al. 2007; Douglas et al. 2008b; Lien 1994; Perkins and Beamish 1979; Waring et al. 2007). Between 1969 and 1990, 14 fin whales were captured in coastal fisheries off Newfoundland and Labrador; of these seven are known to have died because of capture (Lien 1994; Perkins and Beamish 1979). In 1999, one fin whale was reported killed in the Gulf of Alaska pollock trawl fishery and one was killed the same year in the offshore drift gillnet fishery (Angliss and Outlaw 2005; Carretta and Chivers. 2004). According to Waring et al. (2007), four fin whales in the western North Atlantic died or were seriously injured in fishing gear, while another five were killed or injured as a result of ship strikes between January 2000 and December 2004.

Jensen and Silber (2004) review of the NMFS' ship strike database revealed fin whales as the most frequently confirmed victims of ship strikes (26 percent of the recorded ship strikes [n = 75/292 records]), with most collisions occurring off the east coast, followed by the west coast of the U.S. and Alaska/Hawai′i. Between 1999-2005, there were 15 reports of fin whales strikes by vessels along the U.S. and Canadian Atlantic coasts (Cole et al. 2005; Nelson et al. 2007). Of these, 13 were confirmed, resulting in the deaths of 11 individuals. Five of seven fin whales stranded along Washington State and Oregon showed evidence of ship strike with incidence increasing since 2002 (Douglas et al. 2008b). Similarly, 2.4 percent of living fin whales from the Mediterranean show ship strike injury and 16 percent of stranded individuals were killed by vessel collision (Panigada et al. 2006). There are also numerous reports of ship strikes off the Atlantic coasts of France and England (Jensen and Silber 2004b).

Management measures aimed at reducing the risk of ships hitting right whales should also reduce the risk of collisions with fin whales. In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship strike appear to be largely ignored (Vanderlaan et al. 2008). However, new rules for seasonal (June through December) slowing of vessel traffic to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are predicted to be capable of reducing ship strike mortality by 27 percent in the Bay of Fundy region.

The organochlorines DDE, DDT, and PCBs have been identified from fin whale blubber, but levels are lower than in toothed whales due to the lower level in the food chain that fin whales feed at (Aguilar and Borrell 1988; Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983; Marsili and Focardi 1996). Females contained lower burdens than males, likely due to mobilization of contaminants during pregnancy and lactation (Aguilar and Borrell 1988; Gauthier et al. 1997). Contaminant levels increase steadily with age until sexual maturity, at which time levels begin to drop in females and continue to increase in males (Aguilar and Borrell 1988).

Climate change also presents a threat to fin whales, particularly in the Mediterranean Sea, where fin whales appear to rely exclusively upon northern krill as a prey source. These krill occupy the southern extent of their range and increases in water temperature could result in their decline and that of fin whales in the Mediterranean Sea (Gambaiani et al. 2009).

Status and Trends

Fin whales were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973. Although fin whale population structure remains unclear, various abundance estimates are available. Pre-exploitation fin whale abundance is estimated at 464,000 individuals worldwide; the estimate for 1991 was roughly 25 percent of this (Braham 1991). Historically, worldwide populations were severely depleted by commercial whaling, with more than 700,000 whales harvested in the twentieth century (Cherfas 1989).

The current best available abundance estimate for the Hawaiian stock of fin whales is 174 (coefficient of variation = 0.72) (Barlow 2003). The current best available abundance estimate of fin whales in California, Oregon, and Washington waters is 3,044 (coefficient of variation = 0.18) (Carretta et al. 2011). Survey estimate numbers for both stocks are considered to be an underestimate because large whales that could not be identified in the field (due to distance, bad sighting conditions, etc.) were recorded in these and other surveys as “unidentified rorqual” or “unidentified large whale” (Carretta et al. 2010). A recent study indicates that the abundance of fin whales in waters off the U.S. west coast has increased during the 1991–2008 survey period, most likely from *in situ* population growth combined with distribution shifts (Moore and Barlow 2011).

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

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

Diving and Social Behavior

The amount of time fin whales spend at the surface varies. Some authors have reported that fin whales make 5-20 shallow dives, each of 13-20 s duration, followed by a deep dive of 1.5-15 min (Gambell 1985b; Lafortuna et al. 2003; Stone et al. 1992). Other authors have reported that the fin whale's most common dives last 2-6 min (Hain et al. 1992; Watkins 1981b). The most recent data support average dives of 98 m and 6.3 min for foraging fin whales, while non-foraging dives are 59 m and 4.2 min (Croll et al. 2001a). However, Lafortuna et al. (1999) found that foraging fin whales have a higher blow rate than when traveling. Foraging dives in excess of 150 m are known (Panigada et al. 1999). In waters off the U.S. Atlantic Coast, individuals or duos represented about 75 percent of sightings during the Cetacean and Turtle Assessment Program (Hain et al. 1992).

Individuals or groups of less than five individuals represented about 90 percent of the observations. Barlow (2003) reported mean group sizes of 1.1–4.0 during surveys off California, Oregon, and Washington.

Vocalization and Hearing

Fin whales produce a variety of low-frequency sounds in the 10-200 Hz range (Edds 1988; Thompson et al. 1992; Watkins 1981a; Watkins et al. 1987). Typical vocalizations are long, patterned pulses of short duration (0.5-2 s) in the 18-35 Hz range, but only males are known to produce these (Clark et al. 2002; Patterson and Hamilton 1964). Richardson et al. (1995b) reported the most common sound as a 1 s vocalization of about 20 Hz, occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. Au (2000b) reported moans of 14-118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34-150 Hz, and songs of 17-25 Hz (Cummings and Thompson 1994; Edds 1988; Watkins 1981a).

Source levels for fin whale vocalizations are 140-200 dB re 1μPa-m (see also Clark and Gagnon 2004; as compiled by Erbe 2002b). The source depth of calling fin whales has been reported to be about 50 m (Watkins et al. 1987).

Although their function is still in doubt, low-frequency fin whale vocalizations travel over long distances and may aid in long-distance communication (Edds-Walton 1997; Payne and Webb. 1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpbacks (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999).

The inner ear is where sound energy is converted into neural signals that are transmitted to the central nervous system via the auditory nerve. Acoustic energy causes the basilar membrane in the cochlea to vibrate. Sensory cells at different positions along the basilar membrane are excited by different frequencies of sound (Tyack 1999). Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995b).

Fin whales produce a variety of low frequency (< 1 kHz) sounds, but the most typically recorded is a 20 Hz pulse lasting about 1 s, and reaching source levels of 189 ± 4 dB re 1 μPam (Charif et al. 2002; Clark et al. 2002; Edds 1988; Richardson et al. 1995b; Sirovic et al. 2007; Watkins 1981a; Watkins et al. 1987). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23-18 Hz), and can be repeated over the course of many hours (Watkins et al. 1987). In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clarke and Charif 1998). The seasonality and stereotypic nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981a; Watkins et al. 1987); a notion further supported by recent data linking these vocalizations to male fin whales only (Croll et al. 2002). In Southern California, the 20 Hz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (Navy 2010; Navy 2012c). An additional fin whale sound, the 40 Hz call described by Watkins (1981a), was also frequentlyrecorded, although these calls not as common as the 20 Hz fin whale pulses. Seasonality of the 40 Hz calls differed from the 20 Hz calls, since 40 Hz calls were more prominent in the spring, as observed at other sites across the northeast Pacific (Sirovic et al. 2012). Source levels of Eastern Pacific fin whale 20-Hz calls has been reported as 189 +/- 5.8 dB re 1uPa at 1m (Weirathmueller et al. 2013). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20 Hz bandwidth and sequencing when

performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (see (Thompson et al. 1992; Watkins et al. 1987).

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 (Edds-Walton 1997; Payne and Webb. 1971). 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).

Although no studies have directly measured the sound sensitivity of fin whales, experts assume that fin whales are able to receive sound signals in roughly the same frequencies as the signals they produce. This suggests fin whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than at mid- to high-frequencies (Ketten 1997).

In terms of functional hearing capability fin whales belong to the low-frequency group, which have the best hearing ranging from 7 Hz to 22 kHz (Southall et al. 2007b).

A fin whale was observed during monitoring efforts off of Lanai (unpublished data) near the Hawaii Range Complex. Fin whales have also been observed during aerial monitoring in Southern California (Navy 2010; Navy 2012c). Additionally, several fin whales were tagged during the Southern California-10 BRS and no obvious responses to the controlled exposure were detected by the visual observers or in the initial tag analysis (Southall et al. 2011a).

Critical Habitat

Fin whale critical habitat has not been designated.

4.2.3 Western North Pacific Gray Whale

Gray whales (*Eschrichtius robustus*) are mysticetes, or baleen whales. Gray whales are the only species in the family Eschrichtiidae. These large whales can grow to about 50 ft (15 m) long, and weigh approximately 80,000 lb (35,000 kg). Females are slightly larger than males.

They have a mottled gray body, with small eyes located just above the corners of the mouth. Their "pectoral fins" (flippers) are broad, paddle-shaped, and pointed at the tips. Lacking a dorsal fin, they instead have a "dorsal hump" located about two-thirds of the way back on the body, and a series of 8-14 small bumps, known as "knuckles," between the dorsal hump and the tail flukes. The tail flukes are more than 15 ft (3 m) wide, have S-shaped trailing edges, and a deep median notch.

Gray whales are frequently observed traveling alone or in small, unstable groups, although large aggregations may be seen on feeding and breeding grounds. Similar to other baleen whales, long-term bonds between individuals are rare. Gray whales are bottom feeders, and suck sediment and the "benthic" amphipods that are their prey from the sea floor. To do this, they roll on their sides and swim slowly along, filtering their food through coarse baleen plates, of which they have 130-180 on each side of the upper jaw. In doing so, they often leave long trails of mud behind them, and "feeding pits" in the sea floor.

Gray whales become sexually mature between 6-12 years, at an average of 8 years old. After 12-13 months of gestation, females give birth to a single calf. Newborn calves are approximately 14-16 ft (4.5-5 m) long, and weigh about 2,000 lb (920 kg). The average and maximum life span of gray whales is unknown, although one female was estimated at 75-80 years old after death (Jones and Swartz, 2002).

Distribution

Western North Pacific gray whales exhibit extensive plasticity in their occurrence, shifting use areas within and between years, as well as over longer time frames, such as in response to oceanic climate cycles (e.g., El Nino-Southern Oscillation, Pacific Decadal Oscillation, and Arctic Oscillation) (Gardner and Chavez-Rosales 2000; Meier et al. 2007; Tyurneva et al. 2009; Vladimirov et al. 2006a; Vladimirov et al. 2006b; Vladimirov et al. 2005; Vladimirov et al. 2008; Vladimirov et al. 2009; Vladimirov et al. 2010; Weller et al. 2012b; Yablokov and Bogoslovskaya 1984; Yakovlev and Tyurneva 2005). Species distribution extends south along Japan, the Koreas, and China from the Kamchatka Peninsula (IWC 2003; Kato and Kasuya. 2002; Omura 1988; Reeves et al. 2008; Weller et al. 2003). Other possible range states include Vietnam, the Philippines, and Taiwan, although only historical whaling records support occurrence in these areas (Henderson 1990a; Ilyashenko 2009). Range has likely contracted from the Koreas and other southern portions of the range versus pre-whaling periods. Prey availability and, to a lesser extent, sea ice extent, are probably strong influences on the habitats used by western North Pacific gray whales (Clarke and Moore 2002; Moore 2000).

Population Structure

Gray whales occur in two genetically and spatially distinct populations on the eastern and western sides of the North Pacific Ocean (Brownell Jr. et al. 2009; Burdin et al. 2011; Kanda et al. 2010; Lang et al. 2004; Lang et al. 2005; Lang et al. 2010b; Leduc et al. 2002; Swartz et al. 2006; Weller et al. 2007; Weller et al. 2004b; Weller et al. 2006a).

Western North Pacific gray whales migrate annually along Asia during autumn, although migration routes are poorly known. Migration from summer foraging areas off the northeastern coasts of Sakhalin Island and south-eastern Kamchatka along the Japanese coasts to the South China Sea is suspected (Commission 2004; IWC 2003; Omura 1988; Tsidulko et al. 2005; Weller et al. 2008a; Weller et al. 2012b).

Eastern and western North Pacific gray whales were once considered geographically separated along either side of the ocean basin, but recent photoidentification, genetic, and satellite tracking data refute this. Two western North Pacific gray whales have been satellite tracked from Russian foraging areas east along the Aleutian Islands, through the Gulf of Alaska, and south to the Washington State and Oregonian coasts in one case (Mate et al. 2011) and to the southern tip of Baja California and back to Sakhalin Island in another (IWC 2012). Comparisons of eastern and western North Pacific gray whale catalogs have thus far identified 21-23 western gray whales occurring on the eastern side of the basin (IWC 2012; Weller et al. 2011). Burdin et al. (2011) found an additional individual. During one field season off Vancouver Island, western gray whales were found to constitute 6 of 74 (8.1 percent) of photoidentifications (Weller et al. 2012a). In addition, two genetic matches of western gray whales off Santa Barbara, California have been made (Lang et al. 2011). Individuals have also been observed migrating as far as Central Baja Mexico (Weller et al. 2012b).

Group sizes vary, but are roughly 2 (range 1 to 14) for non-calf groups and slightly larger for groups containing calves (Weller et al. 2007; Weller et al. 2004b; Weller et al. 2006a; Weller et al. 1999; Yakovlev and Tyurneva 2004).

Natural Threats

Predation by killer whales is a significant threat to gray whales, with calves being particularly susceptible during their northward migration (Fay et al. 1978; Goley and Straley 1994; Poole 1984; Rice and Wolman 1971; Ternullo and Black 2002). However, not all attacks are fatal and many individuals escape with scars from the encounters. Killer whales are frequently observed in the primary western North Pacific gray whale foraging area and roughly one-third to one half of observed gray whales bear tooth marks from killer whales (30 percent of them during the course of the 10 year study)(Bradford et al. 2003; Bradford et al. 2006a; Weller et al. 2009a; Weller et al. 2002a). Vladimirov (2005) documented an attack on a mother-calf pair in shallow waters of the Piltun Bay foraging area. This rate is among the highest rate found amongst baleen whales. Researchers have also expressed significant concern about whales that appear “skinny”; the cause and consequences remain unknown (Bradford et al. 2007; Bradford et al. 2008a; Bradford et al. 2012b; Burdin et al. 2003; IWC 2003; Weller et al. 2008b; Weller et al. 2007; Weller et al. 2005; Weller et al. 2004a; Weller et al. 2004b; Weller et al. 2006a; Yakovlev and Tyurneva 2004). Lactating females appear to be in particularly poor body condition (Bradford et al. 2012b).

Anthropogenic Threats

Western North Pacific gray whales experience many of the same human-induced threats as other baleen whales, including entanglement and ship strike. At least one fifth of individuals show evidence of entanglement in fishing gear (Bradford et al. 2006b) (Bradford et al. 2009). Four females were bycaught in fishing nets and died along Japan from 2005-2007 (Bradford et al. 2006b; Brownell Jr. 2007; Cooke et al. 2005; Cooke et al. 2008; Cooke et al. 2007; Kato et al.

2006; Kato et al. 2007; Weller et al. 2008b). Bradford et al. (2006b) and (2009) found that 1.8-2.0 percent of individuals showed scars consistent with ship strike. Another individual was found stranded in 1996 with several harpoons in it, likely from Japanese fishers (Brownell Jr. and Kasuya. 1999). Extensive oil and gas exploration and development is occurring near the summer foraging areas for western North Pacific gray whales, introducing noise, additional ship strike, pollutants, and the potential for oil spills to the region that causes concern for the recovery of western North Pacific gray whales (Anonymous 2009; Brownell 2004; Commission 2004; Donovan 2005; Gailey et al. 2007; IWC 2003; Johnson et al. 2007; Nowacek et al. 2012; Reeves et al. 2005; Reeves 2005; Webster 2003; Weller et al. 2008b; Weller et al. 2002b; Weller et al. 2006b; Weller et al. 2006c; Yazvenko et al. 2007a; Yazvenko et al. 2007b).

Status and Trends

Gray whales throughout the North Pacific Ocean were originally listed on June 2, 1970 (35 FR 8495). On June 16, 1994 (59 FR 21094), the eastern North Pacific gray whales were delisted, but western North Pacific gray whales remained listed through the present as endangered.

Alter et al. (2007) concluded that eastern and western North Pacific gray whales historically numbered between 76,000 and 118,000 individuals combined prior to whaling; the proportion of individuals that was in each population is unknown. However, whaling dramatically reduced the population to a tiny fraction of its former abundance, with 100-130 non-calves remaining (Burdin et al. 2010; Cooke et al. 2005; Cooke et al. 2008; Reeves et al. 2008; Wade et al. 2003; Weller et al. 2005; Weller et al. 2006a) . The most recent estimate of western gray whale abundance is 137 individuals (IWC 2012). The population was believed extinct in the 1970's (Bradford et al. 2003). At least 1,700-2,000 individuals were commercially harvested from the late 1800's to the mid 20th century (Commission 2004; IWC 2003). Findings that eastern North Pacific gray whales may be found within the range of western North Pacific gray whales may mean that even fewer individuals compose the western population, as individuals formerly believed to be western individuals may actually be part of the eastern population (Lang et al. 2010b). Fortunately, the latest data on population growth indicates a positive trajectory for available data over 1994-2007 of roughly 2.5-3.2 percent growth per year (Bradford et al. 2008b; Cooke et al. 2008; Cooke et al. 2007; Cooke et al. 2006). However, the loss of a single adult female would strongly decrease this trajectory (Cooke et al. 2005). In 2009, Burdin et al. (2010) reported 26 mature females observed since 1995. Genetic findings have found that although genetic diversity is relatively high in western North Pacific gray whales considering their population size, significant portions of this diversity are retained in a few or single individuals (IWC 2003). The loss of one or a few of these individuals would greatly reduce the genetic diversity of the population as a whole. Also of significance is that only about half of males fathering offspring have been identified, supporting a larger population size than is currently known (Lang et al. 2010a; Lang et al. 2010b). There is a strong male bias in calf production of roughly 2:1 (Burdin et al. 2003; Cooke et al. 2008; Weller et al. 2009b; Weller et al. 2008b; Weller et al. 2004a; Weller et al. 2004b). Clapham et al. (1999) conducted a review of

western North Pacific gray whales, among other endangered whales, and found that this population matches in virtually all characteristics that would make a small population extinction-prone.

Vocalizations and Hearing

No data are available regarding western North Pacific gray whale hearing or communication. We assume that eastern North Pacific gray whale communication is representative of the western population and present information stemming from this population. Individuals produce broadband sounds within the 100 Hz to 12 kHz range (Dahlheim et al. 1984; Jones and Swartz 2002; Thompson et al. 1979). The most common sounds encountered are on feeding and breeding grounds, where "knocks" of roughly 142 dB re: 1 µPa at 1 m (source level) have been recorded (Cummings et al. 1968; Jones and Swartz 2002; Thomson and Richardson 1995). However, other sounds have also been recorded in Russian foraging areas, including rattles, clicks, chirps, squeaks, snorts, thumps, knocks, bellows, and sharp blasts at frequencies of 400 Hz to 5 kHz (Petrochenko et al. 1991). Estimated source levels for these sounds ranged from 167-188 dB re: 1 µPa at 1 m (Petrochenko et al. 1991). Low frequency (<1.5 kHz) "bangs" and "moans" are most often recorded during migration and during ice-entrapment (Carroll et al. 1989; Crane and Lashkari. 1996). Sounds vary by social context and may be associated with startle responses (Rohrkasse-Charles et al. 2011). Calves exhibit the greatest variation in frequency range used, while adults are narrowest; groups with calves were never silent while in calving grounds (Rohrkasse-Charles et al. 2011). Based upon a single captive calf, moans were more frequent when the calf was less than a year old, but after a year, croaks were the predominant call type (Wisdom et al. 1999).

Auditory structure suggests hearing is attuned to low frequencies (Ketten 1992a; Ketten 1992b). Responses of free-ranging and captive individuals to playbacks in the 160 Hz to 2 kHz range demonstrate the ability of individuals to hear within this range (Buck and Tyack 2000; Cummings and Thompson 1971a; Dahlheim and Ljungblad 1990; Moore and Clark 2002; Wisdom et al. 2001). Responses to low-frequency sounds stemming from oil and gas activities also support low-frequency hearing (Malme et al. 1986; Moore and Clark 2002).

Critical Habitat

NMFS has not designated critical habitat for Western North Pacific gray whale.

4.2.4 Humpback Whale

Humpback whales (*Megaptera novaeangliae*) are distinguished from other whales in the same Family (Balaenopteridae) by extraordinarily long flippers (up to 5 m or about 1/3 total body length), a more robust body, fewer throat grooves (14-35), more variable dorsal fin, and utilization of very long (up to 30 min.), complex, repetitive vocalizations (songs) (Payne and McVay 1971) during courtship. Their grayish-black baleen plates, approximately 270-440 on each side of the jaw, are intermediate in length (6570 cm) to those of other baleen whales.

Humpbacks in different geographical areas vary somewhat in body length, but maximum recorded size is 18m (Winn and Reichley 1985).

The whales are generally dark on the back, but the flippers, sides and ventral surface of the body and flukes may have substantial areas of natural white pigmentation plus acquired scars (white or black). Researchers distinguish individual humpbacks by the apparently unique black and white patterns on the underside of the flukes as well as other individually variable features (Glockner and Venus 1983; Katona and Whitehead 1981; Kaufman and Osmond 1987).

Distribution

Humpback whales are a cosmopolitan species that occur in the Atlantic, Indian, Pacific, and Southern oceans. Humpback whales migrate seasonally between warmer, tropical or sub-tropical waters in winter months (where they breed and give birth to calves, although feeding occasionally occurs) and cooler, temperate or sub-Arctic waters in summer months (where they feed). In both regions, humpback whales tend to occupy coastal waters. However, migrations are undertaken through deep, pelagic waters (Winn and Reichley 1985).

In the eastern and central North Pacific Ocean, the summer range of humpback whales includes coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Tomlin 1967, Nemoto 1957, Johnson and Wolman 1984 as cited in NMFS 1991). These whales migrate to calving grounds near Hawaii, southern Japan, the Mariana Islands, and Mexico during the winter months.

In the Hawaii portion of the study area, 947 sightings of 1,594 individuals were made by Navy-funded surveys in 2005-2012 (HDR 2012). Sixty-four of these sightings (11 percent of total, n=107) were observed within the boundaries of the Hawaiian Islands Humpback Whale National Marine Sanctuary, defined by the 100 fathom (183 m) isobaths off portions of the main Hawaiian Islands, and approximately half that number of sightings were observed outside the 1000 fathom (1830m) isobaths.winter.

Population Structure

Descriptions of the population structure of humpback whales differ depending on whether an author focuses on where humpback whales winter or where they feed. During winter months in northern or southern hemispheres, adult humpback whales migrate to specific areas in warmer, tropical waters to reproduce and give birth to calves. During summer months, humpback whales migrate to specific areas in northern temperate or sub-arctic waters to forage. In summer months, humpback whales from different “reproductive areas” will congregate to feed; in the winter months, whales will migrate from different foraging areas to a single wintering area. In either case, humpback whales appear to form “open” populations; that is, populations that are connected through the movement of individual animals.

North Pacific. Based on genetic and photo-identification studies, we currently recognize four stocks, likely corresponding to populations, of humpback whales in the North Pacific Ocean: two in the eastern North Pacific, one in the central North Pacific, and one in the western Pacific (Hill and DeMaster 1998). However, gene flow between them may exist. Humpback whales summer in coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Johnson and Wolman 1984; Nemoto 1957; Tomilin 1967). These whales migrate to Hawaii, southern Japan, the Mariana Islands, and Mexico during winter. However, more northerly penetrations in Arctic waters occur on occasion (Hashagen et al. 2009). The central North Pacific population winters in the waters around Hawaii while the eastern North Pacific population (also called the California-Oregon-Washington stock) winters along Central America and Mexico. However, Calambokidis et al. (1997) identified individuals from several populations wintering (and potentially breeding) in the areas of other populations, highlighting the potential fluidity of population structure. Herman (1979) presented extensive evidence that humpback whales associated with the main Hawaiian Islands immigrated there only in the past 200 years. Winn and Reichley (1985) identified genetic exchange between the humpback whales that winter off Hawaii and Mexico (with further mixing on feeding areas in Alaska) and suggested that humpback whales that winter in Hawaii may have emigrated from Mexican wintering areas. A "population" of humpback whales winters in the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands, with occurrence in the Mariana Islands, at Guam, Rota, and Saipan from January-March (Darling and Cerchio 1993; Eldredge 1991; Eldredge 2003; Fulling et al. 2011; Rice 1998). During summer, whales from this population migrate to the Kuril Islands, Bering Sea, Aleutian Islands, Kodiak, Southeast Alaska, and British Columbia to feed (Angliss and Outlaw 2008; Calambokidis 1997; Calambokidis et al. 2001).

Separate feeding groups of humpback whales are thought to inhabit western U.S. and Canadian waters, with the boundary between them located roughly at the U.S./Canadian border. The southern feeding ground ranges between 32°-48°N, with limited interchange with areas north of Washington State (Calambokidis et al. 2004; Calambokidis et al. 1996).

Humpback whales primarily feed along the shelf break and continental slope (Green et al. 1992; Tynan et al. 2005).

Natural Threats

Natural sources and rates of mortality of humpback whales are not well known. Based upon prevalence of tooth marks, attacks by killer whales appear to be highest among humpback whales migrating between Mexico and California, although populations throughout the Pacific Ocean appear to be targeted to some degree (Steiger et al. 2008). Juveniles appear to be the primary age group targeted. Humpback whales engage in grouping behavior, flailing tails, and

rolling extensively to fight off attacks. Calves remain protected near mothers or within a group and lone calves have been known to be protected by presumably unrelated adults when confronted with attack (Ford and Reeves 2008).

Parasites and biotoxins from red-tide blooms are other potential causes of mortality (Perry et al. 1999a). The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in humpback whales and may be preventing some populations from recovering (Lambertsen 1992). Studies of 14 humpback whales that stranded along Cape Cod between November 1987 and January 1988 indicate they apparently died from a toxin produced by dinoflagellates during this period.

Anthropogenic Threats

Three human activities are known to threaten humpback whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of whales and was ultimately responsible for listing several species as endangered.

Humpback whales are also killed or injured during interactions with commercial fishing gear. Like fin whales, humpback whales have been entangled by fishing gear off Newfoundland and Labrador, Canada. A total of 595 humpback whales were reported captured in coastal fisheries in those two provinces between 1969 and 1990, of which 94 died (Lien 1994; Perkins and Beamish 1979). Along the Atlantic coast of the U.S. and the Maritime Provinces of Canada, there were 160 reports of humpback whales being entangled in fishing gear between 1999 and 2005 (Cole et al. 2005; Nelson et al. 2007). Of these, 95 entangled humpback whales were confirmed, with 11 whales sustaining injuries and nine dying of their wounds. NMFS estimates that between 2002 and 2006, there were incidental serious injuries to 0.2 humpback annually in the Bering Sea/Aleutian Islands sablefish longline fishery. This estimation is not considered reliable. Observers have not been assigned to a number of fisheries known to interact with the Central and Western North Pacific stocks of humpback whale. In addition, the Canadian observation program is also limited and uncertain (Angliss and Allen 2009).

More humpback whales are killed in collisions with ships than any other whale species except fin whales (Jensen and Silber 2003). Along the Pacific coast, a humpback whale is known to be killed about every other year by ship strikes (Barlow et al. 1997b). Of 123 humpback whales that stranded along the Atlantic coast of the U.S. between 1975 and 1996, 10 (8.1 percent) showed evidence of collisions with ships (Laist et al. 2001). Between 1999 and 2005, there were 18 reports of humpback whales being struck by vessels along the Atlantic coast of the U.S. and the Maritime Provinces of Canada (Cole et al. 2005; Nelson et al. 2007). Of these reports, 13 were confirmed as ship strikes and in seven cases, ship strike was determined to be the cause of death. In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship strike appear to be largely ignored (Vanderlaan et al. 2008). However, new rules for seasonal (June through December) slowing of vessel traffic to 10 knots and changing shipping lanes by less than

one nautical mile to avoid the greatest concentrations of right whales are expected to reduce the chance of humpback whales being hit by ships by 9 percent.

Organochlorines, including PCB and DDT, have been identified from humpback whale blubber (Gauthier et al. 1997). Higher PCB levels have been observed in Atlantic waters versus Pacific waters along the United States and levels tend to increase with individual age (Elfes et al. 2010). Although humpback whales in the Gulf of Maine and off Southern California tend to have the highest PCB concentrations, overall levels are on par with other baleen whales, which are generally lower than odontocete cetaceans (Elfes et al. 2010). As with blue whales, these contaminants are transferred to young through the placenta, leaving newborns with contaminant loads equal to that of mothers before bioaccumulating additional contaminants during life and passing the additional burden to the next generation (Metcalfe et al. 2004). Contaminant levels are relatively high in humpback whales as compared to blue whales. Humpback whales feed higher on the food chain, where prey carry higher contaminant loads than the krill that blue whales feed on.

Status and Trends

Humpback whales were originally listed as endangered in 1970 (35 FR 18319), and this status remains under the ESA. On 29 August 2013, NMFS announced a 90-day finding on a April 17, 2013 petition to identify the North Pacific humpback population as a Distinct Population Segment (DPS) and delist this population under the ESA (78 FR 53391). A complete status review is being conducted to determine if delisting is warranted by April 2014.

In the North Pacific the pre-exploitation population size may have been as many as 15,000 humpback whales, and current estimates are 6,000-8,000 whales (Calambokidis et al. 2009a; Rice 1978). It is estimated that 15,000 humpback whales resided in the North Pacific in 1905 (Rice 1978). However, from 1905 to 1965, nearly 28,000 humpback whales were harvested in whaling operations, reducing the number of all North Pacific humpback whale to roughly 1,000 (Perry et al. 1999a). The overall abundance of humpback whales in the north Pacific was recently estimated at 21,808 individuals (coefficient of variation = 0.04), confirming that this population of humpback whales has continued to increase and is now greater than some pre-whaling abundance estimates (Barlow et al. 2011a). Data indicates the north Pacific population has been increasing at a rate of between 5.5 percent and 6.0 percent per year so approximately doubling every 10 years (Calambokidis et al. 2008). The current best estimate for the California, Oregon, and Washington stock is 2,043 (coefficient of variation = 0.10) (Carretta et al. 2010a). Based on ship surveys conducted in the summer and fall from 1991 to 2005, it is estimated that 36 humpback whales (coefficient of variation = 0.51) occur off Southern California in the waters south of Point Conception (Barlow and Forney 2007).The Central North Pacific stock has been estimated at 10,103 individuals on wintering grounds throughout the main Hawaiian Islands (Allen and Angliss 2013).

The Hawaiian Islands Humpback Whale National Marine Sanctuary reported in 2010 that as many as 12,000 humpback whales migrate to Hawaiian waters each year (Barlow et al. 2011b) (Calambokidis et al. 2008). Mobley (2011) remarked on the doubling of this species' sighting rate during a 2011 aerial survey (0.04 sightings/km) when compared to the 2006 North Pacific Acoustic Laboratory aerial survey (0.02 sightings/km) (Mobley 2011). This sighting rate further increased to 0.065 sightings/km during the February 2012 SCC aerial survey (Mobley and Pacini 2012).

Diving

Maximum diving depths are approximately 170 m, with a very deep dive (240 m) recorded off Bermuda (Hamilton et al. 1997). Dives can last for up to 21 min, although feeding dives ranged from 2.1-5.1 min in the north Atlantic (Dolphin 1987). In southeast Alaska, average dive times were 2.8 min for feeding whales, 3.0 min for non-feeding whales, and 4.3 min for resting whales (Dolphin 1987). Because most humpback prey is likely found within 300 m of the surface, most humpback dives are probably relatively shallow. In Alaska, capelin are the primary prey of humpback and are found primarily between 92 and 120 m; depths to which humpbacks apparently dive for foraging (Witteveen et al. 2008).

Social Behavior

During the feeding season, humpback whales form small groups that occasionally aggregate on concentrations of food that may be stable for long-periods of times. Humpbacks use a wide variety of behaviors to feed on various small, schooling prey including krill and fish (Hain et al. 1982; Hain et al. 1995; Jurasz and Jurasz 1979; Weinrich et al. 1992). There is good evidence of some territoriality on feeding and calving areas (Clapham 1994; Clapham 1996; Tyack 1981). Humpback whales are generally believed to fast while migrating and on breeding grounds, but some individuals apparently feed while in low-latitude waters normally believed to be used exclusively for reproduction and calf-rearing (Danilewicz et al. 2009; Pinto De Sa Alves et al. 2009). Some individuals, such as juveniles, may not undertake migrations at all (Findlay and Best 1995).

Humpback whales feed on pelagic schooling euphausiids and small fish including capelin, herring and mackerel. Like other large mysticetes, they are a "lunge feeder" taking advantage of dense prey patches and engulfing as much food as possible in a single gulp. They also blow nets, or curtains, of bubbles around or below prey patches to concentrate the prey in one area, then lunge with open mouths through the middle. Dives appear to be closely correlated with the depths of prey patches, which vary from location to location. In the north Pacific (southeast Alaska), most dives were of fairly short duration (<4 min) with the deepest dive to 148 m (Dolphin 1987), while whales observed feeding on Stellwagen Bank in the North Atlantic dove to <40 m (Hain et al. 1995). Hamilton et al. (1997) tracked one possibly feeding whale near Bermuda to 240 m depth.

Vocalization and Hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz to 4 kHz with estimated source levels from 144-174 dB (Au et al. 2006; Au et al. 2000b; Frazer and Mercado III 2000; Richardson et al. 1995b; Winn et al. 1970). Males also produce sounds associated with aggression, which are generally characterized as frequencies between 50 Hz to 10 kHz and having most energy below 3 kHz (Silber 1986; Tyack 1983). Such sounds can be heard up to 9 km away (Tyack 1983). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also produced in breeding areas (Richardson et al. 1995b; Tyack 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25-89 Hz), and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz) which can be very loud (175-192 dB re 1 μPa at 1 m) (Au et al. 2000b; Erbe 2002a; Payne 1985; Richardson et al. 1995b; Thompson et al. 1986). However, humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995b).

Humpback whales are known to produce three classes of vocalizations: (1) “songs” in the late fall, winter, and spring by solitary males; (2) social sounds made by calves (Zoidis et al. 2008) or within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson and Richardson 1995). The best-known types of sounds produced by humpback whales are songs, which are thought to be reproductive displays used on breeding grounds only by adult males (Clark and Clapham 2004; Gabriele and Frankel. 2002; Helweg et al. 1992; Schevill et al. 1964; Smith et al. 2008). Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard in other regions and seasons (Clark and Clapham 2004; Gabriele and Frankel. 2002; McSweeney et al. 1989). Au et al. (Au et al. 2000a) noted that humpbacks off Hawaii tended to sing louder at night compared to the day. There is geographical variation in humpback whale song, with different populations singing a basic form of a song that is unique to their own group. However, the song evolves over the course of a breeding season, but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983). The song is an elaborate series of patterned vocalizations that are hierarchical in nature, with a series of songs (‘song sessions’) sometimes lasting for hours (Payne and McVay 1971). Components of the song range from below 20 Hz up to 4 kHz, with source levels measured between 151 and 189 dB re 1 μPa-m and high-frequency harmonics extending beyond 24 kHz (Au et al. 2006; Winn et al. 1970).

Social calls range from 20 Hz to 10 kHz, with dominant frequencies below 3 kHz (D'Vincent et al. 1985; Dunlop et al. 2008; Silber 1986; Simao and Moreira 2005). Female vocalizations appear to be simple; Simão and Moreira (2005) noted little complexity.

"Feeding" calls, unlike song and social sounds are a highly stereotyped series of narrow-band trumpeting calls. These calls are 20 Hz to 2 kHz, less than 1 second in duration, and have source levels of 162 to 192 dB re 1 μPa-m (D'Vincent et al. 1985; Thompson et al. 1986). The fundamental frequency of feeding calls is approximately 500 Hz (D'Vincent et al. 1985) (D'Vincent et al., 1985; Thompson et al., 1986). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic has been documented with Digital Acoustic Recording Tags (DTAGs[2]) (Stimpert et al. 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple bouts of broadband click trains that were acoustically different from toothed whale echolocation: Stimpert et al. (Stimpert et al. 2007) termed these sounds "mega-clicks" which showed relatively low received levels at the DTAGs (143 to 154 dB re 1 μPa), with the majority of acoustic energy below 2 kHz.

Houser et al. (Houser et al. 2001a) produced a predicted humpback whale audiogram using a mathematical model based on the internal structure of the ear: estimated sensitivity was from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 and 6 kHz. Previously mentioned research by Au et al. (2001, 2006) off Hawaii indicated the presence of high-frequency harmonics in vocalizations up to and beyond 24 kHz. While recognizing this was the upper limit of the recording equipment, it does not demonstrate that humpbacks can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpbacks to hear frequencies around 3 kHz may have been demonstrated in a playback study. Maybaum (Maybaum 1990) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kHz at 219 dB re 1μPa-m or frequency sweep of 3.1to 3.6 kHz (although it should be noted that this system is significantly different from the Navy's hull mounted sonar). In addition, the system had some low frequency components (below 1 kHz) which may have been an artifact of the acoustic equipment. This possible artifact may have affected the response of the whales to both the control and sonar playback conditions.

In terms of functional hearing capability humpback whales belong to low-frequency cetaceans which have the best hearing ranging from 7 to 22 kHz (Southall et al. 2007b).

Humpback whales are the most abundant ESA-listed species observed during Navy visual surveys and monitoring projects using PMRF range hydrophones (Navy 2012c). Analysis of visual sightings correlated with acoustic detections from the hydrophones was conducted on twelve humpback whales observed during a Navy training event in the Hawaii Range Complex.

[2] DTAG is a novel archival tag, developed to monitor the behavior of marine mammals, and their response to sound, continuously throughout the dive cycle. The tag contains a large array of solid-state memory and records continuously from a built-in hydrophone and suite of sensors. The sensors sample the orientation of the animal in three dimensions with sufficient speed and resolution to capture individual fluke strokes. Audio and sensor recording is synchronous so the relative timing of sounds and motion can be determined precisely (Johnson & Tyack 2003).

A group of five animals were estimated to have received sound pressure levels of 183dB; visual observations showed that while the animals initially continued their initial course towards the DDG allowing them to receive higher levels on sonar, they ultimately reversed their course, dove and resurfaced behind the DDG in two groups (Martin and Manzano-Roth 2012). Audiograms of humpback whales are unavailable; however, it is reasonable to assume that humpback whales can hear MFAS. It is unknown whether the animals' course change was as a result of the approaching vessel or sonar transmissions. Additional analysis of monitoring data, including correlation of behaviors observed during focal follows, is underway (Martin and Manzano-Roth 2012).

Critical Habitat

Humpback whale critical habitat has not been designated.

4.2.5 Sei Whale

Sei whales (pronounced "say" or "sigh"; *Balaenoptera borealis*) are members of the baleen whale family and are considered one of the "great whales" or rorquals. Two subspecies of sei whales are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere.

These large animals can reach lengths of about 40-60 ft (12-18 m) and weigh 100,000 lbs (45,000 kg). Females may be slightly longer than males. Sei whales have a long, sleek body that is dark bluish-gray to black in color and pale underneath. The body is often covered in oval-shaped scars (probably caused from cookie-cutter shark and lamprey bites) and sometimes has subtle "mottling". This species has an erect "falcate", "dorsal" fin located far down (about two-thirds) the animals back. They often look similar in appearance to Bryde's whales, but can be distinguished by the presence of a single ridge located on the animal's "rostrum". Bryde's whales, unlike other rorquals, have three distinct prominent longitudinal ridges on their rostrum. Sei whales have 219-410 baleen plates that are dark in color with gray/white fine inner fringes in their enormous mouths. They also have 30-65 relatively short ventral pleats that extend from below the mouth to the naval area. The number of throat grooves and baleen plates may differ depending on geographic population.

The Sei is regarded as the fastest swimmer among the great whales, reaching bursts of speed in excess of 20 knots. When a sei whale begins a dive it usually submerges by sinking quietly below the surface, often remaining only a few meters deep, leaving a series of swirls or tracks as it move its flukes. When at the water's surface, sei whales can be sighted by a columnar or bushy blow that is about 10-13 feet (3-4 m) in height. The dorsal fin usually appears at the same time as the blowhole, when the animal surfaces to breathe. This species usually does not arch its back or raise its flukes when diving.

Sei whales become sexually mature at 6-12 years of age when they reach about 45 ft (13 m) in length, and generally mate and give birth during the winter in lower latitudes. Females breed every 2-3 years, with a gestation period of 11-13 months. Females give birth to a single calf that is about 15 ft (4.6 m) long and weighs about 1,500 lbs (680 kg). Calves are usually nursed for 6-9 months before being weaned on the preferred feeding grounds. Sei whales have an estimated lifespan of 50-70 years.

Distribution

The sei whale occurs in all oceans of the world except the Arctic. The migratory pattern of this species is thought to encompass long distances from high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999a). Sei whales are often associated with deeper waters and areas along continental shelf edges (Hain et al. 1985). This general offshore pattern is disrupted during occasional incursions into shallower inshore waters (Waring et al. 2004). The species appears to lack a well-defined social structure and individuals are usually found alone or in small groups of up to six whales (Perry et al. 1999a). When on feeding grounds, larger groupings have been observed (Gambell 1985c).

In the western Atlantic Ocean, sei whales occur from Nova Scotia and Labrador in the summer months and migrate south to Florida, the Gulf of Mexico, and the northern Caribbean (Gambell 1985c). In the eastern Atlantic Ocean, sei whales occur in the Norwegian Sea (as far north as Finnmark in northeastern Norway), occasionally occurring as far north as Spitsbergen Island, and migrate south to Spain, Portugal, and northwest Africa (Gambell 1985c).

In the North Pacific Ocean, sei whales occur from the Bering Sea south to California (on the east) and the coasts of Japan and Korea (on the west). During the winter, sei whales are found from 20°-23°N (Gambell 1985c; Masaki 1977). Sasaki et al. (Saski et al. 2013) demonstrated that sei whale in the North Pacific are strongly correlated with sea surface temperatures between 13.1-16.8 degrees C. Sei whales have been seen in monitoring efforts in Hawaii in 2007 and in 2010.

Sei whales occur throughout the Southern Ocean during the summer months, although they do not migrate as far south to feed as blue or fin whales. During the austral winter, sei whales occur off Brazil and the western and eastern coasts of Southern Africa and Australia.

Population Structure

The population structure of sei whales is not well defined, but presumed to be discrete by ocean basin (north and south), except for sei whales in the Southern Ocean, which may form a ubiquitous population or several discrete ones.

North Pacific. Some mark-recapture, catch distribution, and morphological research indicate more than one population may exist – one between 155°-175° W, and another east of 155° W (Masaki 1976; Masaki 1977). Sei whales have been reported primarily south of the Aleutian Islands, in Shelikof Strait and waters surrounding Kodiak Island, in the Gulf of Alaska, and inside waters of southeast Alaska and south to California to the east and Japan and Korea to the west (Leatherwood et al. 1982; Nasu 1974). Sightings have also occurred in Hawaiian waters. In Navy-funded surveys 2007-2012, there were three confirmed sighting of sei whales for a total of five individuals—all made from vessels (HDR 2012). Two sightings were documented northeast of Oahu in 2007 (Smultea et al. 2007), while the third was encountered near Perret Seamount west of the Island of Hawaii in 2010 (HDR 2012). Bottom depths for the sei whale sightings were from 3,100 to 4,500 m. Sightings were made during BSS 2-4. Smultea et al. (2010) noted that the lack of sightings of sei whales in the Hawaiian Islands may be due to misidentification and/or poor sighting conditions. Sei whales have been occasionally reported from the Bering Sea and in low numbers on the central Bering Sea shelf (Hill and DeMaster 1998). Whaling data suggest that sei whales do not venture north of about 55°N (Gregr et al. 2000). Masaki (1977) reported sei whales concentrating in the northern and western Bering Sea from July-September, although other researchers question these observations because no other surveys have reported sei whales in the northern and western Bering Sea. Harwood (1987) evaluated Japanese sighting data and concluded that sei whales rarely occur in the Bering Sea. Harwood (1987) reported that 75-85 percent of the North Pacific population resides east of 180°. During winter, sei whales are found from 20°-23° N (Gambell 1985c; Masaki 1977). Considering the many British Columbia whaling catches in the early to mid 1900s, sei whales have clearly utilized this area in the past (Gregr et al. 2000; Pike and Macaskie 1969). Masaki (1977) reported sei whales concentrating in the northern and western Bering Sea from July-September, although other researchers question these observations because no other surveys have reported sei whales in the northern and western Bering Sea. Harwood (1987) reported that 75-85 percent of the North Pacific population resides east of 180°. During winter, sei whales are found from 20°-23° N (Gambell 1985c; Masaki 1977). Sei whales appear to prefer to forage in regions of steep bathymetric relief, such as continental shelf breaks, canyons, or basins situated between banks and ledges (Best and Lockyer 2002; Gregr and Trites 2001; Kenney and Winn 1987), where local hydrographic features appear to help concentrate zooplankton, especially copepods. In their foraging areas, sei whales appear to associate with oceanic frontal systems (Horwood 1987). In the north Pacific, sei whales are found feeding particularly along the cold eastern currents (Perry et al. 1999a). Masaki (1977) presented sightings data on sei whales in the North Pacific from the mid-1960s to the early 1970s. Over that time interval sei whales did not appear to occur in waters of Washington State and southern British Columbia in May or June, their densities increased in those waters in July and August (1.9 - 2.4 and 0.7 - 0.9 whales per 100 miles of distance for July and August, respectively), then declined again in September. More recently, sei whales have become known for an irruptive migratory habit in which they appear in an area then disappear for time periods that can extend to decades. Sei whales are distributed in offshore waters in the Southern

California portion of the HSTT Study Area. There are records of sightings in California waters as early as May and June, but primarily are encountered there during July to September and leave California waters by mid-October. Aerial surveys conducted in October and November 2008 off the Southern California coast resulted in the sighting of one sei (or possibly fin) whale (Oleson and Hill 2009). The first verified sei whale sighting made nearshore of the main Hawaiian Islands occurred in 2007 (Smultea et al. 2010) and included the first subadults seen in the main Hawaiian islands. A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of three Bryde's/sei whales. An additional sighting occurred in 2010 of Perret Seamount (Navy 2011a). On March 18, 2011 off Maui, the Hawaiian Islands Entanglement Response Network found a subadult sei whale entangled in rope and fishing gear. An attempt to disentangle the whale was unsuccessful although a telemetry buoy attached to the entangled gear was reported to be tracking the whale over 21 days as it moved north and over 250 nm from the Hawaiian Islands.

Natural Threats

Andrews (1916) suggested that killer whales attacked sei whales less frequently than fin and blue whales in the same areas. Sei whales engage in a flight responses to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Endoparasitic helminths (worms) are commonly found in sei whales and can result in pathogenic effects when infestations occur in the liver and kidneys (Rice 1977).

Anthropogenic Threats

Human activities known to threaten sei whales include whaling, commercial fishing, and maritime vessel traffic. Historically, whaling represented the greatest threat to every population of sei whales and was ultimately responsible for listing sei whales as an endangered species. Sei whales are thought to not be widely hunted, although harvest for scientific whaling or illegal harvesting may occur in some areas.

Sei whales, because of their offshore distribution and relative scarcity in U.S. Atlantic and Pacific waters, probably have a lower incidence of entrapment and entanglement than fin whales. Data on entanglement and entrapment in non-U.S. waters are not reported systematically. Heyning and Lewis (1990) made a crude estimate of about 73 rorquals killed/year in the southern California offshore drift gillnet fishery during the 1980s. Some of these may have been fin whales instead of sei whales. Some balaenopterids, particularly fin whales, may also be taken in the drift gillnet fisheries for sharks and swordfish along the Pacific coast of Baja California, Mexico (Barlow et al. 1997b). Heyning and Lewis (1990) suggested that most whales killed by offshore fishing gear do not drift far enough to strand on beaches or to be detected floating in the nearshore corridor where most whale-watching and other types of boat traffic occur. Thus, the small amount of documentation may not mean that entanglement in fishing gear is an insignificant cause of mortality. Observer coverage in the Pacific offshore fisheries has been too low for any confident assessment of species-specific entanglement rates (Barlow et al. 1997b).

The offshore drift gillnet fishery is the only fishery that is likely to take sei whales from this stock, but no fishery mortalities or serious injuries to sei whales have been observed. Sei whales, like other large whales, may break through or carry away fishing gear. Whales carrying gear may die later, become debilitated or seriously injured, or have normal functions impaired, but with no evidence recorded.

Sei whales are occasionally killed in collisions with vessels. Of three sei whales that stranded along the U.S. Atlantic coast between 1975 and 1996, two showed evidence of collisions (Laist et al. 2001). Between 1999 and 2005, there were three reports of sei whales being struck by vessels along the U.S. Atlantic coast and Canada's Maritime Provinces (Cole et al. 2005; Nelson et al. 2007). Two of these ship strikes were reported as having resulted in death. One sei whale was killed in a collision with a vessel off the coast of Washington in 2003 (Waring et al. 2009). New rules for seasonal (June through December) slowing of vessel traffic in the Bay of Fundy to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are predicted to reduce sei whale ship strike mortality by 17 percent.

Sei whales are known to accumulate DDT, DDE, and PCBs (Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983). Males carry larger burdens than females, as gestation and lactation transfer these toxins from mother to offspring.

Status and Trends

The sei whale was originally listed as endangered in 1970 (35 FR 18319), and this status remained since the inception of the ESA in 1973.

Ohsumi and Fukuda (1975) estimated that sei whales in the North Pacific numbered about 49,000 whales in 1963, had been reduced to 37,000-38,000 whales by 1967, and reduced again to 20,600-23,700 whales by 1973. From 1910-1975, approximately 74,215 sei whales were caught in the entire North Pacific Ocean (Harwood and Hembree. 1987; Perry et al. 1999a). From the early 1900s, Japanese whaling operations consisted of a large proportion of sei whales: 300-600 sei whales were killed per year from 1911-1955. The sei whale catch peaked in 1959, when 1,340 sei whales were killed. In 1971, after a decade of high sei whale catch numbers, sei whales were scarce in Japanese waters. Japanese and Soviet catches of sei whales in the North Pacific and Bering Sea increased from 260 whales in 1962 to over 4,500 in 1968-1969, after which the sei whale population declined rapidly (Mizroch et al. 1984). When commercial whaling for sei whales ended in 1974, the population in the North Pacific had been reduced to 7,260-12,620 animals (Tillman 1977). There have been no direct estimates of sei whale populations for the eastern Pacific Ocean (or the entire Pacific). Between 1991 and 2001, during aerial surveys, there were two confirmed sightings of sei whales along the U.S. Pacific coast.

Sei whales are known to occur in the Gulf of Alaska and as far north as the Bering Sea in the north Pacific. However, their distribution is poorly understood. The only stock estimate for U.S. waters is for the eastern north Pacific stock offshore California, Oregon and Washington (Carretta et al. 2009); abundance in Alaskan waters is unknown and they have not been sighted during recent surveys (Rone et al. 2010; Waite et al. 2003).

Diving

Generally, sei whales make 5-20 shallow dives of 20-30 sec duration followed by a deep dive of up to 15 min (Gambell 1985c). The depths of sei whale dives have not been studied; however the composition of their diet suggests that they do not perform dives in excess of 300 meters. Sei whales are usually found in small groups of up to 6 individuals, but they commonly form larger groupings when they are on feeding grounds (Gambell 1985c).

Social Behavior

Sei whales are primarily planktivorous, feeding mainly on euphausiids and copepods, although they are also known to consume fish (Waring et al. 2007). In the Northern Hemisphere, sei whales consume small schooling fish such as anchovies, sardines, and mackerel when locally abundant (Mizroch et al. 1984; Rice 1977). Sei whales in the North Pacific feed on euphausiids and copepods, which make up about 95 percent of their diets (Calkins 1986). The dominant food for sei whales off California during June-August is northern anchovy, while in September-October whales feed primarily on krill (Rice 1977). The balance of their diet consists of squid and schooling fish, including smelt, sand lance, Arctic cod, rockfish, pollack, capelin, and Atka mackerel (Nemoto and Kawamura 1977). In the Southern Ocean, analysis of stomach contents indicates sei whales consume Calanus spp. and small-sized euphasiids with prey composition showing latitudinal trends (Kawamura 1974). Evidence indicates that sei whales in the Southern Hemisphere reduce direct interspecific competition with blue and fin whales by consuming a wider variety of prey and by arriving later to feeding grounds (Kirkwood 1992). Rice (1977) suggested that the diverse diet of sei whales may allow them greater opportunity to take advantage of variable prey resources, but may also increase their potential for competition with commercial fisheries.

Little is known about the actual social system of these animals. Groups of 2-5 individuals are typically observed, but sometimes thousands may gather if food is abundant. However, these large aggregations may not be dependent on food supply alone, as they often occur during times of migration. Norwegian workers call the times of great sei whale abundance "invasion years." During mating season, males and females may form a social unit, but strong data on this issue are lacking.

Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100-600 Hz range with 1.5 s duration and tonal and upsweep calls in the

200-600 Hz range of 1-3 s durations (McDonald et al. 2005). Differences may exist in vocalizations between ocean basins (Rankin et al. 2009). Vocalizations from the North Atlantic consisted of paired sequences (0.5-0.8 sec, separated by 0.4-1.0 sec) of 10-20 short (4 msec) FM sweeps between 1.5-3.5 kHz (Richardson et al. 1995b).

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

Recordings made in the presence of sei whales have shown that they produce sounds ranging from short, mid-frequency pulse sequences (Knowlton et al., 1991; Thompson et al., 1979) to low frequency broadband calls characteristic of mysticetes (Baumgartner et al., 2008; McDonald et al., 2005; Rankin and Barlow, 2007). Off the coast of Nova Scotia, Canada, Knowlton et al. (1991) recorded two-phased calls lasting about 0.5–0.8 s and ranging in frequency from 1.5 to 3.5 kHz in the presence of sei whales—data similar to that reported by Thompson et al. (1979). These mid-frequency calls are distinctly different from low-frequency tonal and frequency swept calls recorded in later studies. For example, calls recorded in the Antarctic averaged 0.45 ± 0.3 s in duration at 433 ± 192 Hz, with a maximum source level of 156 ± 3.6 dB re 1 μPa-m (McDonald et al., 2005). During winter months off Hawaii, Rankin and Barlow (2007) recorded down swept calls by sei whales that exhibited two distinct low frequency ranges of 100 to –44 Hz and 39 to 21 Hz, with the former range usually shorter in duration. Similar sei whale calls were also found near the Gulf of Maine in the northwest Atlantic, ranging from 82.3 to 34.0 Hz and averaging 1.38 s in duration (Baumgartner et al., 2008). These calls were primarily single occurrences, but some double or triple calls were noted as well. It is thought that the difference in call frequency may be functional, with the mid-frequency type serving a reproductive purpose and the low frequency calls aiding in feeding/social communication (McDonald et al., 2005). Sei whales have also been shown to reduce their calling rates near the Gulf of Maine at night, presumably when feeding, and increase them during the day, likely for social activity (Baumgartner and Fratantoni, 2008). Off the Mariana Islands, Norris et al. (2012) recorded 32 sei whale calls, 25 of which were backed up by sightings. The peak mean frequency of these calls ranged from 890.6 to 1,046.9 Hz with a mean duration of 3.5 to 0.2 s.

While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing. In terms of functional hearing capability, sei whales belong to low-frequency cetaceans which have the best hearing ranging from 7 Hz to 22 kHz (Southall et al., 2007). There are no tests or modeling estimates of specific sei whale hearing ranges.

Critical Habitat

Sei whale critical habitat has not been designated.

4.2.6 Sperm Whale

Sperm whales (*Physeter macrocephalus*) are the largest of the odontocetes (toothed whales) and the most sexually dimorphic cetaceans, with males considerably larger than females. Adult females may grow to lengths of 36 feet (11 m) and weigh 15 tons (13,607 kg). Adult males, however, reach about 52 feet (16 m) and may weigh as much as 45 tons (40,823 kg).

The sperm whale is distinguished by its extremely large head, which takes up to 25 to 35 percent of its total body length. It is the only living cetacean that has a single blowhole asymmetrically situated on the left side of the head near the tip. Sperm whales have the largest brain of any animal (on average 17 pounds (7.8 kg) in mature males). However, compared to their large body size, the brain is not exceptional in size.

There are between 20-26 large conical teeth in each side of the lower jaw. The teeth in the upper jaw rarely erupt and are often considered to be vestigial. It appears that teeth may not be necessary for feeding, since they do not break through the gums until puberty, if at all, and healthy sperm whales have been caught that have no teeth.

Sperm whales are mostly dark gray, but oftentimes the interior of the mouth is bright white, and some whales have white patches on the belly. Their flippers are paddle-shaped and small compared to the size of the body, and their flukes are very triangular in shape. They have small dorsal fins that are low, thick, and usually rounded.

Distribution

Sperm whales are distributed in all of the world's oceans, from equatorial to polar waters, and are highly migratory. Mature males range between 70º N in the North Atlantic and 70º S in the Southern Ocean (Perry et al. 1999a; Reeves and Whitehead 1997), whereas mature females and immature individuals of both sexes are seldom found higher than 50º N or S (Reeves and Whitehead 1997). In winter, sperm whales migrate closer to equatorial waters (Kasuya and Miyashita 1988; Waring 1993) where adult males join them to breed.

Population Structure

There is no clear understanding of the global population structure of sperm whales (Dufault et al. 1999). Recent ocean-wide genetic studies indicate low, but statistically significant, genetic diversity and no clear geographic structure, but strong differentiation between social groups (Lyrholm and Gyllensten 1998; Lyrholm et al. 1996; Lyrholm et al. 1999). The IWC currently recognizes four sperm whale stocks: North Atlantic, North Pacific, northern Indian Ocean, and Southern Hemisphere (Dufault et al. 1999; Reeves and Whitehead 1997). The NMFS recognizes six stocks under the MMPA- three in the Atlantic/Gulf of Mexico and three in the Pacific (Alaska, California-Oregon-Washington, and Hawai′i; (Perry et al. 1999b; Waring et al. 2004). Genetic studies indicate that movements of both sexes through expanses of ocean basins are common, and that males, but not females, often breed in different ocean basins than the ones in

which they were born (Whitehead 2003a). Sperm whale populations appear to be structured socially, at the level of the clan, rather than geographically (Whitehead 2003a; Whitehead 2008).

Sperm whales are found throughout the North Pacific and are distributed broadly in tropical and temperate waters to the Bering Sea as far north as Cape Navarin in summer, and occur south of 40° N in winter (Gosho et al. 1984; Miyashita et al. 1995 as cited in Carretta et al. 2005; Rice 1974). Sperm whales are found year-round in Californian and Hawaiian waters (Barlow 1995; Dohl 1983; Forney et al. 1995c; Shallenberger 1981a). In the Hawaii portion of the study area there were 26 confirmed sperm whale sightings for a total of five individuals during Navy-funded surveys from 2006 to 2012 (HDR 2012). Five sightings were noted off the west coast of Kaua‘i and another confirmed sperm whale sighting was in the channel between Oahu and Kaua‘i. The remaining sperm whale sightings were made off the west coast of the island of Hawaii. Bottom depth for this sighting was between 800 and 4,600 m. Cetos (2005) reported on an acoustic detection, and an additional sighting of a probable sperm whale was reported for the Alenuihaha Channel area by Cetos (Smultea et al. 2007). In a Navy-funded survey in May 2011, a pod of 20 sperm whales with at least two calves was seen within the SOCAL Range Complex, approximately 30 miles from San Diego.

They are seen in every season except winter (December-February) in Washington and Oregon (Green et al. 1992). Summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993). In surveys of waters off Oregon and Washington conducted by Green et al. (1992), no sperm whales were encountered in waters less than 200 meters deep, 12 percent of the sperm whales were encountered in waters 200 to 2000 meters deep (the continental slope), and the remaining 88 percent of the sperm whales were encountered in waters greater than 2,000 meters deep. In surveys conducted by Forney and her co-workers (Forney 2007), sperm whales were reported from the Olympic Coast Slope transects (west of the Olympic Coast National Marine Sanctuary), but not from surveys conducted over the National Marine Sanctuary or the area immediately west of Cape Flattery. In May 2011, a pod of 20 sperm whales including two calves was sighted during aerial surveys approximately 44 km west of San Diego in waters 200-300 meters deep (Navy 2011).

Summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993) show that although sperm whales are widely distributed in the tropics, their relative abundance tapers off markedly towards the middle of the tropical Pacific and northward towards the tip of Baja California (Carretta et al. 2006). Sperm whales occupying the California Current region are genetically distinct from those in the eastern tropical Pacific and Hawaiian waters (Mesnick et al. 2011). The discreteness of the later two areas remains uncertain (Mesnick et al. 2011).

Off California, sperm whales are present in offshore waters year-round, with peak abundance from April to mid-June and again from late August through November (Barlow 1997b; Dohl et al. 1981; Dohl et al. 1983b; Gosho et al. 1984). The majority of sightings off central and northern

California were in waters deeper than 1,800 m (5,900 ft), but near the continental shelf edge (well offshore of the action area) (Dohl et al. 1983b). No sperm whales were observed during marine mammal monitoring projects in the action area (NSF 2012). However, Navy surveys have found sperm whales in the action area (Navy 2012).

Natural Threats

Sperm whales are known to be occasionally predated upon by killer whales (Jefferson et al. 1991; Pitman et al. 2001) by pilot whales (Arnbom et al. 1987; Palacios and Mate. 1996; Rice 1989; Weller et al. 1996; Whitehead et al. 1997) and large sharks (Best et al. 1984) and harassed by pilot whales (Arnbom et al. 1987; Palacios and Mate. 1996; Rice 1989; Weller et al. 1996; Whitehead et al. 1997). Strandings are also relatively common events, with one to dozens of individuals generally beaching themselves and dying during any single event. Although several hypotheses, such as navigation errors, illness, and anthropogenic stressors, have been proposed (Goold et al. 2002; Wright 2005), direct widespread causes remain unclear. Calcivirus and papillomavirus are known pathogens of this species (Lambertsen et al. 1987; Smith and Latham 1978).

Anthropogenic Threats

Sperm whales historically faced severe depletion from commercial whaling operations. From 1800 to 1900, the IWC estimated that nearly 250,000 sperm whales were killed by whalers, with another 700,000 from 1910 to 1982 (IWC Statistics 1959-1983). However, other estimates have included 436,000 individuals killed between 1800-1987 (Carretta et al. 2005). However, all of these estimates are likely underestimates due to illegal killings and inaccurate reporting by Soviet whaling Fleets between 1947 and 1973. In the Southern Hemisphere, these whalers killed an estimated 100,000 whales that they did not report to the IWC (Yablokov et al. 1998), with smaller harvests in the Northern Hemisphere, primarily the North Pacific, that extirpated sperm whales from large areas (Yablokov 2000). Additionally, Soviet whalers disproportionately killed adult females in any reproductive condition (pregnant or lactating) as well as immature sperm whales of either gender.

Hill and DeMaster (1999) concluded that about 258,000 sperm whales were harvested in the North Pacific between 1947 and 1987. Although the IWC protected sperm whales from commercial harvest in 1981, Japanese whalers continued to hunt sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). Following a moratorium on whaling by the International Whaling Commission, significant whaling pressures on sperm whales were eliminated. However, sperm whales are known to have become entangled in commercial fishing gear and 17 individuals are known to have been struck by vessels (Jensen and Silber 2004b). Whale-watching vessels are known to influence sperm whale behavior (Richter et al. 2006).

Based on reports from 2000 to 2010, a total of two sperm whales were entangled in fishing gear off California, both of which were reported within the Southern California Bight (Saez et al.

2013). Available data from NMFS indicate that in waters off California between 1991 and 2010, there was one ship strike involving a sperm whale (National Marine Fisheries Service Southwest Region Stranding Database 2011).

Interactions between sperm whales and longline fisheries in the Gulf of Alaska have been reported since 1995 and are increasing in frequency (Hill and DeMaster 1998; Hill et al. 1999; Rice 1989). Between 2002 and 2006, there were three observed serious injuries (considered mortalities) to sperm whales in the Gulf of Alaska from the sablefish longline fishery (Angliss and Outlaw 2008). Sperm whales have also been observed in Gulf of Alaska feeding off longline gear (for sablefish and halibut) at 38 of the surveyed stations (Angliss and Outlaw 2008). Recent findings suggest sperm whales in Alaska may have learned that fishing vessel propeller cavitations (as gear is retrieved) are an indicator that longline gear with fish is present as a predation opportunity (Thode et al. 2007).

Contaminants have been identified in sperm whales, but vary widely in concentration based upon life history and geographic location, with northern hemisphere individuals generally carrying higher burdens (Evans et al. 2004). Contaminants include dieldrin, chlordane, DDT, DDE, PCBs, HCB and HCHs in a variety of body tissues (Aguilar 1983; Evans et al. 2004), as well as several heavy metals (Law et al. 1996). However, unlike other marine mammals, females appear to bioaccumulate toxins at greater levels than males, which may be related to possible dietary differences between females who remain at relatively low latitudes compared to more migratory males (Aguilar 1983; Wise et al. 2009). Chromium levels from sperm whales skin samples worldwide have varied from undetectable to 122.6 μg Cr/g tissue, with the mean (8.8 μg Cr/g tissue) resembling levels found in human lung tissue with chromium-induced cancer (Wise et al. 2009). Older or larger individuals did not appear to accumulate chromium at higher levels.

Status and Trends

Sperm whales were originally listed as endangered in 1970 (35 FR 18319), and this status remained with the inception of the ESA in 1973. Although population structure of sperm whales is unknown, several studies and estimates of abundance are available. Sperm whale populations probably are undergoing the dynamics of small population sizes, which is a threat in and of itself. In particular, the loss of sperm whales to directed Soviet whaling likely inhibits recovery due to the loss of adult females and their calves, leaving sizeable gaps in demographic and age structuring (Whitehead and Mesnick 2003).

There are approximately 76,803 sperm whales in the eastern tropical Pacific, eastern North Pacific, Hawaii, and western North Pacific (Whitehead 2002a). Minimum estimates in the eastern North Pacific are 1,719 individuals and 5,531 in the Hawaiian Islands (Carretta et al. 2007). The tropical Pacific is home to approximately 26,053 sperm whales and the western North Pacific has approximately 29,674 (Whitehead 2002a). There was a dramatic decline in the number of females around the Galapagos Islands during 1985-1999 versus 1978-1992 levels,

likely due to migration to nearshore waters of South and Central America (Whitehead and Mesnick 2003). The current best available estimate of abundance for the California, Oregon, and Washington stock is 971 (coefficient of variation = 0.31) (Carretta et al. 2010). The current best available abundance estimate for the Hawaiian stock of sperm whales is 6,919 (coefficient of variation = 0.81) (Barlow 2003, Carretta et al. 2010). Sperm whales within the northern-most portion of the HSTT area are estimated at 26,300 (Barlow and Taylor 2005).

Sperm whale abundance varied off California between 1979/80 and 1991 (Barlow 1994) and between 1991 and 2008 (Barlow and Forney 2007). The most recent estimate from 2008 is the lowest to date, in sharp contrast to the highest abundance estimates obtained from 2001 and 2005 surveys. There is no reason to believe that the population has declined; the most recent survey estimate likely reflects interannual variability in the study area. To date, there has not been a statistical analysis to detect trends in abundance (Carretta et al. 2013).

Hill and DeMaster (1999) concluded that about 258,000 sperm whales were harvested in the North Pacific between 1947-1987. Although the IWC protected sperm whales from commercial harvest in 1981, Japanese whalers continued to hunt sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). In 2000, the Japanese Whaling Association announced plans to kill 10 sperm whales in the Pacific Ocean for research. Although consequences of these deaths are unclear, the paucity of population data, uncertainly regarding recovery from whaling, and re-establishment of active programs for whale harvesting pose risks for the recovery and survival of this species. Sperm whales are also hunted for subsistence purposes by whalers from Lamalera, Indonesia, where a traditional whaling industry has been reported to kill up to 56 sperm whales per year.

Diving

Sperm whales are probably the deepest and longest diving mammalian species, with dives to 3 km down and durations in excess of 2 hours (Clarke 1976; Watkins 1985; Watkins et al. 1993). However, dives are generally shorter (25- 45 min) and shallower (400-1,000 m). Dives are separated by 8-11 min rests at the surface (Gordon 1987; Watwood et al. 2006) (Jochens et al. 2006; Papastavrou et al. 1989). Sperm whales typically travel ~3 km horizontally and 0.5 km vertically during a foraging dive (Whitehead 2003a). Differences in night and day diving patterns are not known for this species, but, like most diving air-breathers for which there are data (rorquals, fur seals, and chinstrap penguins), sperm whales probably make relatively shallow dives at night when prey are closer to the surface.

Unlike other cetaceans, there is a preponderance of dive information for this species, most likely because it is the deepest diver of all cetacean species so generates a lot of interest. Sperm whales feed on large and medium-sized squid, octopus, rays and sharks, on or near the ocean floor (Clarke 1986; Whitehead 2002b). Some evidence suggests that they do not always dive to the bottom of the sea floor (likely if food is elsewhere in the water column), but that they do

generally feed at the bottom of the dive. Davis et al. (2007) report that dive-depths (100-500 m) of sperm whales in the Gulf of California overlapped with depth distributions (200-400 m) of jumbo squid, based on data from satellite-linked dive recorders placed on both species, particularly during daytime hours. Their research also showed that sperm whales foraged throughout a 24-hour period, and that they rarely dove to the sea floor bottom (>1000 m). The most consistent sperm whale dive type is U-shaped, during which the whale makes a rapid descent to the bottom of the dive, forages at various velocities while at depth (likely while chasing prey) and then ascends rapidly to the surface. There is some evidence that male sperm whales, feeding at higher latitudes during summer months, may forage at several depths including <200 m, and utilize different strategies depending on position in the water column (Teloni et al. 2007).

Social Behavior

Movement patterns of Pacific female and immature male groups appear to follow prey distribution and, although not random, movements are difficult to anticipate and are likely associated with feeding success, perception of the environment, and memory of optimal foraging areas (Whitehead 2008). However, no sperm whale in the Pacific has been known to travel to points over 5,000 km apart and only rarely have been known to move over 4,000 km within a time frame of several years. This means that although sperm whales do not appear to cross from eastern to western sides of the Pacific (or vice-versa), significant mixing occurs that can maintain genetic exchange. Movements of several hundred miles are common, (i.e. between the Galapagos Islands and the Pacific coastal Americas). Movements appear to be group or clan specific, with some groups traveling straighter courses than others over the course of several days. However, general transit speed averages about 4 km/h. Sperm whales in the Caribbean region appear to be much more restricted in their movements, with individuals repeatedly sighted within less than 160 km of previous sightings.

Gaskin (1973) proposed a northward population shift of sperm whales off New Zealand in the austral autumn based on reduction of available food species and probable temperature tolerances of calves.

Sperm whales have a strong preference for waters deeper than 1,000 m (Reeves and Whitehead 1997; Watkins and Schevill 1977), although Berzin (1971) reported that they are restricted to waters deeper than 300 m. While deep water is their typical habitat, sperm whales are rarely found in waters less than 300 m in depth (Clarke 1956; Rice 1989). Sperm whales have been observed near Long Island, New York, in water between 40-55 m deep (Scott and Sadove 1997).

Sperm whales are frequently found in locations of high productivity due to upwelling or steep underwater topography, such as continental slopes, seamounts, or canyon features (Jaquet 1996; Jaquet and Whitehead 1996). Cold-core eddy features are also attractive to sperm whales in the Gulf of Mexico, likely because of the large numbers of squid that are drawn to the high

concentrations of plankton associated with these features (Biggs et al. 2000; Davis et al. 2000; Davis et al. 2002). Surface waters with sharp horizontal thermal gradients, such as along the Gulf Stream in the Atlantic, may also be temporary feeding areas for sperm whales (Griffin 1999; Jaquet and Whitehead 1996; Waring et al. 1993). Sperm whales over George's Bank were associated with surface temperatures of 23.2-24.9°C (Waring et al. 2004).

Local information is inconsistent regarding sperm whale tendencies. Gregr and Trites (2001) reported that female sperm whales off British Columbia were relatively unaffected by the surrounding oceanography. However, Tynan et al. (2005) reported increased sperm whales densities with strong turbulence associated topographic features along the continental slope near Heceta Bank. Two noteworthy strandings in the region include an infamous incident (well publicized by the media) of attempts to dispose of a decomposed sperm whale carcass on an Oregon beach by using explosives. In addition, a mass stranding of 47 individuals in Oregon occurred during June 1979 (Norman et al. 2004a; Rice et al. 1986).

Stable, long-term associations among females form the core of sperm whale societies (Christal et al. 1998). Up to about a dozen females usually live in such groups, accompanied by their female and young male offspring. Young individuals are subject to alloparental care by members of either sex and may be suckled by non-maternal individuals (Gero et al. 2009). Group sizes may be smaller overall in the Caribbean Sea (6-12 individuals) versus the Pacific (25-30 individuals) (Jaquet and Gendron 2009). Males start leaving these family groups at about 6 years of age, after which they live in "bachelor schools," but this may occur more than a decade later (Pinela et al. 2009). The cohesion among males within a bachelor school declines with age. During their breeding prime and old age, male sperm whales are essentially solitary (Christal and Whitehead 1997).

Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Sperm whales produce broad-band clicks in the frequency range of 100 Hz to 20 kHz that can be extremely loud for a biological source (200-236 dB re 1μPa), although lower source level energy has been suggested at around 171 dB re 1 μPa (Goold and Jones 1995; Madsen et al. 2003; Weilgart and Whitehead 1997; Weilgart et al. 1993). Most of the energy in sperm whale clicks is concentrated at around 2-4 kHz and 10-16 kHz (Goold and Jones 1995; NMFS 2006; Weilgart et al. 1993). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Cranford 1992; Norris and Harvey. 1972). These long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). However, clicks are also used in short patterns (codas) during social behavior and intra-group interactions (Weilgart et al. 1993). They may also aid in intra-specific communication. Another class of sound, "squeals", are produced with frequencies of 100 Hz to 20 kHz (e.g., Weir et al. 2007).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5-60 kHz. However, behavioral responses of adult, free-ranging individuals also provide insight into hearing range; sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low-frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999b).

Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirrups, creaks, short trumpets, pips, squeals and clangs (Goold, 1999). Sperm whales typically produce short-duration repetitive broadband clicks with frequencies below 100 Hz to >30 kHz (Watkins, 1977; see Thomson and Richardson, 1995) and dominant frequencies between 1 to 6 kHz and 10 to 16 kHz. The source levels can reach 236 dB re 1 μPa-m (Møhl et al., 2003). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low-frequency (between 300 Hz and 1.7 kHz) with estimated source levels between 140 to 162 dB re 1 μPa-m (Madsen et al., 2003). Clicks are heard most frequently when sperm whales are engaged in diving and foraging behavior (Whitehead and Weilgart, 1991; Miller et al., 2004). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Miller et al., 2004; Laplanche et al., 2005).

When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill, 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Weilgart and Whitehead, 1997; Rendell and Whitehead, 2004). Recent research in the South Pacific suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al., 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects, similar to those of killer whales (Weilgart and Whitehead, 1997; Pavan et al., 2000). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean and those in the Pacific (Weilgart and Whitehead, 1997). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these include codas associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou, 2008).

Direct measures of sperm whale hearing have been conducted on a stranded neonate using the auditory brainstem response technique: the whale showed responses to pulses ranging from 2.5 to 60 kHz and highest sensitivity to frequencies between 5 to 20 kHz (Ridgway and Carder, 2001). Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten, 1992). The sperm whale may also possess better low-frequency hearing than other Odontocetes, although not as low as many baleen whales (Ketten, 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echo-sounders and submarine sonar (Watkins and Schevill, 1975; Watkins et al., 1985). In the Caribbean, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial noise generated by banging on a boat hull (Watkins et al,. 1985). André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely (André et al., 1997). Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re 1 μPa^2 between 250 Hz and 1.0 kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. The full range of functional hearing for the sperm whale is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al., 2007).

Sperm whales have been observed by marine mammal observers aboard Navy surface ships during training events and detected on the PMRF range hydrophones; however, MFAS was not active so no behavioral response data exists. (DoN, 2011).

Critical Habitat

Sperm whale critical habitat has not been designated.

4.2.7 Main Hawaiian Islands Insular False Killer Whale

Main Hawaiian Islands (MHI) Insular false killer whales (*Pseudorca crassidens*) are large members of the dolphin family. Females reach lengths of 15 feet (4.5 m), while males are almost 20 feet (6 m). In adulthood, false killer whales can weigh approximately 1,500 pounds (700 kg). They have a small conical head without a beak. Their dorsal fin is tall and their flippers (pectoral fins) have a distinctive hump or bulge in the middle of the front edge. False killer whales have dark coloration except for some lighter patches near the throat and middle chest. Their body shape is more slender than other large delphinids.

Distribution

The MHI insular false killer whale distinct population segment (DPS) occur near the main Hawaiian Islands. Distribution of MHI insular false killer whales has been assessed using data from visual surveys and satellite tag data. Tagging data from seven groups of individuals tagged off the islands of Hawaii and Oahu indicate that the whales move rapidly and semi-regularly throughout the main Hawaiian Islands and have been documented as far as 112 km offshore over a total range of 82,800 km^2 (Baird et al. 2012a; Baird et al. 2012b). Three high-use areas were identified: (1) off the north half of Hawaii Island, (2) north of Maui and Molokaʻi and (3) southwest of Lanaʻi (Baird et al. 2012a). However, note that limitations in the sampling, suggest the range of the population is likely underestimated, and there are probably other high-use areas that have not been identified. For example, a single satellite track suggests the potential for MHI insular false killer whales to use habitat around the Northwestern Hawaiian Islands, where a separate false killer whale DPS tends to occur (Baird et al. 2012a). Other MHI insular false killer whales tagged off of Kauaʻi circumnavigated Niʻihau and returned to the northwest side of the island of Kauaʻi.

Photo identification studies also document that the animals regularly use both leeward and windward sides of the islands (Baird et al. 2005; Baird et al. 2012a; Baird et al. 2010; Forney et al. 2010; Oleson et al. 2010). Some individual false killer whales tagged off the island of Hawaii have remained around that island for extended periods (days to weeks), but individuals from all tagged groups eventually were found broadly distributed throughout the main Hawaiian Islands (Baird 2009; Forney et al. 2010). Individuals utilize habitat over varying water depths < 50 m to > 4000 m (Baird et al. 2010). It has been hypothesized that interisland movements may depend on the density and movement patterns of their prey species (Baird 2009). Evidence from both tags and individual-identifying photography suggests that the area between Kauaʻi and Niʻihau near the Pacific Missile Range Facility (PMRF) is an area of range overlap between two or three stocks of false killer whales, once of which is the MHI insular stock. It appears that these waters may be at the far northwestern limit of that of the MHI insular stock and the southeastern limit of the Northwestern Hawaiian Islands stock and therefore it is a question how much the animals utilize this distal area near PMRF in proportion to the rest of their larger home range (DoN 2013). Two sightings made near PMRF during Navy monitoring were not from the MHI insular stock. The first was made by Navy monitoring observers between Niʻihau and Kaʻula of an adult male, adult female, and calf (DoN 2010), and when photographs were examined, the individuals did not match any identities in the MHI insular population catalog (Baird, pers. comm.). The second was in June 2012, when three individuals from a group of false killer whales were satellite-tagged. The tag data showed that the group subsequently left the area of PMRF, Niʻihau, and Kauaʻi after few days and travelled to Nihoa, Necker, French Frigate Shoals, and Gardner Pinnacles in the NWHI (Baird 2012). These two sightings comprise a sparse body of evidence that suggests the area between Kauaʻi and Niʻihau is visited by false killer whales from populations other than the MHI insular distinct population segment.

Population Structure

NMFS currently recognizes three stocks of false killer whale in Hawaiian waters: the Main Hawaiian Islands Insular, Hawaii pelagic, and the Northwestern Hawaiian Islands stock (Bradford et al. 2012a; Carretta et al. 2011) (77 FR 70915). NMFS considers all false killer whales found within 40 km (22 nm) of the Main Hawaiian Islands as belonging to the Insular stock and all false killer whales beyond 140 km (76 nm) as belonging to the Pelagic Stock (77 FR 70915). The animals belonging to the Northwest Hawaiian Islands stock are Insular to the Northwest Hawaiian Islands (Bradford et al., 2012), however, this stock was identified by animals encountered off Kaua‘i. It has been previously recognized that the ranges for the two stocks (pelagic and Insular) overlap by 100 km (Bradford et al. 2012a; Carretta et al. 2011), but there is in addition, also overlap between all three stocks given these presently identified ranges.

The MHI insular false killer whale DPS is considered resident to the main Hawaiian Islands and is genetically and behaviorally distinct compared to other stocks (77 FR 70915). Genetic data suggest little immigration into the MHI insular false killer whale population (Baird et al. 2012a). However, because data on ecological relationships among false killer whale groups in the region are uncertain,additional data are being collected to identify whether other false killer whale groups in the Hawaiian Islands should also be considered part of the MHI insular false killer whale DPS (77 FR 70915).

Threats to Species

Natural Threats. Reduced genetic diversity may be a natural, but partially anthropogenically induced factor leading to MHI insular false killer whale decline (Wearmouth and Sims 2008). Only a single instance of depredation on false killer whales has been documented, where killer whales attacked, killed, and consumed a false killer whale calf off New Zealand (Heithaus 2001; Visser et al. 2010). Parasitic infections have risen to levels thought to contribute to the deaths of some false killer whales, but these were from stranded individuals and it is unknown whether other health issues allowed for unhealthy levels of parasitism to develop (Andrade et al. 2001; Hernandez-Garcia 2002; Morimitsu et al. 1987; Odell et al. 1980; Sedlak-Weinstein 1991; Stacey et al. 1994; Zylber et al. 2002).

Various parasites have been documented in tissues of false killer whales, including nematodes (e.g., *Anisakis simplex, Stenurus globicephalae*), trematodes (e.g., *Nasitrema globicephalae*), acanthocephalans (e.g., *Bolbosoma capitatum*), amphipods (e.g., *Isocyamus delphinii, Syncyamus aequus, Syncyamus pseudorcae*) and crustaceans (e.g., *Xenobalanus globicipitus*) (Andrade et al. 2001; Hernandez-Garcia 2002; Sedlak-Weinstein 1991; Stacey et al. 1994; Zylber et al. 2002). In some cases, parasitic infections have been implicated as contributing to false killer whale strandings. For example, following two mass stranding events that occurred along the coasts of Japan and Florida, tissues of false killer whales were examined for parasites (Morimitsu et al. 1987; Odell et al. 1980). In both studies, evidence of parasitic infections (e.g., *Stenurus globicephalus, Nasitrema gondo*) were noted in the lungs, pterygoid sinus complexes,

and tympanic cavities of the whales, and the authors postulated that these infections most likely contributed to the demise of the animals. Currently, no information is available on parasitism in Hawai‘i Insular false killer whales.

Anthropogenic Threats. Several threats have been identified that may have or continue to lead to the decline of MHI insular false killer whales. These include incidental interactions with commercial and recreational fisheries and aquaculture facilities, prey availability, vessel traffic, anthropogenic noise, small populations effects, disease and predation, parasitism, environmental contaminants, harmful algal blooms, and ocean acidification and climate change (Oleson et al. 2010). False killer whales in Hawaiian waters have been seen to take catches from longline and trolling lines (Nitta and Henderson 1993; Shallenberger et al. 1981). Interactions with longline and troll fishery operations appear to result in disfigurement to dorsal fins, with roughly 4 percent of the population showing this injury, as well as entanglement and hooking (Baird and Gorgone 2005; Forney and Kobayashi. 2007; McCracken and Forney 2010; Nitta and Henderson 1993; Shallenberger et al. 1981; Zimmerman 1983). Carretta et al. (2009) estimated that 7.4 individuals per year are killed or seriously injured during the course of fishing operations in the Hawaiian EEZ. In this area, false killer whales are the most frequently hooked or entangled cetacean species, with most interactions occurring in tuna-targeting longline operations (Forney and Kobayashi. 2007; McCracken and Forney 2010). In total, 31 observations of serious injury or mortality have been documented from 1994-2008, which has led to an estimated 13 false killer whales killed or seriously injured throughout the Hawaiian longline fishery (Forney and Kobayashi. 2007; McCracken and Forney 2010). It is noteworthy that most interactions occurred well beyond the range known for main Hawaiian Island Insular False killer whales (0.6 were estimated to have been killed or seriously injured from 2003-2008) (McCracken and Forney 2010). In addition, false killer whales depredate on catches from shortline fisheries at least off northern Maui, with deliberate shootings occurring in some cases (Nitta and Henderson 1993; NMFS 2009a; Schlais 1985; TEC 2009). In January 2010, NMFS established a Take Reduction Team to address the incidental mortality and serious injury of false killer whales in the Hawaii-based deep-set and shallow-set longline fisheries. In November 2012, NMFS published the False Killer Whale Take Reduction Plan, which included regulatory measures and non-regulatory measures and recommendations to reduce mortalities and serious injuries of false killer whales in Hawaii-based longline fisheries (77 FR 71259).

Overfishing of some pelagic fishes, including bigeye and yellowfin tuna, may be adversely affecting MHI insular false killer whales. Catch weights for mahimahi have also declined since 1987 (NMFS 2009b). These changes may limit the prey quantity or quality available for false killer whales.

Bioaccumulation particularly of organic contaminants may be more of a concern for false killer whales than for many other cetaceans due to the high trophic level at which false killer whales

feed. The only available study of false killer whale contaminant burden found PCBs and DDT present, with adult females carrying lower burdens than subadults or adult males (likely due to contaminants being unloaded into fetuses and milk during lactation) (Aguilar and Borrell 1994; Krahn et al. 2009; Ylitalo et al. 2009). PCB levels were high enough that biological effects would be experienced in other mammals (Kannan et al. 2000). Persistent organic pollutant levels are similar between false killer whales sampled in Taiwan and Japan, but smaller (some much smaller) than samples from British Columbia (Chou et al. 2004; Haraguchi et al. 2006; Ylitalo et al. 2009). Although these pollutants are believed to typically be sequestered in blubber, individuals undergoing metabolic stress mobilize fat tissue, resulting in pollutants being mobilized into other body tissues (Aguilar et al. 1999). False killer whales from Australia and Japan have been found to have relatively high body burdens of mercury, lead and cadmium (Endo et al. 2010; Kemper et al. 1994).

Status

Reeves et al. (Reeves et al. 2009a) summarized information on false killer whale sightings near Hawaii between 1989 and 2007, based on various survey methods, and suggested that the MHI stock of false killer whales may have declined during the last two decades. More recently, Baird (Baird 2009) reviewed trends in sighting rates of false killer whales from aerial surveys conducted using consistent methodology around the main Hawaiian Islands between 1994 and 2003 (Mobley Jr 2001; Mobley Jr. 2003; Mobley Jr. 2004; Mobley Jr. 2005). Sighting rates during these surveys exhibited a statistically significant decline that could not be attributed to any weather or methodological changes. Reanalysis of previously published abundance estimates for the Insular stock has led to them generally being discounted (77 FR 70915).

The recent Status Review of Hawaiian Insular false killer whales (Oleson et al. 2010) presented a quantitative analysis of extinction risk using a Population Viability Analysis (PVA). The modeling exercise was conducted to evaluate the probability of actual or near extinction, defined as fewer than 20 animals, given measured, estimated, or inferred information on population size and trends, and varying impacts of catastrophes, environmental stochasticity and Allee effects. A variety of alternative scenarios were evaluated, with all plausible models indicating the probability of decline to fewer than 20 animals within 75 years as greater than 20 percent. Though causation was not evaluated, all models indicated current declines at an average rate of -9 percent since 1989 (95 percent probability intervals -5 percent to -12.5 percent)(Oleson et al. 2010).

The minimum population estimate for the Hawaii Insular stock of false killer whales is the number of distinct individuals identified during the 2008-2011 photo-identification studies, which is 129 false killer whales (Baird, Hawaii insular false killer whale catalog; Carretta et al., 2012a). No data are available on current or maximum net productivity rate for this stock. NMFS

listed the main Hawaiian Island Insular population of false killer whales as an endangered distinct population segment (DPS) under the ESA (77 FR 70915).

Diving and Social Behavior

False killer whale group sizes can vary widely. False killer whale groups can consist of multiple dispersed subgroups, and total group size may be underestimated if encounter duration is insufficient (Baird et al. 2008). Larger dispersed aggregations of false killer whales have been noted during surveys (Baird 2009; Carretta et al. 2007; Reeves et al. 2009b; Wade and Gerrodette 1993) that can move in a coordinated fashion (Baird et al. 2008). Main Hawaiian Island Insular False killer whales form strong long-term bonds (Baird et al. 2008)

Diving is not well-known in false killer whales, but individuals are believed capable of reaching 500 m in depth and possibly 700 m (Cummings and Fish 1971; Wearmouth and Sims 2008). However, most dives are significantly shallower. False killer whales occasionally dive to 150 m (apart from the possible 700 m dive), with frequent dives to 5-20 m during daytime and 30-40 m during nighttime, with durations for nighttime dives running 6-7 minutes (Wearmouth and Sims 2008). Some prey, such as mahimahi, occur most prevalently in the top 100 m of the water column, while others, such as tuna and swordfish, may occur down to several hundred meters (Boggs 1992; Carey and Robinson 1981).

Vocalization and Hearing

Functional hearing in mid-frequency cetaceans, including MHI insular false killer whales, is conservatively estimated to be between approximately 150 Hz and 160 kHz (Southall et al. 2007b). There are three categories of sounds that odontocetes make. The first includes echolocation sounds of high intensity, high frequency, high repetition rate, and very short duration (Au et al., 2000). The second category of odontocete sounds is comprised of pulsed sounds. Burst pulses are generally very complex and fast, with frequency components sometimes above 100 kHz and average repetition rates of 300 per second (Yuen et al. 2007).

The final category of odontocete sounds is the narrowband, low frequency, tonal whistles (Au et al. 2000b; Caldwell et al. 1990). With most of their energy below 20 kHz, whistles have been observed with an extensive variety of frequency patterns, durations, and source levels, each of which can be repeated or combined into more complex phrases (Tyack and Clark 2000a; Yuen et al. 2007).

In general, odontocetes produce sounds across the widest band of frequencies. Their social vocalizations range from a few hundreds of hertz (Hz) to tens of kilohertz (kHz) (Southall et al. 2007b) with source levels in the range of 100–170 dB re 1 µPa (see (Richardson et al. 1995b). They also generate specialized clicks used in echolocation at frequencies above 100 kHz that are used to detect, localize and characterize underwater objects such as prey (Au et al. 1993).

Echolocation clicks have source levels that can be as high as 229 dB re 1 µPa peak-to-peak (Au et al. 1974).

Nachtigall and Supin (2008) investigated the signals from an echolocating false killer whale and found that the majority of clicks had a single-lobed structure with peak energy between 20 and 80 kHz false rather than dual-lobed clicks, as has been demonstrated in the bottlenose dolphin. Navy researchers measured the hearing of a false killer whale and demonstrated the ability of this species to change its hearing during echolocation (Nachtigall and Supin. 2008). They found that there are at least three mechanisms of automatic gain control in odontocete echolocation, suggesting that echolocation and hearing are a very dynamic process (Nachtigall and Supin. 2008). For instance, false killer whales change the focus of the echolocation beam based on the difficulty of the task and the distance to the target. The echo from an outgoing signal can change by as much as 40 dB, but the departing and returning signal are the same strength entering the brain (Nachtigall and Supin. 2008) . The Navy demonstrated that with a warning signal, the false killer whale can adjust hearing by 15 dB prior to sound exposure (Nachtigall and Supin. 2008).

Critical Habitat. NMFS has not designated critical habitat for Main Hawaiian Islands Insular false killer whale.

4.2.8 Guadalupe Fur Seal

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

Distribution

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

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

Population Structure
All Guadalupe fur seals represent a single population.

Natural Threats
Although currently protected from commercial harvest, natural genetic factors are seen as a significant threat to the continued survival of this species. Because few individuals remained after commercial hunting, relatively low genetic diversity means that remaining individuals tend to be more susceptible to disease and inbreeding effects over subsequent generations (Bernardi et al. 1998; Weber et al. 2004). Sharks are known to prey upon Guadalupe fur seals, although mortality level is unknown (Gallo-Reynosa 1992).

Anthropogenic Threats
Due to small population size, this species is highly-susceptible to extinction risk by relatively small mortalities. Guadalupe fur seals have been found stranded with fish hooks and other evidence of fishing gear interaction along the California coast (Hanni et al. 1997).

Status and Trends
Guadalupe fur seals were listed as threatened under the ESA on December 16, 1985 (50 FR 51252). Guadalupe fur seals were hunted to near extinction by the late 1800s, with pre-harvest population estimates of 20,000 to 100,000 individuals. By 1897, the Guadalupe fur seal was believed to be extinct until a small population was found on Guadalupe Island in 1926. The most recent estimate is 7,400 animals in 1993 with a population growth rate of 13.7 percent per year (Carretta et al. 2002). The number of individuals on the San Benito Islands appear to be increasing rapidly, with over 2,000 individuals counted in 2008 and is undergoing an exponential increase in population sizes, likely due to immigration from Guadalupe Island (Aurioles-Gamboa et al. 2010).

Diving
The mean dive depth of Guadalupe fur seal lactating females is 55 feet, with a mean dive duration of 2.6 minutes. Mean surface interval between dives was two minutes. Dives were organized as outings lasting 2.5 hours. Foraging occurred during the night and transit during the day, with a maximum of 168 dives per day. Generally diving occurred at night, between eight in the evening and five in the morning (Croll et al. 199**9**c). Little is known about Guadalupe fur seal behavior during non-breeding season. They appear to spend long periods foraging at shallow depths during this time, but little information is known on their distribution at sea (Belcher and T.E. Lee 2002).

Vocalization and Hearing
Pinnipeds produce sounds both in air and water that range in frequency from approximately 100 Hz to several tens of kHz and it is believed that these sounds serve social functions such as mother-pup recognition and reproduction. Source levels for pinniped vocalizations range from approximately 95–190 dB re 1 μPa (see Richardson et al. 1995).

Underwater hearing in otariid seals is adapted to low frequency sound and less auditory bandwidth than phocid seals. Hearing in otariid seals has been tested in two species present in the Study Area: California sea lion (Kastak and Schusterman 1998) and northern fur seal (Babushina et al. 1991; Moore and Schusterman 1987). Based on these studies, Guadalupe fur seals would be expected to hear sounds within the ranges of 50 Hz–75 kHz in air and 50 Hz–50 kHz in water.

Critical Habitat

NMFS has not designated critical habitat for Guadalupe fur seals.

4.2.9 Hawaiian Monk Seal

The Hawaiian monk seal has a silvery-grey colored back with lighter creamy coloration on the underside; newborns are black. Additional light patches and red and green tinged coloration from attached algae are common. The back of the animals may become darker with age, especially in males. Adults generally range in size from 375 lbs-450 lbs (170-205 kg); females are slightly larger than males; pups are 35 lbs (16 kg) at birth. Monk seals grow to 7.0-7.5 feet (2.1-2.3 m) in length with females being slightly larger than males; pups are 3 feet (1 m) at birth. The lifespan is estimated at 25-30 years.

Distribution

The Hawaiian monk seal is found primarily on the Northwestern Hawaiian Islands, especially Nihoa, Necker, French Frigate Shoals, Pearl and Hermes Reef, Kure Atoll, Laysan, and Lisianski. Sightings on the main Hawaiian Islands have become more common in the past 15 years and monk seals have been born on the Islands of Kaua‘i, Moloka‘i, Ni‘ihau, and Oahu (Carretta et al. 2005; Johanos and Baker. 2004; Kenyon 1981). Midway was an important breeding rookery, but is now used by a small number of monk seals (Reeves et al. 1992). Hawaiian monk seals breed primarily at Laysan Island, Lisianski Island, and Pearl and Hermes Reefs (Tomich 1986). Monk seals have been reported on at least three occasions at Johnston Island over the past 30 years (not counting nine adult males that were translocated there from Laysan Island in 1984).

During Navy-funded marine mammal surveys 2007-2012, there were 41 sightings of Hawaiian monk seals for a total of 58 individuals on (or near) Kaua‘i, Ka‘ula, Ni‘ihau, Oahu, and Moloka‘i (Table 26)(HDR 2012). Forty-seven (81 percent) individuals were seen during aerial surveys, and eleven (19 percent) during vessel surveys. Monk seals were most frequently observed at Ni‘ihau. Fifty-two (88 percent) individual seals were observed hauled out, and six (10 percent) were in the water as deep as 800m. In addition, six seals were observed on the ledges of Kaula Islet during an aerial survey in 2013 (Normandeau Associates 2013).

Table 26. Hawaiian Monk Seal sightings during Navy-funded surveys 2007-2012 (From HDR 2012).

Location	Total # of Animals Observed	Total # of Groups	X̄ Group Size (SD)
Kaua‘i	11	10	1.1 (0.32)
Ka‘ula	8*	2	4.0 (1.41)
Moloka‘i	2	1	2.0
Ni‘ihau	31	23	1.4 (0.78)
In-water	6	5	1.2 (0.45)
Total	**58**	**41**	**1.41**

** In addition, six seals were observed on the ledges of Kaula Islet during an aerial survey in 2013 (Normandeau Associates. August 2013. Aerial Survey of Seabirds and Marine Mammals at Ka`ula Island, Hawai`i- Spring 2013. Prepared for U.S.Pacific Fleet under NAVFACPAC contract N62742-13-F-1872)*

The distribution, destinations, routes, food sources, and causes of monk seal movements when they are not traveling between islands are not well known (Johnson and Johnson 1979), but recent tagging studies have shown individuals sometimes travel between the breeding populations in the Northwest Hawaiian Islands. Based on one study, on average, 10 to 15 percent of the monk seals migrate among the northwestern Hawaiian Islands and the main Hawaiian Islands (Carretta et al. 2010a). Another source suggests that 35.6 percent of the main Hawaiian Island seals travel between islands throughout the year (Littnan 2011).

Navy-funded tagging studies in the main Hawaiian Islands demonstrate that mean foraging trip distance and duration, as well as maximum dive depth are similar between seals (Littnan and Wilson 2011). However, there were multiple outlying data points for all seals which varied by individual home ranges. Excluding one seal (R012) extended pelagic foraging trip, none of the seals traveled more than 300 km per trip and most traveled less than 50 km and remained within the 600 m depth contour near the MHI. The mean dive depth was 27.03 ± 44.97 m with a maximum of 529.4 m and a median depth of 14.4 m. The average dive duration was 5.006 ± 3.10 min with a median of 5.07 min with 28 percent of the time between dives was spent at the surface. Although foraging trip distances and durations were similar among seals, there were high levels of individual variation in where the seals travelled (Wilson and D’Amico 2012). Based on the activity budgets obtained by the tags, more accurate information is now known for modeling and estimation purposes for the percentage of time seals spend in the water and what the likely proportion of the monk seal is in the water at any given time.

Population Structure

Hawaiian monk seals appear to exist as a single population that occurs in the Northwest Hawaiian Islands and main Hawaiian Islands. However, groups of individuals that occupy specific islands or atolls in the Hawaiian Archipelago are treated as sub-populations for the purposes of research and management activity.

Pearl and Hermes Reef, the Midway Islands, and Kure Atoll form the three westernmost sub-populations of Hawaiian monk seals. There is a higher degree of migration among these sub-populations than among the sub-populations that occupy Laysan, Lisianski and French Frigate Shoals, which are more isolated. As a result, population growth in the westernmost sub-populations can be influenced more by immigration than by intrinsic growth. Several recent cohorts (groups of individuals born in the same year) at all three sites indicate that survival of juveniles has declined.

Threats to the Species

Natural Threats. Monk seals are threatened by natural predation, disease outbreaks, biotoxins, and agonistic behavior by male monk seals (NMFS 2011a). Monk seals, particularly pups, are also subjected to extensive predation by sharks, which appear to be a particular problem for the monk seals occupying French Frigate Shoals in the Northwest Hawaiian Islands Islands (Antonelis et al. 2006). Monk seal remains have been found in the stomachs of both tiger and Galapagos sharks. Sharks predation has increased significantly in the Northwest Hawaiian Islands, particularly French Frigate Shoals.

Hawaiian monk seals appear to be threatened by the spread of infectious diseases, including leptospirosis, toxoplasmosis, and West Nile virus, although domestic animals and humans may be vectors for these diseases (which would make them anthropogenic rather than natural threats). The absence of antibodies to these diseases in monk seals would make them extremely vulnerable to infection. Biotoxins such as ciguatera can cause mortality in phocids, but its role in mortality of monk seals was implicated and not confirmed, remaining unclear due to the lack of assays for testing tissues and the lack of epidemiological data on the distribution of toxin in monk seal prey.

The primary cause of adult female mortality affecting the recovery in the monk seal population during the 1980s and early 1990s was injury and death of female monk seals caused by "mobbing" attacks initiated by male monk seals. Although NMFS has developed and implemented measures to mitigate the effects of mobbing attacks, they are still considered a serious threat to Hawaiian monk seals. In recent years, low juvenile survival, in part due to food limitation, has been evident at all subpopulations of Hawaiian monk seals in the Northwest Hawaiian Islands. Nevertheless, the death of adult and immature females that resulted from this behavior would reduce the total number of breeding females and the recruitment of immature females into the adult, breeding population. Fewer breeding adults would produce fewer pups

which, by itself, would increase the population's rate of decline; when coupled with reductions in the survival probability of pups, it would create a feedback loop that would tend to cause the population to decline.

One of the most substantial threats to Hawaiian monk seals results from dramatic declines in the survival of juveniles and appears to be related to significantly reduced body sizes in pup and juvenile seals. These declines in body size appear to be evidence of chronic or episodic limitations in available prey. In recent years, low juvenile survival, in part due to food limitation, has been evident at all subpopulations of monk seals in the Northwest Hawaiian Islands. The mean age-specific birth rates of adult female Hawaiian monk seals, which are low relative to other phocid seals, could also be evidence of food limitation (NMFS 2007a).

Anthropogenic Threats. Several human activities are known to threaten Hawaiian monk seals: commercial and subsistence hunting, intentional harassment, competition with commercial fisheries, entanglement in fishing gear, habitat destruction on breeding beaches, pollution, and unintentional human disturbance (Kenyon 1981; Reeves et al. 1992; Riedman 1990). The revised recovery plan for Hawaiian monk seals identifies food limitation, entanglements, and shark predation as crucial threats to the continued existence of this species (NMFS 2007a).

Entangled monk seals were first observed in 1974 (Henderson 1984). Historically, monk seals have become entangled in net, line (including monofilament nylon line), net and line combinations, straps, rings (including hagfish or eel traps), and other random items such as discarded lifejackets, buckets (portion of rims), bicycle tires, rubber hoses, etc. (Henderson 1990b). Monk seal pups (including newly weaned pups) are entangled at higher rates than other age classes (Henderson 1985; Henderson 1990b; Henderson 2001). Between 1982 and 1988, pups comprised 11 percent of the population, but represent about 42 percent of observed entanglements (for comparison, adults represented about 49 percent of the population but only 16 percent of entanglements)(Henderson 1990b). Collectively immature monk seals were involved in almost 80 percent of all observed entanglements, even though they represented only 46 percent of the population (Henderson 2001).

Between 1982 and 2006, a total of 268 entanglements of monk seals were documented, including 118 in fishing gear. There were 57 serious injuries (including 32 from fishing gear) and 8 mortalities (including 7 from fishery items). From 1982 – 2000, there was an estimated minimum rate of 2.3 serious injuries or deaths per year attributable to fishery related marine debris (NMFS 2007a). In recent years, there have been several shooting deaths of monk seals in the MHI (Carretta et al. 2013) ("Who Would Kill a Monk Seal" NY Times Magazine, May 8, 2013). There is also a multiagency marine debris working group that was established in 1998 to remove derelict fishing gear, which has been identified as a top threat to this species, from the Northwestern Hawaiian Islands (Donohue and Foley 2007). Agencies involved in these efforts include The Ocean Conservancy, the City and County of Honolulu, the Coast Guard, the Fish

and Wildlife Service, the Hawaii Wildlife Fund, the Hawaii Sea Grant Program, the National Fish and Wildlife Foundation, the Navy, the University of Alaska Marine Advisory Program, and numerous other state and private agencies and groups (MMC 2002).

Recovery Actions. Over the past decade, there have been several attempts to combat or mitigate the effects of shark predation on Hawaiian monk seals. From 2000 through 2003, sharks were removed (through hazing or targeted fishing) at Trig Island, which was followed by declines in the number of monk seal pups killed at the island. These effects were only successful temporarily and, in 2002 and 2003, hazing was discontinued because it made the sharks wary and difficult to catch.

There have been several attempts to balance sex ratios at Laysan Island by removing problem males. In 1984, a group of ten adult males that had been observed attacking females, or whose behavior profile was similar to those that attacked females, were captured on Laysan and transported to Johnston Atoll. One of the ten died prior to release, and of the remaining nine, most were not seen after a few months. The last male was not observed until after a period of 16 months. Another group of five problem males was removed from Laysan and entered into captivity in 1987 for studies identified in the plan. Males in the 1987 group were used to define the testosterone cycle in males and to evaluate a drug to suppress testosterone for possible field application to reduce aggressive behavior. The captive trials proved effective at suppressing testosterone levels in the male seals (Atkinson et al. 1993) and a pilot field trial was performed (Atkinson et al. 1998). However, severe limitations in this approach (each male had to be captured and injected a number of times over the course of the breeding season; these repeated captures would have resulted in extensive disturbance to most seals on the island during the breeding season) caused it to be terminated.

In June 2006, the Papahanaumokuakea Marine National Monument (71 FR 51134, August 29, 2006) was established in the Northwest Hawaiian Islands. The boundary of the Monument includes about 140,000 square miles of emergent and submerged lands and waters of the northwest Hawaiian Islands, and some activities such as fishing that pose risks to the marine habitat of Hawaiian monk seals are regulated.

Status

Hawaiian monk seals were listed as endangered under the Endangered Species Act of 1973 on November 23, 1976 (41 FR 51611). A 5-year status review completed in 2007 recommended retaining monk seals as an endangered species (72 FR 46966, August 22, 2007). Critical habitat was originally designated for Hawaiian monk seals on April 30, 1986 (51 FR 16047), and was extended on May 26, 1988 (53 FR 18988; CFR 226.201). NMFS proposed an expansion of critical habitat for Hawaiian monk seals in 2011 (76 FR 32026) to include near shore areas of the main Hawaiian Islands but proposed national security exclusions for some Navy training areas including Puuloa Training Range and the Naval Defensive Sea Area.

Monk seals are considered one of the most endangered groups of pinnipeds on the planet because all of their populations are either extinct (for example, the Caribbean monk seal) or exist at numbers that are precariously close to extinction (Mediterranean and Hawaiian monk seals). Two periods of decline have been reported for Hawaiian monk seals. The first decline occurred in the 1800s when sealers, crews of wrecked vessels, and guano and feather hunters nearly hunted the population to extinction (Dill and Bryan 1912; Kenyon and Rice 1959). Following the collapse of this population, expeditions to the Northwest Hawaiian Islands reported increasing numbers of seals (Bailey 1952). A survey in 1958 suggested that the population had partially recovered from its initial collapse.

Consistent declines in the monk seal population trends have been recorded since range-wide surveys began in the late 1950s (survey results that were reported by Kenyon and Rice (1959) and Rice (1960). Rice (1960) conducted additional counts at Midway Islands in 1956-1958 and Wirtz (1968) conducted counts at Kure Atoll in 1963-1965. Between the late 1950s and 1980s, counts at the atolls, islands, and reefs in the Northwest Hawaiian Islands suggested a 50 percent decline in this population (Johnson et al. 1982). 1982). The total population for the five major breeding locations plus Necker Island for 1987 was estimated to be 1,718 seals including 202 pups of the year (Gilmartin 1988). This compares with 1,488 animals estimated for 1983 (Gerrodette 1985). In 1992 the Hawaiian monk seal population was estimated to be 1580 (standard error = 147) (Ragen 1993). The best estimate of total abundance for 1993 was 1,406 (standard error = 131, assuming a constant coefficient of variation).

Beach counts of juveniles, sub-adults, and adults declined by about 5 percent per year from 1985 – 1993, and then became relatively stable until the current decline began in 2001 (NMFS 2007a). Between 1958 and 1993, mean beach counts declined by 60 percent and included declines in the number of monk seals at French Frigate Shoals, which once accounted for more than 50 percent of the total non-pup beach counts among the six primary Northwest Hawaiian Island sub-populations. Between the years 1958 and 2006, beach counts of juveniles, sub-adults and adults declined by 66 percent; the total abundance of monk seals at the six primary subpopulations in the Northwest Hawaiian Islands is declining at an annual rate of 3.9 percent (95 percent CI = -4.8 to - 3.0 percent)(NMFS 2007a). The best estimate of the total population size is 1,212. This estimate is the sum of estimated abundance at the six main Northwestern Hawaiian Islands subpopulations, an extrapolation of counts at Necker and Nihoa Islands, and an estimate of minimum abundance in the main Hawaiian Islands (Carretta et al. 2013).

Sightings and births are increasing in the MHI, although systematic surveys were not conducted before 2000, and counts do not represent total abundance, as they do not account for seals in the water, and not every seal on land is detected. In 2000, the count in the MHI was 45 seals, and in 2001, 52 were counted. In 2005, the total number of unique seals identified was 77, based on non-systematic sightings. Annual births have increased since the mid-1990s. Although this could

be a positive indication for the survival of the species, the increased chance of contraction of diseases such as leptospirosis and toxoplasmosis from wild and domestic animals, and increased interactions with humans, including fishermen, boaters, and divers raise conservation concerns which do not apply to the NWHI (NMFS 2007b). The only available estimate of abundance in the MHI is 152 individuals, with an annual population growth rate of 7 percent (Baker et al. 2011). Survival to one year of age is 77 percent in the MHI, versus 42-57 percent in the NWHI (Baker et al. 2011).

Currently, the best estimate for the total population of monk seals is 1,212 (Carretta et al. 2013). Population dynamics at the different locations in the northwestern Hawaiian Islands and the main Hawaiian Islands has varied considerably (Antonelis et al. 2006). The overall trend has been a steady decline, with the total number of Hawaiian monk seals decreasing from a 2007 estimate of 1,146 individuals (Littnan 2011). In the northwestern Hawaiian Islands, where most seals reside, the decline in abundance is approximately 4 percent per year. While this decline has been occurring in the northwestern Hawaiian Islands, the number of documented sightings and annual births in the main Hawaiian Islands (where Navy training and testing occurs) has increased since the mid-1990s (Baker and Johanos 2004). In the main Hawaiian Islands, a minimum abundance of 45 seals was found in 2000, and this increased to 52 in 2001 (Baker and Johanos 2004). In 2009, 113 individual seals were identified in the main Hawaiian Islands based on flipper tag ID numbers or unique natural markings. The total number in the main Hawaiian Islands is estimated to be around 153 animals (Baker and Johanos 2004; Carretta et al. 2013).

Hawaiian monk seal pups weaned in the MHI exhibit higher girths and lengths compared to pups from the NWHI, as a result of pre- and post-partum maternal investment – a partial reflection of prey availability – contradicting the studies that indicate better foraging conditions in the NWHI. Suggested explanations for this include a higher per capita availability of prey in the MHI, similar absolute preferred prey densities when apex predators are not included in the biomass, and increased prey availability due to reduced competition from apex predators (Baker and Johanos 2004).

Based on the evidence available, Hawaiian monk seals exist as a population that is subject to the dynamics of "small" populations. That is, they 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. For example, Hawaiian monk seals have very low juvenile and sub-adult survival rates (due to starvation which is believed to be caused by limitations in the food base), low juvenile survival has led to low juvenile recruitment into the adult population, and the adult population increasingly consists of ageing females whose reproductive success is expected to decline (if it has not already declined) in the reasonably foreseeable future. A positive feedback loop between reduced reproductive success of adult females and reduced recruitment into the adult population (which reduces the number of adult

females) is the kind of demographic pattern that is likely to increase the monk seal's decline toward extinction. As a result, we assume that Hawaiian monk seals have elevated extinction probabilities because of exogenous threats caused by anthropogenic activities (primarily reductions in prey base due to competition with commercial and subsistence hunting, entanglement in fishing gear, and habitat destruction), natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate), and endogenous threats caused by the small size of their population.

Diving and Social Behavior

Several recent studies of the foraging patterns of Hawaiian monk seals near rookeries in the northwestern Hawaiian Islands provide insight into their diving behavior. Monk seals spend most of their time at sea in nearshore, shallow marine habitats (Littnan et al. 2007; Littnan and Stewart. 2007) (Littnan et al. 2007 ; Littnan 2011. Dive depths appear to differ slightly between rookeries as well as between age classes and genders. At Pearl and Hermes Reef, most dives were from 8-40 m with a second much smaller node at 100- 120 m (Stewart 2004; Stewart et al. 2006).

At Kure Atoll, most dives were shallower than 40 m, with males tending to dive deeper than females (Stewart and Yochem. 2004). At Laysan Island, a similar dive pattern was recorded with most dives shallower than 40 m, but at that location females tended to dive deeper than males (250-350 m) (Stewart and Yochem 2004). Parrish et al. (2002) noted a tendency towards night diving at French Frigate Shoals, with dives to ~80-90 m. Based on these data, the following are rough order estimates of time at depth: 90 percent at 0-40 m; 9 percent at 40-120 m; 1 percent at >120 m. In Hawaii, overall results showed most foraging trips to last from a few days to 1 to 2 weeks, with seals remaining within the 650 ft. (200 m) isobaths surrounding the main Hawaiian Islands and nearby banks (Littnan et al. 2007).

Vocalizations and Hearing

The information on the hearing capabilities of endangered Hawaiian monk seals is somewhat limited, but they appear to have their most sensitive hearing at 12 to 28 kHz. Below 8 kHz, their hearing is less sensitive than that of other pinnipeds. Their sensitivity to high frequency sound drops off sharply above 30 kHz (Richardson et al. 1995a; Richardson et al. 1995b; Thomas et al. 1990). An underwater audiogram for Hawaiian monk seal, based on a single animal whose hearing may have been affected by disease or age, was best at 12 to 28 kHz and 60 to 70 kHz (Thomas et al. 1990). The hearing showed relatively poor hearing sensitivity, as well as a narrow range of best sensitivity and a relatively low upper frequency limit (Thomas et al. 1990).

4.2.10 Green Turtle

Green turtles (*Chelonia mydas*) are the largest of all the hard-shelled sea turtles, but have a comparatively small head. While hatchlings are just 2 inches (50 mm) long, adults can grow to more than 3 feet (0.91 m) long and weigh 300-350 pounds (136-159 kg).

Adult green turtles are unique among sea turtles in that they are herbivorous, feeding primarily on sea grasses and algae. This diet is thought to give them greenish colored fat, from which they take their name. A green turtle's carapace (top shell) is smooth and can be shades of black, gray, green, brown, and yellow. Their plastron (bottom shell) is yellowish white.

Scientists estimate green turtles reach sexual maturity anywhere between 20 and 50 years, at which time females begin returning to their natal beaches (i.e., the same beaches where they were born) every 2-4 years to lay eggs.

Nesting in the Hawiian Islands occurs from May to September, peaking in early June, laying an average of two but up to six nests per season with a mean of 104 eggs per clutch (Balazs 1979). The only nesting population in the Study Area is in Hawaii, with 200 to 700 females nesting annually at French Frigate Shoals, as well as nesting on the Big Island of Hawaii and other minor nesting grounds on other main Hawaiian Islands (NMFS and USFWS 2007a). Four other populations are located in the eastern Pacific Ocean, south of the Study Area, with nesting occurring along the western Mexico coast, as well as within the Gulf of California (NMFS and USFWS 2007a).

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°Celsius in the coldest month. During warm spells (e.g., El Niño), green turtles may be found considerably north of their normal distribution. Stinson (1984a) found green turtles to appear most frequently in U.S. coastal waters with temperatures exceeding 18°C. Further, green 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 1998b). 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 areas (NMFS and USFWS 1998b).

The green turtle is the most common sea turtle species in the Hawaii region of the Study Area, occurring in the coastal waters of the main Hawaiian Islands throughout the year and commonly migrating seasonally to the Northwestern Hawaiian Islands to reproduce. The first recorded

green turtle nest on the Island of Hawaii occurred in 2011. Green sea turtles are found in inshore waters around all of the main Hawaiian Islands and Nihoa Island, where reefs, their preferred habitats for feeding and resting, are most abundant. They are also common in an oceanic zone surrounding the Hawaiian Islands. This area is frequently inhabited by adults migrating to the Northwestern Hawaiian Islands to reproduce during the summer and by ocean-dwelling individuals that have yet to settle into coastal feeding grounds of the main Hawaiian Islands. Farther offshore, green turtles occur in much lower numbers and densities.

Green sea turtles have been sighted in Pearl Harbor, but do not nest in the harbor; they are routinely seen in the outer reaches of the entrance channel (Navy 2012b). The number of resident turtles at the entrance channel is estimated at 30 to 40, with the largest number occurring at Tripod Reef and the Outfall Extension Pipe. They are also found beneath the outfall pipe of the Fort Kamehameha wastewater treatment plant, at depths of approximately 65 ft. (20 m) (Smith 2010). Green sea turtles are also regularly seen in West Loch (Smith et al. 2006). In the spring of 2010, two green turtles nested at Pacific Missile Range Facility for the first time in more than a decade, with successful hatching in August 2010 (O'Malley 2010). Green sea turtles are also common at all three landing beaches of U.S. Marine Corps Base Hawaii in Kaneohe Bay, where they forage in the shallow water seagrass beds.

More than 90 percent of all Hawaiian Island green turtle breeding and nesting occurs at French Frigate Shoals in the Northwestern Hawaiian Islands, the largest nesting colony in the central Pacific Ocean, where 200 to 700 females nest each year (NMFS and USFWS 2007a). A large foraging population resides in and returns to the shallow waters surrounding the main Hawaiian Islands (especially around Maui and Kaua‘i), where they are known to come ashore at several locations on all eight of the main Hawaiian Islands for basking or nesting.

Green sea turtles are widely distributed in the subtropical coastal waters of southern Baja California, Mexico, and Central America, several hundred kilometers (km) south of the Study Area (NMFS and USFWS 1998b). The main group of eastern Pacific Ocean green turtles is found on the breeding grounds of Michoacán, Mexico, from August through January and year-round in the feeding areas, such as those on the western coast of Baja California, along the coast of Oaxaca, and in the Gulf of California (the Sea of Cortez) (NMFS and USFWS 1998b). Bahía de Los Angeles in the Gulf of California has been identified as an important foraging area for green turtles (Seminoff et al. 2003). Eastern Pacific Ocean green turtles have been reported as far north as British Columbia (48.15° N) (Eckert 1993b; NMFS and USFWS 1998b). The western coasts of Central America, Mexico, and the United States constitute a shared habitat for this population (NMFS and USFWS 1998b). The green turtle is not known to nest on Southern California beaches.

In general, turtle sightings increase during summer as warm water moves northward along the coast (NMFS and USFWS 1998b). Sightings may also be more numerous in warmer years

compared to colder years. In waters south of Point Conception, Stinson (Stinson 1984a) found this seasonal sighting pattern to be independent of interyear temperature fluctuations. More sightings occurred during warmer years north of Point Conception. Stinson also reported that more than 60 percent of eastern Pacific Ocean green turtles observed in California were in areas where the water was less than 165 ft. (50 m) deep, often observed along shore in areas of eelgrass.

San Diego Bay is home to a resident population of green turtles (Dutton and McDonald 1990; Stinson 1984a). A 20-year monitoring program of these turtles indicates an annual abundance of between 16 and 61 turtles (Eguchi et al. 2010). Eelgrass beds and marine algae are particularly abundant in the southern half of the bay, and green turtles are frequently observed foraging on these items (Dutton et al. 2002). Until December 2010, the southern part of San Diego Bay was warmed by the effluent from the Duke Energy power plant, a fossil fuel power generation facility in operation since 1960. Green sea turtles are known to congregate in this area. The closure of the power plant may impact these resident turtles and alter movement patterns. Ultrasonic tracking studies have shown that green turtles in southern San Diego Bay have relatively small home ranges (Dutton et al. 2002). Between 2009 and 2011, MacDonald et al. (MacDonald et al. 2012) used acoustic telemetry to track 25 green turtles in San Diego Bay. The results of the study suggest that resident turtles likely do not spend much, if any, time foraging in central or northern San Diego Bay, where human activities are greatest (including Navy activities). A few sea turtles have been observed in northern San Diego Bay, but these are likely transient green turtles that enter the bay in warmer months (MacDonald et al. 2012). Another green turtle population resides in Long Beach, California, although less is known about this population (Eguchi et al. 2010).

Ocean waters off Southern California and northern Baja California are also designated as areas of occurrence because of the presence of rocky ridges and channels and floating kelp habitats suitable for green turtle foraging and resting (Stinson 1984a); however, these waters are often at temperatures below the thermal preferences of this primarily tropical species.

Population Structure

The population dynamics of green 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), Iles Eparses Islands (Tromelin Island, Europa Island), Indonesia, Malaysia, Myanmar, Oman, Philippines, Saudi Arabia, Seychelles Islands, Suriname, and United States (Florida; NMFS and USFWS 1998c; Seminoff et al. 2002).

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 (Hawaii), Venezuela, and Vietnam.

Molecular genetic techniques have helped researchers gain insight into the distribution and ecology of migrating and nesting green turtles. In the Pacific Ocean, green 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, Hawaii. 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 et al. 2003).

Threats to the Species

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

Green turtles in the Pacific are afflicted with a tumor disease, fibropapillomatosis, 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 (Chaloupka et al. 2008b; Reséndiz et al. 2012; Work and Balazs 1999; Work et al. 2009). 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). Preliminary evidence suggests an association between the distribution of fibropapillomatosis in the Hawaiian Islands and the distribution of toxic benthic dinoflagellates (*Prorocentrum* spp.) known to produce a tumor promoter, okadaic acid (Landsberg et al. 1999).

Anthropogenic Threats. Three human activities are known to threaten green 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 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 populations of green turtles still lose a large number 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 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 turtles are captured and killed in turtle fisheries in Colombia, Grenada, the Lesser Antilles, Nicaragua, St. Vincent and the Grenadines (Brautigam and Eckert 2006); the turtle fishery along the Caribbean coast of Nicaragua, by itself, has captured more than 11,000 green turtles each year (Brautigam 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 1998c).

Green sea turtles are also captured and killed in commercial fisheries. Gillnets account for the highest number of green 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 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 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 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.

Oil spills are a risk for all sea turtles. Several aspects of sea turtles life histories put them at risk, including the lack of avoidance behavior of oiled waters and indiscriminate feeding in convergence zones. Sea turtles are air breathers and all must come to the surface frequently to take a breath of air. In a large oil spill, these animals may be exposed to volatile chemicals during inhalation (NMFS 2010d).

Additionally, sea turtles may experience oiling impacts on nesting beaches when they come ashore to lay their eggs, and their eggs may be exposed during incubation potentially resulting in increased egg mortality and/or possibly developmental defects in hatchlings. Hatchlings emerging from their nests may encounter oil on the beach and in the water as they begin their lives at sea (NMFS 2010d).

Oil and other chemicals on skin and body may result in skin and eye irritation, burns to mucous membranes of eyes and mouth, and increased susceptibility to infection (NMFS 2010d). Inhalation of volatile organics from oil or dispersants may result in respiratory irritation, tissue injury, and pneumonia. Ingestion of oil or dispersants may result in gastrointestinal inflammation, ulcers, bleeding, diarrhea, and maldigestion. Absorption of inhaled and ingested chemicals may damage organs such as the liver or kidney, result in anemia and immune suppression, or lead to reproductive failure or death (NMFS 2010d).

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. On August 1, 2013, NMFS initiated a status review of green turtles in the Hawiian Islands to determine whether they should be delisted (77 FR 45571). Using a precautionary approach, Seminoff (2002) estimates that the global green turtle population has declined by 34 percent to 58 percent over the last three generations (approximately 150 years); although actual declines may be closer to 70 percent to 80 percent. 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 percent 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 percent and 88 percent since the late 1970s. Population trend variations also appear in the Indian Ocean. Declines greater than 50 percent 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 2004).

Green turtles are thought to be declining throughout the Pacific Ocean, with the exception of Hawaii, as a direct consequence of a historical combination of overexploitation and habitat loss (Eckert 1993a; Seminoff 2004). 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 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 turtles, we do not know whether green 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 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 Hawaiian nesting aggregations, we assume that green turtles are endangered because of both anthropogenic and natural threats as well as changes in their population dynamics.

A recovery plan for the U.S Population of Atlantic Green Turtles was written in 1991 (NMFS and USFWS 1991a). A recovery plan for the U.S. Pacific Populations of the Green Turtle was written in 1998 (NMFS and USFWS 1998c). Critical habitat was designated in 1998 for green turtles in coastal waters around Culebra Island, Puerto Rico.

Diving and Social 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 1998c).). The maximum recorded dive depth for an adult green turtle was 110 meters (Berkson 1967; 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

Sea turtles do not appear to use sound for communication, and there are no published recordings of green turtle vocalizations. Nesting leatherback turtles have been recorded producing sounds (sighs, grunts or belch-like sounds) up to 1,200 Hz with maximum energy from 300 to 500 Hz (Cook and Forrest 2005), however these sounds appeared to be associated with breathing (Cook and Forrest 2005).

Several studies have been conducted to measure green turtle hearing sensitivity, each using a slightly different methodology. Ridgway et al. (1969) studied the auditory evoked potentials of three green turtles (in air and through direct mechanical stimulation of the inner 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.

Bartol and Ketten (2006) measured auditory brainstem responses (short latency auditory evoked potentials) to aerial tones in partially submerged green turtles and documented hearing between 100 and 800 Hz, with maximum sensitivity between 600 and 700 Hz in Atlantic juvenile greens, and100 and 500 Hz with maximum sensitivity between 200 and 400 Hz in Pacific subadult greens (Moein Bartol and Ketten 2006).

Dow Piniak et al. (2012b) recorded auditory evoked potential in response to both aerial and underwater acoustic stimuli. Green turtles detected acoustic stimuli in both media, responding to underwater signals between 50 and 1,600 Hz (turtles completely submerged) and aerial signals between 50 and 800 Hz, with maximum sensitivity between 200 and 400 Hz underwater and 300 and 400 Hz in air (Piniak et al. 2012b).

4.2.11 Hawksbill Turtle

The hawksbill turtle (*Eretmochelys imbricata*) is a small to medium-sized sea turtle; adults typically range between 65 and 90 cm (26 to 35 in) in carapace length and weigh around 80 kg (176 lb) (Witzell 1983). Hawksbills are distinguished from other sea turtles by their hawk-like beaks, posteriorly overlapping carapace scutes, and two pairs of claws on their flippers (NMFS and USFWS 1993). The carapace of this species is often brown or amber with irregularly radiating streaks of yellow, orange, black, and reddish-brown.

Distribution

Hawksbill sea turtles occur in tropical and subtropical seas of the Atlantic, Pacific and Indian Oceans. The species is widely distributed in the Caribbean Sea and western Atlantic Ocean, with individuals from several life history stages occurring regularly along southern Florida and the northern Gulf of Mexico (especially Texas); in the Greater and Lesser Antilles; and along the Central American mainland south to Brazil. Within the United States, hawksbills are most common in Puerto Rico and its associated islands, and in the U.S. Virgin Islands.

Within United States territories and U.S. dependencies in the Caribbean Region, hawksbill turtles nest principally in Puerto Rico and the U.S. Virgin Islands, particularly on Mona Island and Buck Island. They also nest on other beaches on St. Croix, Culebra Island, Vieques Island, mainland Puerto Rico, St. John, and St. Thomas. Within the continental United States, hawksbill turtles nest only on beaches along the southeast coast of Florida and in the Florida Keys.

Hawksbill sea turtles occupy different habitats depending on their life history stage. After entering the sea, hawksbill turtles occupy pelagic waters and occupy weed-lines that accumulate at convergence points. When they grow to about 20-25 cm carapace length, hawksbill turtles re-

enter coastal waters where they inhabit and forage in coral reefs as juveniles, sub-adults and adults. Hawksbill sea turtles also occur around rocky outcrops and high energy shoals, where sponges grow and provide forage, and they are known to inhabit mangrove-fringed bays and estuaries, particularly along the eastern shore of continents where coral reefs are absent.

Hawksbills are considered the most coastal of the sea turtles that inhabit the Study Area, with juveniles and adults preferring coral reef habitats (National Marine Fisheries Service 2010b). Reefs provide shelter for resting hawksbills day and night, and they are known to visit the same resting spot repeatedly. Hawksbills are also found around rocky outcrops and high-energy shoals—optimum sites for sponge growth—as well as in mangrove-lined bays and estuaries (NMFS and USFWS 2013).

Hatchling and early juvenile hawksbills have also been found in the open ocean, in floating mats of seaweed (Musick and Limpus 1997). Although information about foraging areas is largely unavailable due to research limitations, juvenile and adult hawksbills may also be present in open ocean environments (NMFS and USFWS 2007a). Very little is known about the open ocean habitat and distribution of hawksbills in the Transit Corridor.

Hawksbills are mostly found in the coastal waters of the eight main islands of the Hawaiian Island chain. Stranded or injured hawksbills are occasionally found in the Northwestern Hawaiian Islands (Parker et al. 2009). Hawksbills are the second-most-common species in the offshore waters of the Hawaiian Islands, yet they are far less abundant than green turtles (Chaloupka et al. 2008b). The lack of hawksbill sightings during aerial and shipboard surveys likely reflects the species' small size and difficulty in identifying them from a distance.

Hawksbills have been captured in Kiholo Bay and Kau (Hawaii), Palaau (Molokaʻi), and Makaha (Oahu). Strandings have been reported in Kaneohe and Kahana Bays (Oahu) and throughout the main Hawaiian Islands (Eckert 1993b; NMFS and USFWS 1998b). Hawksbills primarily nest on the southeastern beaches of the Island of Hawaii. Since 1991, 81 nesting female hawksbills have been tagged on the Island of Hawaii at various locations. This number does not include nesting females from Maui or Molokaʻi, which would add a small number to the total. Post-nesting hawksbills have been tracked moving between Hawaii and Maui over the deep waters of the Alenuihaha Channel (Parker et al. 2009). Only two hawksbills have ever been sighted in the Pearl Harbor entrance channel, and none have been sighted inside the harbor (Smith 2010).

Water temperature in the Southern California region of the Study Area is generally too low for hawksbills, and they are rare. Nesting is rare in the eastern Pacific Ocean region, and does not occur along the U.S. west coast (NMFS and USFWS 1998b; Witzell 1983). Stinson (1984b) did not mention the hawksbill turtle in her summary of sea turtle occurrences in eastern north Pacific waters from Baja California to the Gulf of Alaska, and no hawksbill sightings have been

confirmed along the U.S. west coast in recent history (Eckert 1993b; NMFS and USFWS 2007a) . If hawksbills were to occur in the Southern California region of the Study Area, it would most likely be during an El Niño event, when waters along the California current are unusually warm.

Hawksbills were once thought to be a nonmigratory species because of the proximity of suitable nesting beaches to coral reef feeding habitats and the high rates of marked turtles recaptured in these areas; however, tagging studies have shown otherwise. For example, a post-nesting female traveled 995 miles (1,601 kilometers [km]) from the Solomon Islands to Papua New Guinea (Meylan 1995), indicating that adult hawksbills can migrate distances comparable to those of green and loggerhead turtles.

Research suggests that movements of Hawaiian hawksbills are relatively short, with individuals generally migrating through shallow coastal waters and few deepwater transits between the islands. Nine hawksbill turtles were tracked within the Hawaiian Islands using satellite telemetry. Turtles traveled from 55 to 215 mi. (89 to 346 km) and took between 5 and 18 days to complete the trip from nesting to foraging areas (Parker et al. 2009).

Population Structure

Hawksbill 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 hawksbill turtles are usually based on the distribution of their nesting aggregations.

Threats to the Species

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

Anthropogenic Threats. Three human activities are known to threaten hawksbill turtles: overharvests of individual animals, incidental capture in commercial fisheries, and human development of coastlines. Historically, the primary cause of the global decline of hawksbill turtle populations was overharvests by humans for subsistence and commercial purposes. In the Atlantic, hawksbill turtles are still captured and killed in turtle fisheries in Colombia, Grenada, the Lesser Antilles, Nicaragua, St. Vincent and the Grenadines (Brautigam and Eckert 2006).

For centuries, hawksbill turtles have been captured for their shells, which have commercial value, rather than food (the meat of hawksbill turtles is considered to have a bad taste and can be toxic to humans) (NMFS and USFWS 1998d). Until recently, tens of thousands of hawksbills

were captured and killed each year to meet demand for jewellery, ornamentation, and whole stuffed turtles (Eckert 1993a; Milliken and Tokunaga 1987). In 1988, Japan's imports from Jamaica, Haiti and Cuba represented some 13,383 hawksbills: it is extremely unlikely that this volume could have originated solely from local waters (Greenpeace 1989 cited in Eckert 1993a). Although Japan banned the importation of turtle shell in 1994, domestic harvests of eggs and turtles continue in the United States, its territories, and dependencies, particularly in the Caribbean and Pacific Island territories. Large numbers of nesting and foraging hawksbill turtles are captured and killed for trade in Micronesia, the Mexican Pacific coast, southeast Asia and Indonesia (NMFS and USFWS 1998d). In addition to the demand for the hawksbill's shell, there is a demand for other products including leather, oil, perfume, and cosmetics. Before the U.S. certified Japan under the Pelly Amendment, Japan had been importing about 20 metric tons of hawksbill shell per year, representing approximately 19,000 turtles.

The second most important threat to hawksbill turtles is the loss of nesting habitat caused by the expansion of resident human populations in coastal areas of the world and increased destruction or modification of coastal ecosystems to support tourism. Hawksbill sea turtles are also captured and killed in commercial fisheries. Like green turtles, hawksbill 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

Hawksbill turtles were listed as endangered under the ESA in 1970. Critical habitat for hawksbill turtles was designated in 1998 to include the coastal waters surrounding Mona and Monito Islands, Puerto Rico. Under the Convention on International Trade in Endangered Species of Wild Fauna and Flora, hawksbill turtles are identified as "critically endangered" (IUCN 2010).

The Hawksbill Sea Turtle (*Eretmochelys imbricata*) 5-year Review: Summary and Evaluation (NMFS and USFWS 2013) assessed nesting abundance and nesting trends in all regions that the hawksbill turtles inhabit. Where possible, historical population trends were determined, and most showed declines for the 20 to 100 year period of evaluation. Recent trends for 42 of the sites indicated that 69 percent were decreasing, seven percent were stable, and that 24 percent were increasing. Seven of the 83 sites occur in the central Pacific Ocean and one occurs in the eastern Pacific Ocean (Baja California, Mexico), all with decreasing long-term population trends; only the Hawaii site has a recent increasing trend. Hawksbills in the eastern Pacific Ocean are probably the most endangered sea turtle population in the world (Gaos et al. 2008). Hawksbills sometimes nest in the southern part of the Baja Peninsula, while juveniles and subadults are seen foraging in coastal waters regularly. No nesting occurs on the western coast of the United States. Hawksbills in the U.S. Pacific region nest only on eastern beaches of the Island of Hawaii (5 to

10 nesting females annually, although 13 were reported in 2011 (Rivers 2011)), as well as in the Northwestern Hawaiian Islands (NMFS and USFWS 2013).

Hawksbill turtles, like green turtles, are thought to be declining globally as a direct consequence of a historical combination of overexploitation and habitat loss. However, like several of the species we have already discussed, the information available on the status and trend of hawksbill turtles do not allow us to make definitive statements about the global extinction risks facing these sea turtles or the risks facing particular populations (nesting aggregations) of these turtles. However, the limited data available suggests that several hawksbill turtles populations 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) while others are large enough to avoid these problems. Exogenous threats such as overharvests and entanglement in fishing gear only increase their probabilities of becoming extinct in the reasonably foreseeable future.

Diving and Social Behavior

The duration of foraging dives in hawksbill turtles commonly depends on the size of the turtle: larger turtles diving deeper and longer. Shorter and more active foraging dives occur predominantly during the day, while longer resting dives occur at night (Blumenthal et al. 2009; Storch et al. 2005). Lutcavage and Lutz (1997) cited a maximum dive duration of 73.5 minutes for a female hawksbill in the U.S. Virgin Islands. Van Dam and Diez (Diez and van Dam 2002) reported that foraging dives at a study site in the northern Caribbean ranged from 19 to 26 minutes at depths of 26 to 33 ft. (8 to 10 m), with resting night dives from 35 to 47 minutes. Foraging dives of immature hawksbills are shorter, ranging from 8.6 to 14 minutes, with a mean and maximum depth of 16.4 and 65.6 ft. (5 and 20 m), respectively (van Dam and Diez 1996). Blumenthal et al. (2009) reported consistent diving characteristics for juvenile hawksbill in the Cayman Islands, with an average daytime dive depth of 25 ft. (8 m), a maximum depth of 140 ft. (43 m), and a mean nighttime dive depth of 15 ft. (5 m). A change in water temperature affects dive duration; cooler water temperatures in the winter result in increased nighttime dive durations (Storch et al. 2005).

Vocalizations and Hearing

Sea turtles do not appear to use sound for communication, and there are no published recordings of hawksbill turtle vocalizations. Nesting leatherback turtles have been recorded producing sounds (sighs, grunts or belch-like sounds) up to 1,200 Hz with maximum energy from 300 to 500 Hz (Cook and Forrest 2005), however these sounds appeared to be associated with breathing (Cook and Forrest 2005).

Recent research measureing hatchling hawksbill turtle auditory evoked potentials has shown that aerial and underwater acoustic stimuli elicited auditory evoked potential responses between 50

and 1,600 Hz (underwater fully submerged and in air), with maximum sensitivity between 200 and 400 Hz in hatchling hawksbill (Dow Piniak et al. 2011).

4.2.12 Leatherback Turtle

The leatherback turtle (*Dermochelys coriacea*) is the largest turtle and the largest living reptile in the world. Mature males and females can be as long as six and a half feet (2 m) and weigh almost 2000 lbs. (900 kg). The leatherback is the only sea turtle that lacks a hard, bony shell. A leatherback's carapace is approximately 1.5 inches (4 cm) thick and consists of leathery, oil saturated connective tissue overlaying loosely interlocking dermal bones. The carapace has seven longitudinal ridges and tapers to a blunt point. Adult leatherbacks are primarily black with a pinkish white mottled ventral surface and pale white and pink spotting on the top of the head. The front flippers lack claws and scales and are proportionally longer than in other sea turtles; back flippers are paddle-shaped. The ridged carapace and large flippers are characteristics that make the leatherback uniquely equipped for long distance foraging migrations.

Female leatherbacks lay clutches of approximately 100 eggs on sandy, tropical beaches. Females nest several times during a nesting season, typically at 8-12 day intervals. After 60-65 days, leatherback hatchlings with white striping along the ridges of their backs and on the margins of the flippers emerge from the nest. Leatherback hatchlings are approximately 50-77 cm (2-3 inches) in length, with fore flippers as long as their bodies, and weigh approximately 40-50 grams (1.4-1.8 ounces).

Leatherbacks lack the crushing chewing plates characteristic of sea turtles that feed on hard-bodied prey (Pritchard 1971) Instead, they have pointed tooth-like cusps and sharp edged jaws that are perfectly adapted for a diet of soft-bodied pelagic (open ocean) prey, such as jellyfish and salps.

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 and KwaZulu Natal, South Africa.

Leatherback turtles are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Eckert and Eckert 1988; Eckert 1999; Morreale et al. 1994). 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 1998a). 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 turtles probably mate outside of tropical waters, before females swim to their nesting beaches (Eckert and Eckert 1988).

Few quantitative data are available concerning the seasonality, abundance, or distribution of leatherbacks in the central northern Pacific Ocean. Satellite tracking studies and occasional incidental captures of the species in the Hawaii-based longline fishery indicate that deep ocean waters are the preferred habitats of leatherback turtles in the central Pacific Ocean (NMFS and USFWS 2007b). The primary migration corridors for leatherbacks are across the North Pacific Subtropical Gyre, with the eastward migration route possibly to the north of the westward migration.

The primary data available for leatherbacks in the North Pacific Transition Zone come from longline fishing bycatch reports, as well as several satellite telemetry data sets (Benson et al. 2007). Leatherbacks from both eastern and western Pacific Ocean nesting populations migrate to northern Pacific Ocean foraging grounds, where longline fisheries operate (Dutton et al. 1998). Leatherbacks from nesting beaches in the Indo-Pacific region have been tracked migrating thousands of kilometers through the North Pacific Transition Zone to summer foraging grounds off the coast of northern California (Benson et al. 2007). Genetic sampling of 18 leatherback turtles caught in the Hawaiian longline fishery indicated that about 94 percent originated from western Pacific Ocean nesting beaches (NMFS and USFWS 2007b). The remaining six percent of the leatherback turtles found in the open ocean waters north and south of the Hawaiian Islands represent nesting groups from the eastern tropical Pacific Ocean.

Leatherback turtles are regularly sighted by fishermen in offshore waters surrounding the Hawaiian Islands, generally beyond the 3,800 ft. (1,158 m) contour, and especially at the southeastern end of the island chain and off the northern coast of Oahu (Balazs 1995). Leatherbacks encountered in these waters, including those caught accidentally in fishing operations, may be migrating through the Insular Pacific-Hawaiian Large Marine Ecosystem

(NMFS and USFWS 1998a). Sightings and reported interactions with the Hawaii longline fishery commonly occur around seamount habitats above the Northwestern Hawaiian Islands (from 35° N to 45° N and 175° W to 180° W) (Skillman and Balazs 1992; Skillman and Kleiber 1998).

The leatherback turtle occurs within the entire Insular Pacific-Hawaiian Large Marine Ecosystem beyond the 330 ft. (101 m) isobath; inshore of this isobath is the area of rare leatherback occurrence. Incidental captures of leatherbacks have also occurred at several offshore locations around the main Hawaiian Islands (McCracken 2000). Although leatherback bycatches are common off the island chain, leatherback-stranding events on Hawaiian beaches are uncommon. Since 1982, only five leatherbacks have stranded in the Hawaiian Islands (Chaloupka et al. 2008a). Leatherbacks were not sighted during any of the aerial surveys, all of which took place over waters lying close to the Hawaiian shoreline. Leatherbacks were also not sighted during any of the NMFS shipboard surveys; their deep diving capabilities and long submergence times reduce the probability that observers could spot them during marine surveys. One leatherback turtle was observed along the Hawaiian shoreline during monitoring surveys in 2006 (Rivers 2011).

In the eastern North Pacific Ocean, leatherback turtles are broadly distributed from the tropics to as far north as Alaska, where 19 occurrences were documented between 1960 and 2001 (Eckert 1993a; Eckert 1993b; Hodge and Wing 2000). Stinson (Stinson 1984a) concluded that the leatherback was the most common sea turtle in U.S. waters north of Mexico. Aerial surveys off California, Oregon, and Washington indicate that most leatherbacks occur in waters over the continental slope, with a few beyond the continental shelf (Eckert 1993a). While the leatherback is known to occur throughout the California Current Large Marine Ecosystem, it is not known to nest anywhere along the U.S. Pacific Ocean coast. In general, turtle sightings increase during summer, as warm water moves northward along the coast (Stinson 1984a). Sightings may also be more numerous in warm years than in cold years.

Leatherback turtles are regularly seen off the western coast of the United States, with the greatest densities found off central California. Off central California, sea surface temperatures are highest during the summer and fall, and oceanographic conditions create favorable habitat for leatherback turtle prey (jellyfish). Satellite telemetry data indicate that these animals are within the California Current Large Marine Ecosystem, as well as that portion of the Study Area that is included within it (Benson et al. 2007). There is some evidence that they follow the 61°F (16°C) isotherm into Monterey Bay, and the length of their stay apparently depends on prey availability (Starbird et al. 1993). Satellite telemetry studies link leatherback turtles off the U.S. west coast to one of the two largest remaining Pacific Ocean breeding populations in Jamursba Medi, Indonesia. Thus, nearshore waters off central California represent an important foraging region for the critically endangered Pacific Ocean leatherback turtle. There were 96 sightings of

leatherbacks within 50 km of Monterey Bay from 1986 to 1991, mostly by recreational boaters (Starbird et al. 1993).

Threats to the Species

Natural Threats. The various habitat types leatherback turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural threats. The beaches on which leatherback 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 (Caut et al. 2009). Hatchlings are hunted by predators like herons, gulls, dogfish, and sharks. Larger leatherback turtles, including adults, are also killed by sharks and other large, marine predators (Pitman and Dutton 2004).

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 1998e).

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 percent mortality rate (or 33 percent if most mortality was focused on the East Pacific population). Spotila (2000) asserts that most of the mortality associated with the Playa Grande nesting site was fishery related.

Leatherback sea turtles are exposed to commercial fisheries in many areas of the Atlantic Ocean. For example, leatherback entanglements in fishing gear are common in Canadian waters where Goff and Lien (1988) reported that 14 of 20 leatherbacks encountered off the coast of Newfoundland and Labrador were entangled in fishing gear including salmon net, herring net, gillnet, trawl line and crab pot line. Leatherbacks are reported taken by the many other nations that participate in Atlantic pelagic longline fisheries (see NMFS 2001, for a complete description of take records), including Taiwan, Brazil, Trinidad, Morocco, Cyprus, Venezuela, Korea, Mexico, Cuba, U.K., Bermuda, People's Republic of China, Grenada, Canada, Belize, France, and Ireland.

In the Pacific Ocean, between 1,000 and 1,300 leatherback 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 Hawaii are estimated to have captured and killed several hundred leatherback 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 turtles each year. Between 2004 and 2008, shallow-set fisheries based out of Hawaii are estimated to have captured about 19 leatherback 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 reasonably foreseeable future (NMFS 2008b). 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 Hawaii and American Samoa.

Shrimp fisheries in the Gulf of Mexico capture the largest number of leatherback turtles: each year, they have been estimated to capture about 1,393 leatherback turtles with 144 of those sea turtles dying as a result. Along the Atlantic coast of the U.S., NMFS estimated that about 800 leatherback 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 turtles each year; the health effects of being captured on the sea turtles that survive remain unknown.

Leatherback sea turtles are known to drown in fish nets set in coastal waters of Sao Tome, West Africa (Tomás et al. 2000). Gillnets are one of the suspected causes for the decline in the leatherback turtle population in French Guiana (Chevalier et al. 1999), and gillnets targeting green and hawksbill turtles in the waters of coastal Nicaragua also incidentally catch leatherback turtles (Lagueux 1998). Observers on shrimp trawlers operating in the northeastern region of Venezuela documented the capture of six leatherbacks from 13,600 trawls (Marcano and Alió-M 2000). An estimated 1,000 mature female leatherback turtles are caught annually off of Trinidad and Tobago with mortality estimated to be between 50-95 percent (Eckert et al. 2007). However, many of the turtles do not die as a result of drowning, but rather because the fishermen butcher them in order to get them out of their nets. There are known to be many sizeable populations of leatherbacks nesting in West Africa, possibly as many as 20,000 females nesting annually (Fretey 2001). In Ghana, nearly two thirds of the leatherback turtles that come up to nest on the beach are killed by local fishermen.

On some beaches, nearly 100 percent of the eggs laid have been harvested. Spotila et al. (1996) and Eckert et al. (2007) note that adult mortality has also increased significantly, particularly as a result of driftnet and longline fisheries. Like green and hawksbill turtles, leatherback turtles are threatened by domestic or domesticated animals that prey on their nests; artificial lighting that disorients adult female and hatchling sea turtles, which can dramatically increase the mortality rates of hatchling sea turtles; beach replenishment; ingestion and entanglement in marine debris; and environmental contaminants.

Oil spills are a risk for all sea turtles. Several aspects of sea turtles life histories put them at risk, including the lack of avoidance behavior of oiled waters and indiscriminate feeding in convergence zones. Sea turtles are air breathers and all must come to the surface frequently to take a breath of air. In a large oil spill, these animals may be exposed to volatile chemicals during inhalation (NMFS 2010d).

Additionally, sea turtles may experience oiling impacts on nesting beaches when they come ashore to lay their eggs, and their eggs may be exposed during incubation potentially resulting in increased egg mortality and/or possibly developmental defects in hatchlings. Hatchlings emerging from their nests may encounter oil on the beach and in the water as they begin their lives at sea (NMFS 2010d).

Oil and other chemicals on skin and body may result in skin and eye irritation, burns to mucous membranes of eyes and mouth, and increased susceptibility to infection (NMFS 2010d). Inhalation of volatile organics from oil or dispersants may result in respiratory irritation, tissue injury, and pneumonia. Ingestion of oil or dispersants may result in gastrointestinal inflammation, ulcers, bleeding, diarrhea, and maldigestion. Absorption of inhaled and ingested chemicals may damage organs such as the liver or kidney, result in anemia and immune suppression, or lead to reproductive failure or death (NMFS 2010d).

Status

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

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

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 et al. 1996), but is now estimated to number less than 3,000 total adult and subadult animals (Spotila et al. 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 percent 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

et al. 2000). In the western Pacific, the decline is equally severe. Current nestings at Terengganu, Malaysia represent 1 percent 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 percent 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 (NMFS and USFWS 1998a; Spotila et al. 1996; 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 (Eckert and Sarti 1997; Sarti et al. 1996).

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 turtles are critically endangered as a direct consequence of a historical combination of overexploitation and habitat loss. The information available suggests that leatherback 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 turtles exist at population sizes small enough to be classified as "small" populations (that is, populations that exhibit population dynamics that increase the extinction probabilities of the species or several of its populations) as evidenced by biases in the male to female ratios in the Pacific. The status of leatherback turtles in the Atlantic Ocean remains uncertain.

In 1979, NMFS designated critical habitat for leatherback turtles to include the coastal waters adjacent to Sandy Point, St. Croix, U.S. Virgin Islands. In 2012, NMFS designated additional critical habitat to provide protection for endangered leatherback sea turtles along the U.S. West Coast (77 FR 4170).

Diving and Social 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 inter-nesting intervals and during the 1995 through 1998 nesting seasons. The turtles dived continuously for the majority of their time at sea, spending 57 - 68 percent 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 percent of the time the leatherback turtles were at depths less than 80 meters.

Vocalizations and Hearing

Sea turtles do not appear to use sound for communication. Nesting leatherback turtles have been recorded producing sounds (sighs, grunts or belch-like sounds) up to 1,200 Hz with maximum energy from 300 to 500 Hz (Cook and Forrest 2005; Mrosovsky 1972). However these sounds appeared to be associated with breathing (Cook and Forrest 2005; Mrosovsky 1972).

Recent research measureing hatchling leatherback turtle auditory evoked potentials has shown that hatchling leatherbacks respond to tonal stimuli between 50 and 1,200 underwater (maximum sensitivity: 100-400 Hz) and 50 and 1,600 in air (maximum sensitivity: 50-400Hz) (Dow Piniak et al. 2012a).

4.2.13 Loggerhead Turtle

Loggerhead turtles (*Caretta caretta*) were named for their relatively large heads, which support powerful jaws and enable them to feed on hard-shelled prey, such as whelks and conch. The carapace (top shell) is slightly heart-shaped and reddish-brown in adults and sub-adults, while the plastron (bottom shell) is generally a pale yellowish color. The neck and flippers are usually dull brown to reddish brown on top and medium to pale yellow on the sides and bottom. Mean straight carapace length of adults in the southeastern U.S. is approximately 36 in (92 cm); corresponding weight is about 250 lbs (113 kg).

Loggerheads reach sexual maturity at around 35 years of age. In the southeastern U.S., mating occurs in late March to early June and females lay eggs between late April and early September. Females lay three to five nests, and sometimes more, during a single nesting season. The eggs incubate approximately two months before hatching sometime between late June and mid-November.

Hatchlings vary from light to dark brown to dark gray dorsally and lack the reddish-brown coloration of adults and juveniles. Flippers are dark gray to brown above with white to white-gray margins. The coloration of the plastron is generally yellowish to tan. At emergence, hatchlings average 1.8 in (45 mm) in length and weigh approximately 0.04 lbs (20 g).

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 (NMFS and USFWS 1998e). The majority of loggerhead nesting is at the western rims of the Atlantic and Indian Oceans. Nesting aggregations occur in the eastern Atlantic at Cape Verde, Greece, Libya, Turkey and along the West African Coast. The western Atlantic and Caribbean hosts nesting aggregations along the U.S. east coast from Virginia through the Florida peninsula, the Dry Tortugas and Northern Gulf of Mexico, the Bahamas, the Yucatan Peninsula, Central America and the Caribbean and into South America. Within the Indian Ocean, nesting aggregations occur at Oman, Yemen, Sri Lanka and Madagascar and South Africa. Pacific Ocean nesting sites include western and eastern Australia and Japan.

Adult loggerheads are known to make considerable migrations from nesting beaches to foraging grounds (TEWG 2009); and evidence indicates turtles entering the benthic environment undertake routine migrations along the coast that are limited by seasonal water temperatures.

Small juveniles are found in pelagic waters (e.g., of the North Atlantic and the Mediterranean Sea); and the transition from oceanic to neritic juvenile stages can involve trans-oceanic migrations (Bowen et al. 2004). Loggerhead nesting is confined to lower latitudes, concentrated in temperate zones and subtropics; the species generally does not nest in tropical areas (NMFS and USFWS 1991b; NRC 1990; Witherington et al. 2006). Loggerhead turtles travel to northern waters during spring and summer as water temperatures warm, and southward and offshore toward warmer waters in fall and winter; loggerheads are noted to occur year round in offshore waters of sufficient temperature.

Population Structure

Loggerhead 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 is usually based on the distribution of their nesting aggregations. 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 southwestern 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.

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

Threats to the Species

Natural Threats. The various habitat types loggerhead turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural and anthropogenic threats. The beaches on which loggerhead 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 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 increase 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 represent a primary threat because of number of individuals that are captured and killed in fishing gear each year.

Loggerhead turtles are also captured and killed in commercial fisheries. In the Pacific Ocean, between 2,600 and 6,000 loggerhead 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 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 turtles each year. Between 2004 and 2008, shallow-set fisheries based out of Hawai‘i are estimated to have captured about 45 loggerhead 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 reasonably foreseeable future (NMFS and USFWS 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 fisheries account for the highest number of loggerhead 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 81,620 loggerhead turtles are captured in shrimp fisheries each year in the Gulf of Mexico, with 7,701 of those sea turtles dying as a result of their capture. Each year, several hundred loggerhead 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 are combined to capture about 2,000 loggerhead 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 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. 2002). 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 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

Loggerhead turtles are currently listed as nine Distinct Population Segments (DPSs); four listed as threatened and five listed as Endangered under the ESA (Table 27).

Table 27. Loggerhead turtle distinct population segments (76 FR 58868).

Population Segment	Population Boundaries	Status
Mediterranean Sea	Mediterranean Sea east of 5°36’ W. Long.	Endangered
North Indian Ocean	North Indian Ocean north of the equator and south of 30° N. Lat.	Endangered
North Pacific Ocean	North Pacific north of the equator and south of 60° N. Lat.	Endangered

Northeast Atlantic Ocean	Northeast Atlantic Ocean north of the equator, south of 60° N. Lat, east of 40° W. Long, and west of 5°36' W. Long	Endangered
Northwest Atlantic Ocean	Northwest Atlantic Ocean north of the equator, south of 60° N. Lat, and west of 40° W. Long	Threatened
South Atlantic Ocean	South Atlantic Ocean south of the equator, north of 60° S. Lat, west of 20° E. Long, and east of 67° W. Long	Threatened
South Pacific Ocean	South Pacific south of the equator, north of 60° S. Lat, west of 67° W. Long, and east of 139° E. Long.	Endangered
Southeast Indo-Pacific Ocean	Southeast Indian Ocean south of the equator, north of 60° S. Lat, and east of 80° E. Long; South Pacific Ocean south of the equator, north of 60° S. Lat, and west of 139° E. Long	Threatened
Southwest Indian Ocean	Southwest Indian Ocean north of the equator, south of 30° N. Lat, west of 20° E. Long, and east of 80° E. Long	Threatened

All loggerheads inhabiting the North Pacific Ocean are derived primarily, if not entirely, from Japanese beaches (although low level nesting may occur in areas around the South China Sea). Along the Japanese coast, nine major nesting beaches (greater than 100 nests per season) and six "submajor" beaches (10– 100 nests per season) were identified. Using information collected from these nine beaches (Kamezaki et al. 2003) found a substantial decline (50–90 percent) in the size of the annual loggerhead nesting population over the last half of the 20th century. Also, nest count data for the last two decades suggests that the North Pacific population is "small" and lacks a robust gene pool when compared to the larger northwest Atlantic and north Indian Ocean loggerhead populations. Small populations are more susceptible to demographic variability which increases their probability of extinction. Available evidence indicates that due to loss of adult and juvenile mortalities from fishery bycatch and, to a lesser degree the loss of nesting habitat, the North Pacific loggerhead population is declining.

In the South Pacific, loggerhead nesting is almost entirely restricted to eastern Australia (primarily Queensland) and New Caledonia, with the majority of nesting occurring in eastern Australia. The total nesting population for Queensland was approximately 3,500 females in the 1976–1977 nesting season (Limpus and Reimer 1994; Limpus 1985), however, by the 1999-2000 season Limpus and Limpus (2003) estimated this population at less than 500 females. This represents an estimated 50 to 80 percent decline in the number of breeding females at various Australian rookeries up to 1990 (Limpus and Reimer 1994) and a decline of approximately 86 percent by 1999 (Limpus and Limpus 2003).

Information from pilot surveys conducted in 2005 in New Caledonia, combined with oral history information collected, suggests a decline in loggerhead nesting with 60-70 loggerheads nesting on the four surveyed New Caledonia beaches during the 2004–2005 nesting season (Limpus et al. 2006). Chaloupka and Limpus (2001) determined that the resident non-breeding loggerhead population on coral reefs of the southern Great Barrier Reef in eastern Australia declined at 3 percent per year from 1985 to the late 1990s. The observed decline was hypothesized as a result of recruitment failure, given few anthropogenic impacts and constant high annual survivorship measured at this foraging habitat (Chaloupka and Limpus 2001). This decline also coincided with a measured decline in new recruits in these foraging areas (Limpus and Limpus 2003). Available evidence indicates that due to loss of adult and juvenile mortalities from fishery bycatch the South Pacific population is declining.

Loggerhead turtles nesting densities in the North Indian Ocean are the largest in the eastern hemisphere with the vast majority of these nests in Oman (Baldwin et al. 2003). Nesting is rare in the rest of the northern Indian Ocean. Nesting surveys and tagging data were used to extrapolate the number of females nesting at Masirah Island during 1977-78 resulting in 19,000 to 60,000 turtles (assuming 100 percent nesting success) and a partial survey of the island in 1991 estimated 23,000 nesters (Baldwin 1992; Ross 1998). Comparing the nesting data collected after 2008 when nesting surveys were standardized at Masirah to the 1977-78 and 1991 yielded an estimate of 20,000-40,000 nesters (assuming 50 percent nesting success). These estimates suggest a decline in the nesting population over the past three decades which is consistent with observations by local rangers. Mortality across all life stages, fishery bycatch, and the loss of nesting habitat is likely to cause this population to decline further.

In the southeast Indo-Pacific Ocean, loggerhead nesting is restricted to Western Australia (Dodd Jr. 1988), which is the largest nesting population in Australia (Natural Heritage Trust, 2005 as cited in (NMFS and USFWS 2007c). Evidence suggests the nesting population in the Muiron Islands and North West Cape region was depleted before recent beach monitoring programs began although the data are insufficient to determine trends (Nishemura and Nakahigashi 1990; Poiner et al. 1990; Poiner and Harris 1996). Juvenile and adult mortality from fishery bycatch presents the greatest threat to this population's probability of extinction.

In the Southwest Indian Ocean, the highest concentration of nesting occurs on the coast of Tongaland, South Africa, where surveys and management practices were instituted in 1963 (Baldwin et al. 2003). Nesting beach data from this region from 1965 to 2008 indicates an increasing nesting population between the first decade of surveys, which documented 500–800 nests annually, and the last 8 years, which documented 1,100–1,500 nests annually (Nel 2006). These data represent approximately 50 percent of all nesting within South Africa and are believed to be representative of trends in the region. Loggerhead nesting occurs elsewhere in South Africa and Madagascar, but sampling is not consistent and no trend data are available.

This population, although small, is increasing but juvenile mortality from fishery bycatch remains a concern.

Loggerheads in the Northwest Atlantic Ocean comprise one of the two largest nesting assemblages in the world and have been identified as the most significant assemblage in the western hemisphere. Data collected over a period of 10 to 23 years indicates that there has been a significant overall decline in nesting numbers (TEWG 2009; Witherington et al. 2009). The annual number of nests has been declining for all subpopulations of Northwest Atlantic loggerheads for which there were adequate data available. Available evidence indicates that this population is declining due to juvenile and adult mortality from fishery bycatch. Five nesting subpopulations have been identified in the Northwest Atlantic Ocean (NMFS and USFWS 2008). Their status follows:

(1) Northern U.S. (Florida/Georgia border to southern Virginia). The Northern U.S. subpopulation is the second largest unit within the Northwest Atlantic population and has been declining significantly at 1.3 percent annually since 1983 (NMFS and USFWS 2008);
(2) PenInsular Florida (Florida/Georgia border south through Pinellas County, excluding the islands west of Key West, Florida). The most significant declining trend has been documented for the PenInsular Florida subpopulation, where nesting declined 26 percent over the 20-year period from 1989–2008, and declined 41 percent over the period 1998–2008 (NMFS and USFWS 2008; Witherington et al. 2009). This subpopulation represents approximately 87 percent of all nesting effort in the Northwest Atlantic Ocean DPS (Ehrhart et al. 2003);
(3) Dry Tortugas (islands west of Key West, Florida). Data are currently not adequate to assess trends in the annual number of nests for this subpopulation;
(4) Northern Gulf of Mexico (Franklin County, Florida, west through Texas). Data are currently not adequate to assess trends in the annual number of nests for this subpopulation; and
(5) Greater Caribbean (Mexico through French Guiana, the Bahamas, Lesser and Greater Antilles). This is the third largest subpopulation within the Northwest Atlantic population, with the majority of nesting at Quintana Roo, Mexico. The TEWG (2009) reported a greater than 5 percent annual decline in loggerhead nesting from 1995–2006 at Quintana Roo.

In the northeastern Atlantic, the Cape Verde Islands support the only large nesting population of loggerheads in the region (Fretey 2001). Nesting occurs at some level on most of the islands in the archipelago with the largest nesting numbers reported from Boa Vista Island where 833 and 1,917 nests were reported in 2001 and 2002, respectively, and between 1998 and 2002 the local project had tagged 2,856 females (Cruz et al. 2007). More recently, in 2005, about 3,121 females

were reported (López-Jurado et al. 2003). Elsewhere in the northeastern Atlantic, loggerhead nesting is non-existent or occurs at very low levels. Population trends could not be determined for the Cape Verde population because of limited data; however, evidence of directed killing of nesting females suggests that this nesting population is under severe pressure and likely significantly reduced from historic levels. Available evidence indicates that this population is declining due to ongoing mortality of mature females and eggs, low hatchling and emergence success and mortality of juveniles and adults from fishery bycatch.

Nesting occurs throughout the central and eastern Mediterranean and sporadic nesting has been reported in the western Mediterranean, however, the vast majority of nesting (greater than 80 percent) occurs in Greece and Turkey (Margaritoulis et al. 2003). The documented annual nesting of loggerheads in the Mediterranean averages about 5,000 nests (Margaritoulis et al. 2003). There is no discernible trend in nesting at the two longest monitoring projects in Greece, Laganas Bay (Margaritoulis 2006) and southern Kyparissia Bay (Margaritoulis and Rees 2001). However, nesting at two beaches, Rethymno Beach, which accounts for approximately 7 percent of all documented loggerhead nesting in the Mediterranean, and Fethiye Beach in Turkey which accounts for 10 percent of nesting in Turkey, showed a declining trend in 1990–2004 and 1993-2004, respectively (Ilgaz et al. 2007). Juvenile and adult mortality from fishery bycatch and the loss of nesting habitat, eggs and hatchlings remain a concern for this population.

In the South Atlantic nesting occurs primarily along the mainland coast of Brazil. Prior to 1980, loggerhead nesting populations in Brazil were considered depleted, however, an increasing trend has been reported from 1988 through 2003 on beaches representing more than 75 percent of all loggerhead nesting in Brazil. A total of 4,837 nests were reported from these survey beaches for the 2003–2004 nesting season (Marcovaldi and Chaloupka 2007). Juvenile mortality from fishery bycatch remains a concern for this population.

Diving and Social 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 (Sakamot et al. 1990 cited in Lutcavage and Lutz 1997).Two loggerheads tagged by Hawaii-based longline observers in the North Pacific and attached with satellite-linked dive recorders were tracked for about 5 months. Analyses of the dive data indicate that most of the dives were very shallow - 70 percent of the dives were no deeper than 5 meters. In addition, the loggerheads spent approximately 40 percent of their time in the top meter and nearly all of their time at depths shallower than 100 meters. On 5 percent 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

Sea turtles do not appear to use sound for communication, and there are no published recordings of loggerhead turtle vocalizations. Nesting leatherback turtles have been recorded producing sounds (sighs, grunts or belch-like sounds) up to 1,200 Hz with maximum energy from 300 to 500 Hz (Cook and Forrest 2005; Mrosovsky 1972). However these sounds appeared to be associated with breathing (Cook and Forrest 2005; Mrosovsky 1972).

Two studies have been conducted to measure loggerhead turtle hearing sensitivity, each using a slightly different methodology. Vibratory stimuli delivered directly to the tympanun produced auditory brainstem responses in loggerheads between 250 and 750 Hz (Bartol et al. 1999). Underwater tones elicited behavioral responses to frequencies between 50 and 800 Hz and auditory evoked potential responses between 100 and 1,131 Hz in one adult loggerhead (Martin et al. 2012). The lowest threshold recorded in this study was 98 dB re: 1 µPa at 100 Hz.

4.2.14 Olive Ridley Turtle

The olive ridley turtle (*Lepidochelys olivacea*) is a small to medium-sized sea turtle; adults typically range between 55 and 80 cm (22 to 31 in) in carapace length and weigh around 45 kg (100 lb). They are olive/grayish-green (darker in the Atlantic than in the Pacific) with a heart-shaped top shell (carapace) with 5-9 pairs of costal "scutes" with 1-2 claws on their flippers; hatchlings emerge mostly black with a greenish hue on the sides.

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 Pacific 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 (Groombridge 1982; Sternberg and Pritchard 1981).

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 2007). Although they are the most abundant north Pacific sea turtle, surprisingly little is known of the oceanic distribution and critical foraging areas of Pacific ridley turtles.

Most records of olive ridley turtles are from protected, relative shallow marine waters. Nevertheless, olive ridley turtles have also been observed in the open ocean. Since olive ridley turtles throughout the eastern Pacific Ocean depend on rich upwelling areas off South America for food, Pacific 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 turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural threats. The beaches on which olive ridley 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 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 (NMFS and USFWS 1998f). 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 1998f). 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 (Arenas et al. 2000). 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 turtle as “endangered” (IUCN 2010).

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). 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 1998f). In an 11-year review of the nesting at Playa Ostional, (Ballestero et al. 2000) report that the data on numbers of nests deposited is 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 (NMFS and USFWS 1998f). 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 Pacific ridleys on Nicaragua, Ruiz (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 reports 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 1993a; 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 has 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 1993a), while only 187 nests were reported from the area in 1990 (Eckert 1993a). In eastern Malaysia, olive ridleys nest very rarely in Sabah and only a few records are available from Sarak (Eckert 1993a).

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 Pacific 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 percent of the eggs were lost due to inundation and erosion (Shanker and Mohanty 1999). During 1999-2000, over 700,000 olive ridleys nested at Nasi Islands and Babubali Island, in the Gahirmatha coast.

Diving and Social Behavior

Although olive ridley turtles are probably surface feeders, they have been caught in trawls at depths of 80-110 meters (NMFS and USFWS 1998f), 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

Sea turtles do not appear to use sound for communication, and there are no published recordings of olive ridley turtle vocalizations. There is no information on olive ridley turtle hearing. However, we assume that their hearing sensitivities will be similar to those of green, hawksbill, leatherback and loggerhead turtles: their best hearing sensitivity will be in the low frequency range, with maximum sensivitiy below 400 Hz and an upper hearing range not likely to exceed 2000 Hz.

5 ENVIRONMENTAL BASELINE

By regulation, environmental baselines for biological opinions include the past and present impacts of all state, Federal or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR § 402.02). The environmental baseline for this opinion includes the effects of several activities that affect the survival and recovery of listed resources in the action area.

A number of human activities have contributed to the listed status and, in some cases, continued decline of populations of large whales, Hawaiian monk and Guadalupe fur seals, and sea turtles in the action area. Some of those activities, most notably commercial whaling for large whales, occurred extensively in the past. Some of these activities have largely been curtailed through local, national, and international agreements and practices, but continue to impact the status of species now and into the future. The following information summarizes the principal natural and human phenomena in the Hawaiian Islands and Southern California that are believed to affect the survival and recovery of these species in the wild.

5.1 Climate Change

There is now widespread consensus within the scientific community that average atmospheric temperatures on earth are increasing (warming) and that this will continue for at least the next several decades (IPCC 2001; Oreskes 2004; Poloczanska et al. 2013). There is also consensus within the scientific community that this warming trend will alter current weather patterns and patterns associated with climatic phenomena, including the timing and intensity of extreme events such as heat-waves, floods, storms, and wet-dry cycles. The threats posed by the direct and indirect effects of global climate change are, or will be, common to all of the species we discuss in this opinion (Doney et al. 2012; Hazen et al. 2012; Poloczanska et al. 2013).

The Intergovernmental Panel on Climate Change (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. Eleven of the 12 warmest years on record since 1850 have occurred since 1995 (Poloczanska et al. 2009). Furthermore, the Northern Hemisphere (where a greater proportion of ESA-listed species occur) is warming faster than the Southern Hemisphere, although land temperatures are rising more rapidly than over the oceans (Poloczanska et al. 2009). This temperature increase is greater than what would be expected given the range of natural climatic variability recorded over the past 1,000 years (Crowley 2000). Furthermore, the Northern Hemisphere (where a greater proportion of ESA-listed species occur) is warming faster than the Southern Hemisphere, although land temperatures are rising more rapidly than over the oceans (Poloczanska et al. 2009). The Intergovernmental Panel on Climate Change reviewed

computer simulations of the effect of greenhouse gas emissions on observed climate variations that have been recorded in the past and evaluated the influence of natural phenomena such as solar and volcanic activity. Based on their review, the Intergovernmental Panel on Climate Change concluded that natural phenomena are insufficient to explain the increasing trend in land and sea surface temperature, and that most of the warming observed over the last 50 years is likely to be attributable to human activities (IPCC 2001). Climatic models estimate that global temperatures would increase between 1.4 to 5.8°C from 1990 to 2100 if humans do nothing to reduce greenhouse gas emissions (IPCC 2001). Fiedler et al. (2013) for the 50-year period from 1958-2008 concluded that climatic variability has led to documented changes in the pycnocline in the eastern tropical and North Pacific. In particular, "in the eastern equatorial Pacific the pycnocline shoaled by 10 m and weakened by 5 percent over the 50 years, while in the California Current the pycnocline deepened by ~5 m but showed little net change in stratification (which weakened by 5 percent to the mid-1970s, strengthened by 8 percent to the mid-1990s, and then weakened by 4 percent to 2008)". These projections identify a suite of changes in global climate conditions that are relevant to the future status and trend of endangered and threatened species (Table 28).

Climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the reasonably foreseeable future (Houghton 2001; IPCC 2001; Parry et al. 2007) (IPCC 2001; IPCC 2002). The direct effects of climate change will result in increases in atmospheric temperatures, changes in sea surface temperatures, patterns of precipitation, and sea level. Oceanographic models project a weakening of the thermohaline circulation resulting in a reduction of heat transport into high latitudes of Europe, an increase in the mass of the Antarctic ice sheet, and a decrease in the Greenland ice sheet, although the magnitude of these changes remain unknown. Species that are shorter-lived, of larger body size, or generalist in nature are liable to be better able to adapt to climate change over the long term versus those that are longer-lived, smaller-sized, or rely upon specialized habitats (Brashares 2003; Cardillo 2003; Cardillo et al. 2005; Issac 2009; Purvis et al. 2000). Climate change is most likely to have its most pronounced effects on species whose populations are already in tenuous positions (Issac 2009). As such, we expect the risk of extinction to listed species to rise with the degree of climate shift associated with global warming.

Table 28. Phenomena associated with projections of global climate change including levels of confidence associated with projections (adapted from (IPCC 2001) and (Patz et al. 2008)).

Phenomenon	Confidence in Observed Changes (observed in the latter 20th Century)	Confidence in Projected Changes (during the 21st Century)
Higher maximum temperatures and a greater number of hot days over almost all land areas	Likely	Very likely

Higher minimum temperatures with fewer cold days and frost days over almost all land areas	Very likely	Very likely
Reduced diurnal temperature range over most land areas	Very likely	Very likely
Increased heat index over most land areas	Likely over many areas	Very likely over most areas
More intense precipitation events	Likely over many mid- to high-latitude areas in Northern Hemisphere	Very likely over many areas
Increased summer continental drying and associated probability of drought	Likely in a few areas	Likely over most mid-latitude continental interiors (projections are inconsistent for other areas)
Increase in peak wind intensities in tropical cyclones	Not observed	Likely over some areas
Increase in mean and peak precipitation intensities in tropical cyclones	Insufficient data	Likely over some areas

The indirect effects of climate change would result from changes in the distribution of temperatures suitable for calving and rearing calves, the distribution and abundance of prey, and the distribution and abundance of competitors or predators. For example, variations in the recruitment of krill (*Euphausia superba*) and the reproductive success of krill predators have been linked to variations in sea-surface temperatures and the extent of sea-ice cover during the winter months. The 2001 Intergovernmental Panel on Climate Change (2001) did not detect significant changes in the extent of Antarctic sea-ice using satellite measurements, Curran (2003) analyzed ice-core samples from 1841 to 1995 and concluded Antarctic sea ice cover had declined by about 20 percent since the 1950s. The most recent report by the Intergovernmental Panel on Climate Change has found that over the last two decades, the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink almost worldwide, and Arctic sea ice and Northern Hemisphere spring snow cover have continued to decrease in extent (www.climatechange2013.org/images/uploads/WGIAR5-SPM_Approved27Sep2013.pdf).

The indirect effects of climate change would result from changes in the distribution of temperatures suitable for reproduction, the distribution and abundance of prey and abundance of competitors or predators. For species that undergo long migrations, individual movements are usually associated with prey availability or habitat suitability. If either is disrupted by changing ocean temperature regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott. 2009). For sea turtles, warming ocean temperatures may extend poleward the habitat which they can utilize (Poloczanska et al. 2009). Seagrass habitats have declined by 29 percent in the last 130 years and 19 percent of coral reefs have been lost due to human degradation, reducing lower latitude habitat for some sea turtle species (Poloczanska et al. 2009). Primary production is estimated to have declined by 6 percent between the early 1980s and 2010, making foraging more difficult for marine species (Hoegh-Guldberg and Bruno 2010).

The Antarctic Peninsula, which is the northern extension of the Antarctic continent, contains the richest areas of krill in the Southern Ocean. The extent of sea ice cover around this Peninsula has

the highest degree of variability relative to other areas within the distribution of krill. Relatively small changes in climate conditions are likely to exert a strong influence on the seasonal pack-ice zone in the Peninsula area, which is likely to affect densities of krill in this region. Because krill are important prey for baleen whales or form a critical component of the food chains on which baleen whales depend, increasing the variability of krill densities or causing those densities to decline dramatically is likely to have adverse effect on populations of baleen whales in the Southern Ocean.

Reid and Croxall (2001) analyzed a 23-year time series of the reproductive performance of predators that depend on krill for prey — Antarctic fur seals (*Arctocephalus gazella*), gentoo penguins (*Pygoscelis papua*), macaroni penguins (*Eudyptes chrysolophus*), and black-browed albatrosses (*Thalassarche melanophrys*) — at South Georgia Island and concluded that these populations experienced increases in the 1980s followed by significant declines in the 1990s accompanied by an increase in the frequency of years with reduced reproductive success. The authors concluded that macaroni penguins and black-browed albatrosses had declined by as much as 50 percent in the 1990s, although incidental mortalities in longline fisheries probably contributed to the decline of the albatross. These authors concluded, however, that these declines result, at least in part, from changes in the structure of the krill population, particularly reduced recruitment into older age classes, which lowers the number of predators this prey species can sustain. The authors concluded that the biomass of krill within the largest size class was sufficient to support predator demand in the 1980s but not in the 1990s.

Similarly, a study of relationships between climate and sea-temperature changes and the arrival of squid off southwestern England over a 20-year period concluded that veined squid (*Loligo forbesi*) migrate eastwards in the English Channel earlier when water in the preceding months is warmer, and that higher temperatures and early arrival correspond with warm phases of the North Atlantic oscillation (Sims et al. 2001). The timing of squid peak abundance advanced by 120- 150 days in the warmest years compared with the coldest. Seabottom temperatures were closely linked to the extent of squid movement and temperature increases over the five months prior to and during the month of peak squid abundance did not differ between early and late years. These authors concluded that the temporal variation in peak abundance of squid seen off Plymouth represents temperature-dependent movement, which is in turn mediated by climatic changes associated with the North Atlantic Oscillation. Changes in oxygen concentrations and positon within the California Current have the potential to impact the prey of sperm whales.

Hazen et al. (2012) predicted up to 35 pecent change in core habitat for some key Pacific species based on climate change scenarios predicated on the rise in average sea surface temperature by 2100. Climate-mediated changes in the distribution and abundance of keystone prey species like krill and climate-mediated changes in the distribution of cephalopod populations worldwide is likely to affect marine mammal populations as they re-distribute throughout the world's oceans

in search of prey. Blue whales, as predators that specialize in eating krill, seem likely to change their distribution in response to changes in the distribution of krill (for example, see Payne et al. 1990; Payne 1986); if they did not change their distribution or could not find the biomass of krill necessary to sustain their population numbers, their populations seem likely to experience declines similar to those observed in other krill predators, which would cause dramatic declines in their population sizes or would increase the year-to-year variation in population size; either of these outcomes would dramatically increase the extinction probabilities of these whales.

Sperm whales, whose diets can be dominated by cephalopods, would have to re-distribute following changes in the distribution and abundance of their prey. This statement assumes that projected changes in global climate would only affect the distribution of cephalopod populations, but would not reduce the number or density of cephalopod populations. If, however, cephalopod populations collapse or decline dramatically, sperm whale populations are likely to collapse or decline dramatically as well.

Periodic weather patterns such as El Niño, La Niña, the Pacific decadal oscillation, and North Pacific Gyre Oscillation can fundamentally change oceanographic conditions in the northeastern Pacific and the biology that is based upon it (Chenillat et al. 2013; Chenillat et al. 2012; Doney et al. 2012; Kudela et al. 2008; Litzow and Mueter 2013; Mundy and Cooney 2005; Mundy and Olsson 2005; Stabeno et al. 2004; Sydeman et al. 2013). (. Roughly every 3-7 years, El Niño can influence the northeastern Pacific (JOI/USSSP 2003; Stabeno et al. 2004). Typical changes include increased winter air temperature, precipitation, sea level, and down welling favorable conditions (Royer and Weingartner 1999; Whitney et al. 1999). La Niña events tend to swing these conditions in the negative direction (Stabeno et al. 2004). However, sea surface temperatures (SSTs) can take 1 year to change following an El Niño event or change to varying degrees (Bailey et al. 1995; Brodeur et al. 1996a; Freeland 1990; Royer 2005). The 1982/1983 El Niño and other down welling events are generally regarded to have reduced food supplies for marine mammals along the U.S. west coast (Feldkamp et al. 1991; Hayward 2000; Le Boeuf and Crocker 2005). During La Niña conditions in the Gulf of California, Bryde's whales were found to be more abundant, possibly due to increased availability of their prey under La Niña conditions (Salvadeo et al. 2011). Marine mammal distribution and social organization (group size) is also believed to have shifted northward in response to persistent or extralimital prey occurrence in more northerly waters during El Niño events (Benson et al. 2002; Danil and Chivers 2005; Lusseau et al. 2004; Norman et al. 2004b; Shane 1994; Shane 1995). Low reproductive success and body condition in humpback whales have also been suggested to have resulted from the 1997/1998 El Niño (Cerchio et al. 2005). El Niño events in the winters of 1952-1953, 1957-1958, 1965-1966, and 1982-1983 were associated with strong down welling anomalies, which reduces nutrient availability for plankton (Bailey et al. 1995; Thomas and Strub 2001; Wheeler and Hill 1999). Plankton diversity also shifts, as smaller plankton are better able to cope with reduced nutrient availability (Corwith and Wheeler 2002; Sherr et al. 2005).

The Pacific decadal oscillation is the leading mode of variability in the North Pacific and operates over longer periods than either El Niño or La Niña and is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua 2002; Mantua and Hare 2002b; Stabeno et al. 2004). Unlike El Niño and La Niña events, Pacific decadal oscillation events can persist for 20-30 years, are more prominent outside the tropics, and mechanisms controlling them are relatively unknown (Hare and Mantua 2000; Mantua and Hare 2002b; Minobe 1997; Minobe 1999). During positive Pacific decadal oscillations, the northeastern Pacific experiences above-average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Mundy and Olsson 2005; Royer 2005). Warm Pacific decadal oscillation regimes, as with El Niño events, tends to decrease productivity along the U.S. west coast (Childers et al. 2005; Hare et al. 1999). However, during the 1977 warm phase of the Pacific decadal oscillation, euphausiid biomass remained the same and copepod abundance actually increased in the Pacific northwest; zooplankton biomass doubled in offshore waters of the Gulf of Alaska (Brodeur et al. 1996b; Brodeur and Ware 1992; Francis and Hare 1997; MacCall et al. 2005; McFarlane and Beamish 1992). Opposite sea surface temperature regimes occur during negative Pacific decadal oscillations (Mundy and Olsson 2005). Positive Pacific decadal oscillations occurred from 1925-1946 and 1977-1999. Negative Pacific decadal oscillations occurred from 1890-1924, 1947-1976, and 1999-present (Childers et al. 2005; Mantua et al. 1997; Minobe 1997).

Recently, additional research has shown that the North Pacific Gyre Oscillation as impacted by the Pacific Decadal Oscillation and El Niño or La Niña events may have a dominant influence on California Current oceanography and associated biological productively (Chenillat et al. 2013; Di Lorenzo et al. 2008; Litzow and Mueter 2013; Patara et al. 2012; Sydeman et al. 2013). While fluctuations in the North Pacific Gyre Oscillation are strongly influenced by the Pacific Decadal Oscillation, the North Pacific Gyre Oscillation in turn has a more dramatic impact and is better correlated with North Pacific variability in salinity, nutrients, chlorophyll, and a variety of zooplankton taxa (Di Lorenzo et al. 2008). Chenillat et al. (2013) found that within the California Current System, changes in the North Pacific Gyre Oscillation impacted timing of spring time favorable winds responsible for the wind driven upwelling and associated nutrient and biological productivity. Sydeman et al. (2013) showed how variation in the North Pacific Gyre Oscillation could account for North Pacific krill productively (primarily *Thysanoessa spinifera*). Thysanoessa spinifera is a key prey species for blue whales off Central and Southern California (Fiedler et al. 1998; Schoenherr 1991).

Foraging is not the only aspect that climate change could influence. Acevedo-Whitehouse and Duffus (2009) proposed that the rapidity of environmental changes, such as those resulting from global warming, can harm immunocompetence and reproductive parameters in wildlife to the detriment of population viability and persistence. An example of this is the altered sex ratios observed in sea turtle populations worldwide (Fuentes et al. 2009a; Mazaris et al. 2008; Reina et

al. 2008; Robinson et al. 2008). This does not appear to have yet affected population viabilities through reduced reproductive success, although nesting and emergence dates of days to weeks in some locations have changed over the past several decades (Poloczanska et al. 2009). Altered ranges can also result in the spread of novel diseases to new areas via shifts in host ranges (Simmonds and Eliott. 2009). It has also been suggested that increases in harmful algal blooms could be a result from increases in sea surface temperature (Simmonds and Eliott. 2009).

Changes in global climatic patterns will likely have profound effects on the coastlines of every continent by increasing sea levels and the intensity, if not the frequency, of hurricanes and tropical storms (Wilkinson and Souter 2008). A half degree Celsius increase in temperatures during hurricane season from 1965-2005 correlated with a 40 percent increase in cyclone activity in the Atlantic. Sea levels have risen an average of 1.7 mm/year over the 20th century due to glacial melting and thermal expansion of ocean water; this rate will likely increase. Based on computer models, these phenomena would inundate nesting beaches of sea turtles, change patterns of coastal erosion and sand accretion that are necessary to maintain those beaches, and would increase the number of turtle nests destroyed by tropical storms and hurricanes (Wilkinson and Souter 2008). The loss of nesting beaches, by itself, would have catastrophic effects on sea turtle populations globally if they are unable to colonize new beaches that form or if the beaches do not provide the habitat attributes (sand depth, temperature regimes, refuge) necessary for egg survival. In some areas, increases in sea level alone may be sufficient to inundate sea turtle nests and reduce hatching success (Caut et al. 2009). Storms may also cause direct harm to sea turtles, causing “mass” strandings and mortality (Poloczanska et al. 2009). Increasing temperatures in sea turtle nests alters sex ratios, reduces incubation times (producing smaller hatchling), and reduces nesting success due to exceeded thermal tolerances (Fuentes et al. 2009b; Fuentes et al. 2010; Fuentes et al. 2009c). Additionally, green sea turtle hatchling size also appears to be influenced by incubation temperatures, with smaller hatchlings produced at higher temperatures (Glen et al. 2003). More ominously, an air temperature increase of 3°C is likely to exceed the thermal threshold of most clutches, leading to death (Hawkes et al. 2007). Smaller individuals likely experience increased predation (Fuentes et al. 2009b) Climatic anomalies influencing the Marianas Islands include El Niño/Southern Oscillation (ENSO) and La Niña events (Giese and Carton 1999; Mantua and Hare 2002a; NOAA 2005a; NOAA 2005b; Sugimoto et al. 2001; Trenberth 1997). Although Guam and the Southern Marianas Islands do not appear to experience altered rainfall patterns during El Niño events, the Northern Marianas tend to experience drier dry seasons and wetter wet seasons (Pacific ENSO Applications Center 1995). Sea surface temperature in the regions also increases due to a weakening of a high pressure system over the western Pacific, potentially influencing the distribution of fish (Kubota 1987; Lehodey et al. 1997). Although typhoons tend to be more frequent during El Niño events (likely occurring at present), their tracks tend to be more to the northwest, away from the action area (Elsner and Liu 2003; Saunders et al. 2000).

Recent research egg and hatchling mortality of leatherback turtles in northwest Costa Rica were affected by climatic variability (precipitation and air temperature) driven by the El Niño Southern Oscillation (ENSO). Drier and warmer conditions associated with El Niño increased egg and hatchling mortality (Santidrián Tomillo et al. 2012). The fourth assessment report of the IPCC projects a warming and drying in Central America and other regions of the World (IPCC 2007). Using projections from an ensemble of global climate models contributed to the Intergovernmental Panel on Climate Change report, Santidrián et al. (2012) projected that egg and hatchling survival will rapidly decline in the region over the next 100 years, due to warming and drying in northwestern Costa Rica. Warming and drying trends may threaten the survival of sea turtles.

5.2 Natural Mortality

Natural mortality rates in cetaceans, especially large whale species, are largely unknown. Although factors contributing to natural mortality cannot be quantified at this time, there are a number of suspected causes, including parasites, predation, red tide toxins and ice entrapment. For example, the giant spirurid nematode (*Crassicauda boopis*) has been attributed to congestive kidney failure and death in some large whale species (Lambertsen 1986). A well-documented observation of killer whales attacking a blue whale off Baja, California, 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. Nitta (1991) reported that between 1936 and 1988, 8 humpback whales, 1 fin whale, and 5 sperm whales stranded in the Hawaiian Archipelago. In a partial update of that earlier report, Maldini et al. (2005) identified 202 toothed cetaceans that had stranded between 1950 and 2002. Sperm whales represented 10 percent of that total. Although these two studies did not specify the cause or causes of death in these cases, we include these strandings in this discussion of sources of natural mortality because the causes of death remain unknown. Most of these stranding events consisted of individual animals and many of the multiple stranding events identified in these reports occurred prior to the mid-1960s (4 of the 8 multiple stranding events identified by Maldini et al. occurred between 1957 and 1959, 3 of 8 occurred in 1976, and 1 occurred in 1981).

Sea turtles are exposed to a wide variety of natural threats. The beaches on which 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 individuals, including adults, are also killed by sharks and other large, marine predators.

Monk seals are threatened by natural predation, disease outbreaks, biotoxins, and agonistic behavior by male monk seals. Monk seals, particularly pups, are also subjected to extensive

predation by sharks, which appear to be a particular problem for the monk seals occupying French Frigate Shoals in the Northwest Hawaiian Islands. Monk seal remains have been found in the stomachs of both tiger and Galapagos sharks. Sharks predation has increased significantly in the Northwest Hawaiian Islands, particularly French Frigate Shoals.

5.3 Human-induced Mortality

Sources of human-induced mortality on whales, monk seals, and sea turtles include commercial whaling, subsistence hunting, commercial fishing, ship strikes, and habitat degradation. These sources of mortality are discussed below.

5.3.1 Hawaiian Monk Seal Killings

Several Hawaiian monk seals have been shot and killed in the main Hawaiian Islands over the past several years, including three mortalities in 2009 (Carretta et al. 2013). Another dead individual individual was found with multiple skull fractures in 2010 (Carretta et al. 2013).

5.3.2 Commercial Whaling and Subsistence Hunting

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. 1999a). Sei whales are estimated to have been reduced to 20 percent (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific (Tillman 1977). In addition, 9,500 blue whales were reported killed by commercial whalers in the North Pacific between 1910-1965 (Ohsumi and Wada 1972) and 25,800 sperm whales (Barlow et al. 1997b). North Pacific right whales once numbered 11,000 animals prior to commercial whaling, which largely reduced their population to 29-100 animals (Wada 1973). These numbers likely represent minimums harvested, as illegal or underreported harvests are not included. 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.

5.3.3 Entrapment and Entanglement Bycatch 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 and sea turtle 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). Many of the entangled humpback whales

observed in Hawaiian 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 Hawaiian Islands have been confirmed to have been entangled in gear from Alaska. Nevertheless, humpback whales are also entangled in fishing gear in the Hawaiian Islands. Since 2001, there have been 5 observed interactions between humpback whales and gear associated with the Hawaii-based longline fisheries (NMFS 2008a). 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. A photography study of humpback whales in southeastern Alaska in 2003 and 2004 found at least 53 percent of individuals showed some kind of scarring from fishing gear entanglement (Neilson et al. 2005).

False killer whales in Hawaiian waters have been seen to take catches from longline and trolling lines (Nitta and Henderson 1993; Shallenberger et al. 1981). Interactions with longline and troll fishery operations appear to result in disfigurement to dorsal fins, with roughly 4 percent of the population showing this injury, as well as entanglement and hooking (Baird and Gorgone 2005; Forney and Kobayashi. 2007; McCracken and Forney 2010; Nitta and Henderson 1993; Shallenberger et al. 1981; Zimmerman 1983). Carretta et al. (2013) estimated that less than one (0.5, CV=1.7) individuals per year from the MHI insular false killer whale stock are killed or seriously injured during the course of fishing operations in the Hawaiian exclusive economic zone.

Saez et al (2012) reported that gray and humpback whales were the most commonly entangled species in fishing gear along the U.S. West Coast. Of the 272 reported entangled whales from 1982 to 2010, off California there were 150 gray whale entanglements, 47 humpback whale entanglements, 27 unidentified whale species entanglements, 14 sperm whale species entanglements,6 minke whale entanglements, 3 fin whale entanglements, and zero blue whale entanglements. Traps and pots are the most common fishing gear reported as entangling West Coast whales (45 percent).

To date, no sei whales have been killed in interactions with any eastern North Pacific fisheries, but the true mortality rate must be considered unknown because of unobserved mortality. Sperm whale interactions with the longline fisheries in the Gulf of Alaska are increasing in frequency with the first documented entanglement occurring in June of 1997 (Hill et al. 1999; Sigler et al. 2008).

In 1999, one fin whale was killed as a result of interactions with gear that is being used in the Bering Sea/Aleutian Island groundfish trawl fishery. Because the size of the fin whale population remains unknown, the effect of that whale's death on the trend of the fin whale population is uncertain.

From 2003 to 2007, there were 86 reports of human-related mortalities or injuries of humpback whales in Alaskan waters. Of these, there were 54 incidents which involved commercial fishing gear, and 23 of those incidents involved serious injuries or mortalities (Allen and Angliss 2010).

Sea turtles are also impacted by commercial fisheries. The foremost threat is the number of sea 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 percent mortality rate (or 33 percent if most mortality was focused on the East Pacific population). Spotila (2000) asserts that most of the mortality associated with the Playa Grande nesting site was fishery related. In the Pacific Ocean, between 1,000 and 1,300 leatherback 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 Hawaii are estimated to have captured and killed several hundred leatherback 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 turtles each year. Between 2004 and 2008, shallow-set fisheries based out of Hawaii are estimated to have captured about 19 leatherback 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 reasonably foreseeable future. Leatherback sea turtles have also been and are expected to continue to be captured and killed in the deep-set based longline fisheries based out of Hawaii and American Samoa.

Loggerhead sea turtles are also captured and killed in commercial fisheries. In the Pacific Ocean, between 2,600 and 6,000 loggerhead turtles were estimated to have been captured and killed in longline fisheries in 2000 (Lewison et al. 2004). Shallow-set Hawaii based longline fisheries are estimated to have captured and killed several hundred loggerhead 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 turtles each year. Between 2004 and 2008, shallow-set fisheries based out of Hawaii are estimated to have captured about 45 loggerhead turtles, killing about 10 of these sea turtles. This fishery has interacted with 3 loggerhead and 9 leatherback turtles in 2009 and 7 loggerhead and 8 leatherback turtles in 2010 (NMFS 2011b). These fisheries are expected to continue at similar rates of interaction and deaths into the reasonably foreseeable future. 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 Hawaii and American Samoa. Green, hawksbill and Pacific ridley sea turtles are not expected to be captured in the longline fishery.

Historically, monk seals have become entangled in net, line (including monofilament nylon line), net and line combinations, straps, rings (including hagfish or eel traps), and other random items such as discarded lifejackets, buckets (portion of rims), bicycle tires, rubber hoses, etc.

(Henderson 1990c). Between 1982 and 2006, a total of 268 entanglements of monk seals were documented, including 118 in fishing gear. There were 57 serious injuries (including 32 from fishing gear) and 8 mortalities (including 7 from fishery items). From 1982 – 2000, there was an estimated minimum rate of 2.3 serious injuries or deaths per year attributable to fishery related marine debris (NMFS 2007c).

5.3.4 Vessel Strikes

Vessel strike of sea turtles is a poorly-studied threat to sea turtles, but has the potential to be highly-significant (Work et al. 2010a). All sea turtles must surface to breath and several species are known to bask at the surface for long periods, including loggerhead sea turtles. Although sea turtles can move rapidly, sea turtles apparently are not well able to move out of the way of vessels moving at more than 4 km/hr; most vessels move far faster than this in open water (Hazel et al. 2007; Work et al. 2010a). This, combined with the massive level of vessel traffic in the Gulf of Mexico, has the potential to result in frequent injury and mortality to sea turtles in the region (MMS 2007). Hazel et al. (2007) suggested that green sea turtles may use auditory cues to react to approaching vessels rather than visual cues, making them more susceptible to strike as vessel speed increases.

Collisions with commercial ships are an increasing threat to many large whale species, particularly as shipping lanes cross important large whale breeding and feeding habitats or migratory routes. The number of observed physical injuries to humpback whales as a result of ship collisions has increased in Hawaiian waters (Glockner-Ferrari et al. 1987; Lammers et al. 2007), possibly partly stemming from rapid humpback whale population growth. On the Pacific coast, a humpback whale is probably killed about every other year by ship strikes (Barlow et al. 1997b). Through 2008, 82 instances of humpback whale shipstrike have been found (Gabriele et al. 2011).

In the California/Mexico stock of blue whales, annual incidental mortality due to vessel strikes averaged one whale every 5 years, but we cannot determine if this reflects the actual number of blue whales struck and killed by vessels (i.e., individuals not observed when struck and those who do not strand; Barlow et al. (1997a)). Vessel strikes have recently averaged roughly one every other year (eight strike incidents are known (Jensen and Silber 2004a), but in September 2007, vessels struck five blue whales within a few-day period off southern California (Calambokidis pers. comm. 2008)(Berman-Kowalewski et al. 2010). Dive data support a surface-oriented behavior during nighttime that would make blue whales particularly vulnerable to vessel strikes during this time. Vessel strikes were implicated in the deaths of five blue whales, from 2004-2008 (Carretta et al. 2011). Four of these deaths occurred in 2007, the highest number recorded for any year. During 2004-2008, there were an additional eight injuries of unidentified large whales attributed to vessel strikes. Several blue whales have been photographed in California with large gashes in their dorsal surface that appear to be from vessel

strikes. Blue whale mortality and injuries attributed to vessel strikes in California waters averaged 1.0 per year for 2004-2008. Additional mortality from vessel strikes probably goes unreported because the whales do not strand or, if they do, they do not always have obvious signs of trauma. Studies have shown that blue whales respond to approaching vessels 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 1983b).

The vast majority of vessel strike mortalities are never identified, and actual mortality is higher than currently documented. Jensen and Silber's (2004a) review of the NMFS' ship strike database revealed fin whales as the most frequently confirmed victims of ship strikes (26 percent of the recorded ship strikes [n = 75/292 records]), with most collisions occurring off the east coast, followed by the west coast of the U.S. and Alaska/Hawaii. Five of seven fin whales stranded along Washington State and Oregon showed evidence of vessel strike with incidence increasing since 2002 (Douglas et al. 2008a). From 1994-1998, two fin whales were presumed killed by vessel strikes. More recently, in 2002, three fin whales were struck and killed by vessels in the eastern North Pacific (Jensen and Silber 2003). From 1991-2010, 11 fin whales were involved in vessel strikes off California (82 percent north of the HSTT Study Area). From 1994 – 1998, two fin whales were presumed to have been killed in ship strikes. In 2006-2007, the stranding network in Hawaii reported eight ship strikes, three of which were reported to have injured the whale involved. In 1996, a humpback whale calf was found stranded on Oahu with evidence of vessel collision (propeller cuts; NMFS unpublished data). From 1991-2010, eight ship strikes of humpback whales in California waters were documented, all of which were north of the action area.

Despite these reports, the magnitude of the risks commercial ship traffic poses to large whales in the Action Area is difficult to quantify or estimate. We struggle to estimate the number of whales that are killed or seriously injured in vessel 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. With the information available, we know those interactions occur but we cannot estimate their significance to the different species of whales in the Action Area.

5.3.5 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 paralytic shellfish poisoning toxins are affecting marine mammals, possibly resulting in lower respiratory function, changes in feeding behavior and a lower reproduction fitness (Durbin et al. 2002). There are four types of "shellfish" poisoning including; paralytic shellfish poisoning from *Alexandrium spp*

(dinoflagellate) and amnesic shellfish poisoning from domoic acid from *Pseudonitzschia spp* (diatom). Domoic acid poisoning also impairs nervous and respiratoiry function, sometimes to point of death (Bargu et al. 2002; Fire et al. 2010; Lefebvre et al. 2002; Lewitus et al. 2012; Scholin et al. 2000; Silvagni et al. 2005).

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, 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 and sea turtles in the proposed action area.

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

Very little is known about baseline levels and physiological effects of environmental contaminants on marine turtle populations (Bishop et al. 1991; Witkowski and Frazier 1982). There are a few isolated studies on organic contaminants and trace metal accumulation in green and leatherback turtles (Aguirre et al. 1994; Davenport et al. 1990). Mckenzie et al. (McKenzie et al. 1999) measured concentrations of chlorobiphenyls and organochlorine pesticides in marine turtle tissues collected from the Mediterranean (Cyprus, Greece) and European Atlantic waters (Scotland) between 1994 and 1996. Omnivorous loggerhead turtles had the highest organochlorine contaminant concentrations in all the tissues sampled, including those from green and leatherback turtles. It is thought that dietary preferences were likely to be the main differentiating factor among species (Storelli et al. 2008). Keller et al. (2005) found that chronic exposure of sea turtles to organochlorine contaminants (such as PCBs and pesticides) may modulate the immune response in these animals by suppressing innate immunity and enhancing

certain lymphocyte activity. More research is needed on the short- and long-term health and fecundity effects of chlorobiphenyl, organochlorine, and heavy metal accumulation in sea turtles. Domoic acid can also impact sea turtles of the action area (Jacobson et al. 2006).

Anthropogenic Noise. The marine mammals and sea turtles that occur in the action area are regularly exposed to several sources of natural and anthropogenic sounds. Anthropogenic noises that could affect ambient noise arise from the following general types of activities in and near the sea, any combination of which can contribute to the total noise at any one place and time. These noises include transportation, dredging, construction; oil, gas, and mineral exploration in offshore areas; geophysical (seismic) surveys; sonars; explosions; and ocean research activities (Richardson et al. 1995b).

Noise in the marine environment has received a lot of attention in recent years and is likely to continue to receive attention in the reasonably 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; NRC 2000; NRC 2003b; NRC 2005; Richardson et al. 1995b). Recent measurements suggest that there has been a reduction in commercial shipping noise in Southern California watersMcKenna et al. 2012. McKenna et al. (2012) documenting a 12 dB net reduction in average noise levels in Southern California. McDonald et al. 2008 noted that from a site near San Clemente Island in Southern California, when local ship were excluded from analysis, ambient noise from 2005-2006 was similar to levels reported in 1958 and 1963.

Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003b). 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 2003b).

Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995b). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Baker et al. 1983; Bauer and Herman 1986; Hall 1982; Krieger and Wing 1984), but the long-term effects, if any, are unclear or not detectable.

Anthropogenic noise may interfere with active echolocation, which is the primary foraging tool for odontocete cetaceans. Researchers have found that either lower levels of anthropogenic noise presented for long time periods or intense sonar pings for short time periods (Mooney et al.

2009b) can produce a temporary reduction in hearing sensitivity and temporary threshold shifts(Nachtigall et al. 2012). Intense sounds intended to disrupt echolocation can also reduce echolocation performance (Mooney et al. 2009a; Mooney et al. 2009c; Nachtigall et al. 2012) (Nachtigall et al. 2003; Nachtigall et al. 2004). Carretta et al. (2001) and Jasny et al. (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate.

Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans (Simmonds and Hutchinson 1996). The radiated noise spectrum of merchant ships ranges from 20 to 500 Hz and peaks at approximately 60 Hz. 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 (Navy 2001). 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. The National Research Council (NRC 2000) 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. 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.

Several major ports occur along the U.S. west coast, including Portland, San Francisco, Los Angeles, Long Beach, and San Diego (DoT 2005). These ports service a wide variety of vessels, including cargo, tug and barges, small ships, liquid bulk, dry bulk, break bulk, intermodal (container, roll-on/roll-off, lighter aboard ship), ferry, tourist passenger vessels (sailboats, ferry, party-boat fishing, whale watching) and cruise ships. Long Beach is among the largest ports in the U.S., accounting for 6 percent of the total cargo entering the U.S., and increasing rapidly (growing 122 percent between 2003 and 2006) (DoT 2007a; DoT 2007b). Los Angeles is also the fifth largest cruise ship terminal in the U.S.A. shipping lane runs along the U.S. west coast south to southern California and additional shipping lanes extend westward from San Francisco and near Santa Barbara Island. Shipping lanes also extend from Hawaii (primarily Honolulu) to other regions along the Pacific Rim.

5.3.6 Invasive Species

Invasive species have been referred to as one of the top four threats to the world's oceans consistently ranked behind habitat degradation and alteration (Pughiuc 2010; Raaymakers 2003; Raaymakers and Hilliard 2002; Terdalkar et al. 2005; Wambiji et al. 2007). In most cases, habitat is directly affected by human alterations, as identified in the baseline section, such as hydromodification, mining, dredging, drilling, and construction. However, invasive species,

facilitated by human commerce, have the ability to directly alter ecosystems upon which listed species rely.

Invasive species are a major threat to many ESA-listed species. For species listed by the USFWS, 26 percent were listed partially because of the impacts of invasive species and 7 percent were listed because invasive species were the major cause of listing (Anttila et al. 1998). Pimentel et al. (2004) found that roughly 40 percent of listed species are at risk of becoming endangered or extinct completely or in part due to invasive species, while Wilcove et al. (1998) found this to be 49 percent, with 27 percent of invertebrates, 37 percent of reptiles, 53 percent of fishes, and 57 percent of plants imperiled partly or wholly due to non-native invasions. In some regions of the world, up to 80 percent of species facing extinction are threatened by invasive species (Pimentel et al. 2004; Yan et al. 2002). Clavero and Garcia-Bertro (2005) found that invasive species were a contributing cause to over half of the extinct species in the IUCN database; invasive species were the only cited cause in 20 percent of those cases. Richter et al. (1997) identified invasive species as one of three top threats to threatened and endangered freshwater species in the U.S. as a whole.

5.3.7 Diseases

The impacts of introduced pathogens in the aquatic environment has been poorly explored and we likely know very little about the true frequency and significance of pathogen invasions (Drake et al. 2001). Pathogens have adverse effects to invertebrate communities. Molluscs such as black and white abalone seem to be particularly sensitive to pathogens. Various species of the genus *Vibrio*, known to cause cholera in humans, white pox and white plague type II diseases in corals, and mortality in abalone of the same genus as black and white abalone, have been identified in ports and ballast water of vessels (Aguirremacedo et al. 2008; Anguiano-Beltrán et al. 1998; Ben-Haim and Rosenberg 2002). Oyster species have sustained several outbreaks from invasive pathogens, including *Haplosporidium nelsoni* (the cause of MSX disease, which Chesapeake Bay eastern oysters have shown 75-92 percent mortality to) and *Perkinsus marinus* (the cause of Dermo disease) in California, eastern North America, and Europe (Andrews 1984; Burreson and Ford 2004; Burreson et al. 2000; Ford and Haskin 1982; Renault et al. 2000), *Bonamia ostreae* in Europe (Ciguarria and Elston 1997; Van Banning 1987), and in the northeastern US, respectively (Ford 1996).

5.3.8 Habitat Impacts

In general, species located higher within a food web (including most ESA-listed species under NMFS' jurisdiction) are more likely to become extinct as a result of an invasion; conversely, species that are more centrally or bottom-oriented within a food web are more likely to establish (Byrnes et al. 2007; Harvey and May 1997). Propagule pressure is generally the reason for this trend; as individuals lower in the food web tend to have higher fecundity and lower survival rates (r-selection). This unbalancing of food webs makes subsequent introductions more likely as resource utilization shifts, increasing resource availability, and exploitation success by non-

native species (Barko and Smart 1981; Byrnes et al. 2007). Such shifts in the base of food webs fundamentally alters predator-prey dynamics up and across food chains (Moncheva and Kamburska 2002). The number of extinction events seems to be roughly correlated with the number of invasive establishments within an area (Harvey and May 1997).

Pathogens and species with toxic effects not only have direct effects to listed species, but also may affect primary constituent elements of critical habitat or indirectly affect the species through ecosystem-mediated impacts. There are a number of non-native species that have the potential to either expel toxins at low levels, only becoming problematic for other members of the ecosystem if their population grows to very large sizes, resulting in very large amounts of toxins being released. In other cases, pathogens are introduced to an environment affecting organisms in the environment that would directly affect critical habitat primary constituent elements or indirectly affect listed species. Pathogens are in some cases very specific to hosts, but when a species similar to a listed species is introduced, eventually that parasite that specific to the non-native species can shift to also affecting similar native populations. In these cases, the effects may be directly adverse to listed species or indirect to food resources as identified in a species' critical habitat. And in other cases, parasites can have direct effects to primary constituent elements of designated critical habitat or indirectly affect listed species.

Red tide dinoflagellates have been introduced via ballast water discharges and have the potential to undergo extreme seasonal population fluctuations. During bloom conditions, high levels of neurotoxins are released into local and regional surface water and air that can cause illness and death in fishes, sea turtles, marine mammals, and invertebrates (as well as their larvae) (Hallegraeff and Bolch 1992; Hallegraeff 1998; Hamer et al. 2001; Hamer et al. 2000; Lilly et al. 2002; McMinn et al. 1997). The brown alga, *Aureococcus anophagefferens*, causes brown tide when it blooms, causing diebacks of eelgrass habitat due to blooms decreasing light availability and failure of scallops and mussels to recruit (Doblin et al. 2004).

The most commonly reported impact of non-native species in the freshwater and coastal environment is competition for limited resources (Nyberg 2007). Molluscs, decapods, and aquatic plants as taxonomic groups tend to be especially capable invaders and have proven to be disruptive to food webs. The most common impacts are alteration of habitat and nutrient availability as well as altering species composition and diversity within an ecosystem (Strayer 2010). Crabs, polychaetes, and mussels can increase bioturbation and aerate the sediment (Nyberg 2007). Gastropods can alter the biogeochemical cycle through excretion of biogenic silicate in the faeces and pseudofaeces (Ragueneau et al. 2005). Molluscan invasions can also provide substrate for epibionts, shelter for benthic species, remove nutrients from the water, decrease turbidity and increase light penetration, remove sediments, and promote phytoplankton blooms by releasing nutrients from sediments (Bertness 1984; Gutierrez et al. 2003; Hecky et al. 2004).

There are many examples of invertebrate competition either indirectly affecting similar species to listed species under NMFS jurisdiction or directly affecting the habitat they rely on. The compound tunicate, *Botrylloides sandiegensis*, was released near Woods Hole, Massachussetts and has outcompeted other encrusting organism in the coastal environment of southern New England (Lafferty and Kuris 1996). The invasive green mussel *Perna viridis* may competitively displace the native scorched mussel *Brachidontes exustus* through its greater growth rate and maximum size in Tampa Bay (Ranwell 1964).

Other taxa also significantly alter habitat. Invasive plants can cause widespread habitat alteration, including native plant displacement, changes in benthic and pelagic animal communities, altered sediment deposition, altered sediment characteristics, and shifts in chemical processes such as nutrient cycling (Grout et al. 1997; Ruiz et al. 1999; Wigand et al. 1997). Introduced seaweeds alter habitat by colonizing previously unvegetated areas, while algae form extensive mats that exclude most native taxa, dramatically reducing habitat complexity and the ecosystem services provided by it (Wallentinus and Nyberg 2007). Invasive algae can alter native habitats through a variety of impacts, including trapping sediment, reducing the number of suspended particles that reach the benthos for benthic suspension and deposit feeders, reduce light availability, and adversely impact foraging for a variety of animals (Britton-Simmons 2004; Gribsholt and Kristensen 2002; Levi and Francour 2004; Sanchez et al. 2005). Invasive fishes can compose a large portion of fish taxa in at least some areas, including New Zealand where 53 percent of fish taxa are exotic, Puerto Rico where invasive fish are 91 percent of the total species, and Brazil where they are 13 percent of the total (Lövei 1997).

The spiny water flea causes extensive ecosystem disruption (Grout et al. 1997; Johannsson et al. 1991; Kerfoot et al. 2011). *Bythotrephes* is an important contributor to its native habitat, including as prey to salmon; however, in the Great Lakes, they reduce the fitness of many fish that are prey to salmonids (Hessen et al. 2011). *Bythotrephes* preys heavily upon plankton species, severely reducing not only their abundance, but has also caused their diversity to decline by roughly 20 percent (Foster and Sprules 2009; Kerfoot et al. 2011; Rennie et al. 2011). As a result, rotifers decline because of reduced diatom food resources and phytoplankton increase because *Bythotrephes* feeds on their competitors (Beisner et al. 2006; Kerfoot et al. 2011). Further tertiary effects include elevation of contaminant levels in higher-level predators due to extensions in the food web that allow for additional contaminants to accumulate in the underlying prey base (Kerfoot et al. 2011; Rennie et al. 2011). Other macroinvertebrate predators and fishes are also likely adversely impacted by this disruption of their prey base, with less prey available to them (Foster and Sprules 2009; Parker Stetter et al. 2005). These alterations to ecosystem food webs appear to be stable and persistent (Yan et al. 2008). Through these mechanisms, *Bythotrephes* alone represents a significant threat to the biodiversity within temperate North American aquatic environments (Grout et al. 1997).

Other invertebrates can also have major impacts on the ecosystems they invade. The introduced periwinkle, *Littorina littorea*, ranging along the Atlantic Coast from Canada to the mid-Atlantic, is highly-influential in the sedimentation process; because individuals cumulatively engage in so much grazing, some bottom habitats have become dominated by hard-bottom instead of soft bottom as they formerly were (Bertness 1984; Carlton 1999; Wallentinus and Nyberg 2007). Significant declines in soft-sediment habitats and fringing salt marshes are attributed at least partially to the invasion of this species, possibly due to consumption of marsh grasses, such as *S. alterniflora* (Bertness 1984). Species normally adapted to living in soft-bottom systems are gradually replaced by species better adapted for hard-bottom substrates.

5.3.9 Marine Debris

Marine debris is another significant concern for listed species and their habitats. Marine debris has been discovered to be accumulating in gyres throughout the oceans. Law et al. (2010) presented a time series of plastic content at the surface of the western North Atlantic Ocean and Caribbean Sea from 1986 to 2008. More than 60 percent of 6,136 surface plankton net tows collected small, buoyant plastic pieces. The data identified an accumulation zone east of Bermuda that is similar in size to the accumulation zone in the Pacific Ocean.

Ingestion of marine debris can have fatal consequences even for large whales as well as sea turtles. In 1989, a stranded sperm whale along the Mediterranean was found to have died from ingesting plastic that blocked its' digestive tract (Viale et al. 1992). A sperm whale examined in Iceland had a lethal disease thought to have been caused by the complete obstruction of the gut with plastic marine debris (Lambertsen 1990). The stomach contents of two sperm whales that stranded separately in California included extensive amounts of discarded fishing netting (NMFS 2009). A fifth individual from the Pacific was found to contain nylon netting in its stomach when it washed ashore in 2004 (NMFS 2009). Further incidents may occur but remain undocumented when carcasses do not strand.

5.3.10 Current and Past US Navy Activities

Navy Exercises-Hawaii Range Complex. Since 1971, the U.S. Navy has conducted the biennial Rim of the Pacific (RIMPAC) exercises. These exercises, which historically have lasted for about a month, have involved forces from various nations on the Pacific Rim including Australia, Canada, Chile, Japan, and the Republic of Korea. We have limited information on the particular components of those exercises since their inception, but we assume that most of those exercises involved many of the components that are part of current RIMPAC. The majority of the training and testing activities the Navy is proposing for the next five years are similar, if not identical, to activities that have been occurring in the same locations for decades. For example, the mid-frequency sonar system on cruisers, destroyers, and frigates have the same sonar system components in the water as those first deployed in the 1970s. While the signal analysis and computing processes onboard these ships have been upgraded with modern technology, the power and output of the sonar transducer, which puts signals into the water, have not changed.

For this reason, the history of past marine mammal observations, research, and monitoring reports remain applicable to the analysis of effects from the proposed future training exercises and testing activities.

We have limited information on the timing and nature of RIMPAC Exercises prior to 2002 and we have no information on their effects on endangered and threatened marine animals in the Hawaii Range Complex prior to 2006, when we started to consult with the U.S. Navy on the exercises. Several recent RIMPAC exercises have occurred in the Hawaii Range Complex. Between June and July 2006, the U.S. Navy conducted Rim of the Pacific exercises in the Hawaii Range Complex. Based on the U.S. Navy's December 7, 2006, After-Action Report, over the 15 calendar days of the 2006 RIMPAC (Navy 2006), hull-mounted mid-frequency sonars were employed for a total of 472 hours (with 8 hours of transmission lost to comply with shut-down protocols required by a Marine Mammal Protection Act permit). Over the 15 calendar day of the 2006 RIMPAC, active and passive sonobuoys were deployed for 115 hours (which does not translate to 115 hours of sonar transmissions because some of the sonobuoys were deployed but were not transmitting).

During the 2006 RIMPAC, the Navy watchstanders reported marine mammals on 29 occasions (with the exception of two reports of pilot whales, marine mammals were not identified to species). On 12 of those 29 occasions, for a total of 8 hours, mid-frequency sonar associated with the exercise was shut down to avoid exposing marine mammals that had been observed. On two other occasions, marine mammals were observed more than 1,000 yards from a vessel while mid-frequency sonar was active.

The After Action Report for the 2006 RIMPAC concluded that (a) there was no evidence of any behavioral effects on marine mammals throughout the exercise; and (b) there were no reported standing events or observations of behavioral disturbance of marine mammals linked to sonar use during the exercise. The observations contained in the report (1) do not identify or estimate the number of endangered or threatened species that might have been exposed to mid-frequency active sonar during the exercise, (2) did not allow the U.S. Navy to evaluate the efficacy of the mitigation measures the U.S. Navy had implemented during the exercises (that is, those measures the Navy had proposed to implement on its own as well as the additional measures its implemented to comply with the MMPA permit), and (3) did not allow the U.S. Navy to evaluate the efficacy of the monitoring program associated with the exercises.

Between June and July 2008, the U.S. Navy conducted another Rim of the Pacific exercise in the Hawaii Range Complex, with the at-sea portions that involved mid-frequency active sonar occurring between 7 and 31 July 2008. Based on the U.S. Navy's 30 November 2008 After-Action Report, over the 25 calendar days of the 2008 RIMPAC (Navy 2008e), mid-frequency active sonars from hull-mounted (surface vessels), dipping, and directional command active

sonobuoy system (DICASS) were employed for a total of 547 hours. Of this total, active sonar was employed between the shoreline and the 200-meter bathymetric contour for about 6 hours.

Participants in the 2008 RIMPAC exercises reported 29 sightings of marine mammal groups totaling about 200 animals; dolphins represented 21 or 72 percent of these sightings (125 of the individuals). Six whale groups were sighted during the exercise, all in waters more than 100 nm west of the Island of Hawaii. An aerial survey over a portion of the area in which the 2008 RIMPAC exercises occurred reported 24 sightings of marine mammal groups involving eight species of small odontocetes, Hawaiian monk seals, or unidentified dolphins (or sea turtles). A shipboard survey that also occurred in a portion of the area in which the 2008 RIMPAC exercises occurred reported 9 sightings of marine mammal groups consisting of either bottlenose dolphins, rough-toothed dolphins, or Hawaiian spinner dolphins. None of the observers reported unusual behavior or adverse behavioral responses to active sonar exposures or vessel traffic associated with the exercises.

Between 6 and 31 July 2010, the U.S. Navy conducted a Rim of the Pacific exercise in the Hawaii Range Complex, with at-sea portions that involved mid-frequency active sonar (MFAS). Based on the U.S. Navy's 1 October 2010 Annual Range Complex Exercise Report (Navy 2010), there were 47 sightings for a total of 286 marine mammals and 7 sightings for a total of 25 sea turtles. Five whale groups and eight lone whales were sighted during the exercise. None of the observers reported unusual behavior or adverse behavioral responses to active sonar exposures or vessel traffic associated with the exercises. None of these animals occurred at ranges within less than 1,000 yards of mid-frequency sonar use.

The U.S. Navy has also conducted Undersea Warfare Exercises (USWEX) in the Hawaii Range Complex for several years (see the detailed description of these exercises in *Description of the Proposed Action*), but the components (number of vessels involved, amount of active sonar produced, etc.) of these exercises can vary widely. For example, an Undersea Warfare Exercise conducted in the Hawaii Range Complex from 13 to 15 November 2007, involved two ships equipped with AN/SQS-53C, one ship equipped with AN/SQS-56, and entailed a total of 77 hours of mid-frequency active sonar from all sources (hull-mounted sonars, dipping sonars, and DICASS sonobuoys; U.S. (Navy 2008e). An Undersea Warfare Exercise conducted in the Hawaii Range Complex from 25 to 27 March 2008, involved four ships equipped with AN/SQS-53C, one ship equipped with AN/SQS-56, and entailed a total of 169 hours of mid-frequency active sonar from all sources (hull-mounted sonars, dipping sonars, and DICASS). An Undersea Warfare Exercise conducted in the Hawaii Range Complex from 27 to 31 May 2008, involved four ships equipped with AN/SQS-53C, one ship equipped with AN/SQS-56, and entailed a total of 204 hours of mid-frequency active sonar from all sources (hull-mounted sonars, dipping sonars, and DICASS sonobuoys (Navy 2008e). The Undersea Warfare Exercise conducted in the Hawaii Range Complex from August 7-10, 2010 involved only eight ships. The information

regarding the number of ships equipped with active sound sources is recorded but is only reported in the classified addendum to the 2010 Annual Range Complex Exercise Report (Navy 2010).

Monitoring surveys associated with the November 2007 Undersea Warfare Exercises reported 26 sightings of five species during exercise, including green turtles and Hawaiian monk seals. None of the marine animals observed from survey vessels or aircraft were reported to have exhibited unusual behavior or changes in behavior during the surveys. Monitoring surveys associated with the March 2008 Undersea Warfare Exercises reported 47 sightings of five species during exercise, including humpback whales (40 sightings of 68 individuals) and an unidentified sea turtle. None of the marine animals observed from survey vessels or aircraft were reported to have exhibited unusual behavior or changes in behavior during the surveys. Monitoring surveys associated with the August 2010 Undersea Warfare Exercises reported zero sightings of marine mammals during the exercise.

Three Sinking Exercises (SINKEXs) were conducted in the Hawaii Range Complex; one each on July 10, 2010, July 14, 2010, and July 17, 2010. Although observation time totaled 259, 316 and 99 hours for the three dates, respectively, no marine mammals were sighted during the exercises.

During the period from August 2010 to August 2011, the Navy conducted two major training exercises in the Hawaii Range Complex. During these exercises there were approximately 31 sightings of an estimated 84 marine mammals; 32 dolphins, 47 whales, zero pinnipeds and 5 sightings that did not identify the species type. Four marine mammal sightings met the criteria for shut down mitigation - that is the animal was within 200 yards of the vessel or sonar source.

Hull-mounted active sonar was not used within the Humpback Whale Cautionary Area or the “dense humpback areas” inclusive of the 5 km buffer between 15 December and 15 April in 2010 or 2011. With the exception of EER/IEER explosive sonobuoys, the number of explosive exercises was substantially below 50 percent of the level proposed for use in the previous ESA consultation.

Between 29 June and 3 August 2012, the U.S. Navy conducted a Rim of the Pacific exercise in the Hawaii Range Complex, with at-sea portions that involved mid-frequency active sonar. Based on the October 2012 Annual Range Complex Exercise Report (Navy 2012a), there were 35 sightings for a total of 545 marine mammals during the RIMPAC exercise. Additionally, between 2 August 2011 and 1 August 2012 there were five other major training exercises. In total for those five, there were 36 sitings of 130 marine mammals. Only one turtle was observed during the major training events. Of the marine mammals observed, 192 were whales, one was a pinnipeds and the remainder were dolphins. None of the observers reported unusual behavior or adverse behavioral responses to active sonar exposures or vessel traffic associated with the exercises. There were 5 instances of Navy ships actively maneuvering to avoid marine mammals.

Of these 4 maneuvers, 2 were to avoid 1 whale each, 1 was to avoid 2 whales, 1 was to avoid 12 whales, and the last was to avoid 100 dolphins. Mid-frequency sonar was shut down three times as mitigation to reduce or avoid exposing marine mammals to active sonar.

Three SINKEXs were conducted in the Hawaii Range Complex during the RIMPAC exercise on 14 July, 17 July, and from 20 to 22 July 2012. Although observation time totaled 14, 26 and 39 hours for the three dates, respectively, no marine mammals were sighted during the exercises.

SURTASS LFA Sonar Missions in the Hawaii Range Complex. In August 2012, NMFS consulted on a proposal by the U.S. Navy to conduct testing and training missions with the Surveillance Towed Array Sensor System (SURTASS) low frequency active (LFA) sonar system in areas that could include the Hawaii Range Complex between August 2012 and August 2017 (NMFS 2012). On 15 August 2012, NMFS issued a biological opinion on the operation of the SURTASS LFA system specific to the period of August 2012 through August 2013. The 15 August 2012 opinion evaluated the use of SURTASS LFA within the Navy's Hawaii Range Complex.

Based on the current authorization pursuant to the MMPA (77 FR 51969), which was the subject of the 15 August 2012 ESA consultation, up to four SURTASS LFA missions could occur between August 2012 and August 2013 within the Hawaii Range Complex. However, to date no SURTASS LFA missions have occurred in the Hawaii Range Complex. In the ESA consultation, a single mission scenario was modeled in each of 11 training areas to estimate impacts to marine mammals. Nominal operational assumptions for the model were a mission lasting 7 days with an LFA sonar duty cycle of 7.5 percent, which is equal to 12.6 hours of LFA sonar transmission per mission.

The SURTASS LFA system is a long-range, low frequency sonar (between 100 and 500 Hertz (Hz)) that has both active and passive components. The SURTASS LFA is part of the U.S. Navy's Integrated Undersea Surveillance System (IUSS), which is designed to detect, classify and track diesel and nuclear submarines operating in both shallow and deep regions of littoral waters and deep ocean areas.

The active component of the SURTASS LFA sonar system consists of up to 18 low-frequency acoustic-transmitting source elements (called projectors) that are suspended from a cable beneath a ship. The projectors transform electrical energy to mechanical energy by setting up vibrations, or pressure disturbances, with the water to produce the active sound (which is called a "pulse" or a "ping"). The SURTASS LFA's transmitted beam is omnidirectional (full 360 degrees) in the horizontal. The nominal water depth of the center of the array is 400 ft (122 m), with a narrow vertical beam-width that can be steered above or below the horizontal. The source level of an individual projector in the SURTASS LFA sonar array is approximately 215 dB, and the sound field of the array can never have a sound pressure level higher than that of an individual projector. The shallowest water depth that a SURTASS LFA vessel would operate is 100 m

(328.1 ft). Signals transmitted by the SURTASS LFA sources are limited to between 100 and 330 Hertz (Hz) with source levels for each of the 18 projectors not more than 215 dB (re: 1 micro Pascal (μPa) at 1 meter (m)) and a maximum duty cycle of 20 percent.

The typical SURTASS LFA sonar signal is not a constant tone, but is a transmission of various signal types that vary in frequency and duration (including continuous wave and frequency-modulated signals). The Navy refers to a complete sequence of sound transmissions as a "ping" which can range from between 6 and 100 seconds, with no more than 10 seconds at any single frequency. The time between pings will typically range from 6 to 15 minutes. The Navy can control the average duty cycle (the ratio of sound "on" time to total time) for the system but the duty cycle cannot be greater than 20 percent; the Navy anticipates a typical duty cycle between 10 and 15 percent.

The passive or listening component of the system (SURTASS) uses hydrophones to detect echoes of the active signal returning from submerged objects, such as submarines. The hydrophones are mounted on a horizontal array that is towed behind the ship. The SURTASS LFA sonar ship maintains a minimum speed of 3.0 knots (5.6 km/hr; 3.4 mi/hr) in order to keep the array properly deployed. The return signals, which are usually below background or ambient noise levels, are then processed and evaluated to identify and classify potential underwater threats.

Mitigation Associated With The SURTASS LFA Sonar System. To avoid injuries to marine mammals (and possibly sea turtles), the Navy proposes to detect animals within an area they call the "LFA mitigation zone" (the area within the 180-dB isopleth of the SURTASS LFA sonar source sound field) before and during low frequency transmissions. NMFS has also added an additional 1-kilometer buffer zone beyond the LFA mitigation zone.

Monitoring has generally (a) commenced at least 30 minutes before the first SURTASS LFA sonar transmission; (b) continued between pings; and (c) continued for at least 15 minutes after completion of a SURTASS LFA sonar transmission exercise or, if marine mammals exhibited abnormal behavior patterns, for a period of time until those behavior patterns returned to normal or until viewing conditions prevented continued observations.

The Navy has used three monitoring techniques: (a) visual monitoring for marine mammals and sea turtles from the SURTASS LFA sonar vessel during daylight hours; (b) use of the passive (low frequency) SURTASS array to listen for sounds generated by marine mammals as an indicator of their presence; and use of high frequency active sonar (High Frequency Marine Mammal Monitoring or HF/M3 sonar) to detect, locate, and track marine mammals (and possibly sea turtles) that might be affected by low frequency transmissions near the SURTASS LFA sonar vessel and the sound field produced by the SURTASS LFA sonar source array.

Visual Monitoring. Visual monitoring includes daytime observations from observers on the SURTASS LFA sonar vessel to detect marine animals. Visual monitoring begins 30 minutes before sunrise, for ongoing transmissions, or 30 minutes before SURTASS LFA sonar is deployed and continues until 30 minutes after sunset or until SURTASS LFA sonar array is recovered. Personnel trained in detecting and identifying marine animals make observations from the vessel. At least one observer qualified by NMFS, trains, tests and evaluates other visual observers. If a marine mammal is detected within the 180-dB LFA mitigation zone or the 1 km (0.54 nm buffer zone extending beyond the LFA mitigation zone, SURTASS LFA sonar transmissions are immediately suspended. Transmissions do not resume less than 15 minutes after:

- All marine mammals have left the area of the LFA mitigation and buffer zones; and
- There is no further detection of any marine mammal within the LFA mitigation and buffer zones as determined by the visual and/or passive or active acoustic monitoring.

Passive acoustic monitoring. The U.S. Navy also uses passive acoustic monitoring for low frequency sounds generated by marine mammals when SURTASS is deployed. The following actions are associated with this monitoring:

- If sounds are detected and estimated to be from a marine mammal, the technician will notify the Officer in Charge who will alert the HF/M3 sonar operator and visual observers;
- If a sound produced by a marine mammal is detected, the technician will attempt to locate the sound source using localization software; and
- If it is determined that the animal will pass within the LFA mitigation zone or 1-km buffer zone (prior to or during transmissions), then the Officer in Charge will order the delay/suspension of transmissions when the animal is predicted to enter either of these zones.

High frequency active acoustic monitoring. The Navy also conducts high frequency active acoustic monitoring (by using an enhanced, commercial-type high frequency sonar) to detect, locate, and track marine mammals (and possibly sea turtles) that could pass close enough to the SURTASS LFA sonar transmit array to exceed the 180-dB mitigation criterion. This Navy-developed HF/M3 sonar operates with a similar power level, signal type, and frequency as high frequency “fish finder” type sonars used worldwide by both commercial and recreational fishermen.

The U.S. Navy ramps up the HF/M3 source slowly to operating levels over a period of no less than 5 minutes: The HF/M3 source will not increase its sound pressure level once a marine mammal is detected; ramp-up may proceed once marine mammals are no longer detected.

HF/M3 sonar, LFA mitigation zone, and sound propagation. The extent of the LFA mitigation zone (i.e., within the 180-dB sound field) is estimated by onboard acoustic modeling and environmental data collected *in situ*. Factored into this calculation are SURTASS LFA sonar source physical parameters of tow speed, depth, vertical steering, signal waveform/wavetrain selection, and peak transmit source level. The HF/M3 sonar is located near the top of the SURTASS LFA sonar vertical line array. The HF/M3 sonar computer terminal for data acquisition/processing/display will be located in the SURTASS Operations Center. The HF/M3 sonar uses frequencies from 30 to 40 kHz with a variable bandwidth (1.5 to 6 kHz nominal); a 3-4 percent (nominal) duty cycle; a source level of 220 dB re 1 μPa at 1 m; a five-minute ramp-up period; and a maximum, nominal detection range of 2-2.5 km (1.08-1.35 nm).

The HF/M3 sonar operates continuously while the SURTASS LFA sonar is deployed. When a marine animal is detected by the HF/M3 sonar, it automatically triggers an alert to the Watch Supervisor, who notifies the Officer in Charge. The Officer in Charge then orders the immediate delay/suspension of SURTASS LFA sonar transmissions until the animal is determined to have moved beyond the mitigation zone. All contacts are recorded and provided to NMFS as part of the long-term monitoring program associated with the proposed action.

Analysis and testing of the HF/M3 sonar operating capabilities indicate that this system substantially increases the probability of detecting marine mammals within the LFA mitigation zone. It also provides an excellent monitoring capability (particularly for medium to large marine mammals) beyond the LFA mitigation zone, out to 2 to 2.5 km (1.08 to 1.35 nm). Recent testing of the HF/M3 sonar has demonstrated a probability of single-ping detection above 95 percent within the LFA mitigation zone for most marine mammals.

Exposure to low-frequency active sonar. The dominant propagation paths for SURTASS LFA signals in low and middle latitudes would consist of convergence zone and bottom interaction (<2000 m or <6,600 foot depths). In most open water conditions, convergence zone propagation will be most prominent. SURTASS LFA signals will interact with the ocean bottom, but those signals will not penetrate coastal waters with appreciable signal strengths because of high bottom and surface losses. Because of spherical spreading, the 215 dB signal from a SURTASS LFA projector would be expected to attenuate by about 60 dB one kilometer from the source and by about 66 dB two kilometers from the source. In ideal oceanic conditions, a SURTASS LFA signal would lose about 120 dB to spherical spreading, so the signal would probably approach or fall below ambient levels about 960 kilometers from a SURTASS LFA source (about 600 miles).

Inside the LFA mitigation zone during a ping, a marine mammal could be exposed to sound levels at or above 180 dB and could experience permanent threshold shifts or other injury. However, the LFA mitigation zone (which, as we discussed in the *Description of the Proposed Action*, uses active and passive sonar to detect the presence of marine animals) was established and designed to prevent marine mammal or sea turtles from being exposed to these energy levels. Given the size of the LFA mitigation zone (extending to approximately 0.75 to 1.00 km [0.40 to 0.56 nm] from the transmitter) and the additional 1-km buffer zone, the detection probabilities associated with the HF/M3 sonar (above 95 percent probability of detecting small dolphins at about 750 m [0.4 nm], whale calves at 1,000 m [0.56 nm] and large whales at more than 1,500 m [0.81 nm]), and the depth of the transmitters, a marine mammal would have a high probability of being detected within the LFA mitigation zone and, as a result, a low probability of being exposed to sound levels greater than 180 dB.

For an animal to be exposed at received levels greater than 180 dB, the animal would have to occur in the same approximately 4-kilometer wide water column as the LFA transmitter, would have to enter the LFA mitigation zone without being detected, and would have to remain in the LFA mitigation zone when the LFA transmitter was operating. Based on the available information, we believe the probability of all of these events occurring, although possible, is extremely improbable.

Further, SURTASS LFA is operated to ensure that sonar sound fields do not exceed 180 dB (re 1 μPa rms) within 12 nautical miles (22 kilometers) of any coastline, including offshore islands, or designated offshore areas that are biologically important for marine mammals outside the 12 nautical mile (22 kilometer) zone during seasons specified for a particular area. When in the vicinity of known recreational and commercial dive sites, SURTASS LFA sonar would be operated to ensure that the sound field at these sites would not exceed 145 dB, adding an additional level of protection for marine mammals located in dive sites.

Based on the operations of the HF/M3 sonar during missions the Navy conducted between 2002 and 2006, the HF/M3 sonar appears to effectively detect marine animals within 1 to 2 kilometers of the LFA projectors. Recent testing of the HF/M3 sonar demonstrated a probability of single-ping detection above 95 percent within the LFA mitigation zone for most marine mammals (Navy 2005). For example, during seven of the nine SURTASS LFA missions the Navy conducted in 2004, there were twelve HF/M3 alerts that were identified as possible marine mammal or sea turtle detections. Between February 2005 and February 2006 LFA transmissions were delayed or suspended on 33 occasions: operations on the USNS IMPECCABLE were delayed or suspended four times because of possible marine mammal or sea turtle detections and three times due to HF/M3 failures while operations on the R/V *Cory Chouest* were delayed or suspended 12 times because of possible marine mammal or sea turtle detections, 13 times because the HF/M3 system failed, and once because of a visual sighting of dolphins.

Duration of exposure to SURTASS LFA transmissions. The duration of an animal's exposure to SURTASS LFA signals would depend on the animal's proximity to the transmitter and the animal's location in the water column. Nevertheless, because of the length of individual pings, individual animals are likely to be exposed to SURTASS LFA transmissions for periods ranging from 6 to 100 seconds.

Mitigation measures to minimize the likelihood of exposing marine mammals to LFA sonar. The Navy proposes to use a monitoring program to avoid exposing marine mammals to LFA transmissions at high decibel levels. As discussed in the *Description of the Proposed Action*, this monitoring program includes visual, passive acoustic, and active acoustic monitoring of a 180 dB mitigation zone and an additional 1 km buffer zone.

The effectiveness of visual monitoring is limited to daylight hours, and its effectiveness declines during poor weather conditions. In line transect surveys, the range of effective visual sighting (the distance from the ship's track or the *effective strip width*) varies with an animal's size, group size, reliability of conspicuous behaviors (blows), pattern of surfacing behavior, and positions of the observers (which includes the observer's height above the water surface). For most large baleen whales, effective strip width can be about 3 km (1.6 nm) up through Beaufort 6 (Buckland and Borchers 1993). For harbor porpoises the effective strip width is about 250 m (273 yd), because they are much smaller and less demonstrative on the surface than baleen whales (Palka 1996). The percentage of animals that will pass unseen is difficult to determine, but 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 effectiveness of passive acoustic detection is considered to be higher than visual monitoring. Thomas et al. (1986) and Clark and Fristrup (1997) concluded that the effective strip width and detection rates for passive acoustic monitoring is greater than that for visual, but the percentage of animals that will be undetected by the methods is unknown. Frequency coverage for this mitigation method using the SURTASS passive array is between zero and 500 Hz, so vocalizing animals are more likely to be detected than animals that do not vocalize. This would increase the detection rate of gray, humpback, fin, blue, and minke whales, and some of the beaked whale and dolphin species.

The HF/M3 sonar is the final measure the Navy proposes to use to detect animals within 1 to 2 kilometers of the projectors. Recent testing of the HF/M3 sonar demonstrated a probability of single-ping detection above 95 percent within the LFA mitigation zone for most marine mammals. If any of these monitoring methods detects animals within this zone, the projectors would be shut down until an animal moves out of the mitigation zone. Combined with the visual monitoring and passive acoustic monitoring protocols, this should minimize the risk of marine mammals being exposed to sound pressure levels in excess of 180 dB.

Based on SURTASS LFA pre-operational and post-operational estimates within the Hawaii Operating Area within the Hawaii Range Complex blue whales, fin whales, humpback whales, sperm whales, Hawaiian monk seals, and sea turtles would be exposed to SURTASS LFA transmissions (Table 29).

Table 29. Estimated number of ESA-Listed species that may be "taken" in the form of harassment as a result of their exposure to U.S. Navy Surveillance Towed Array Sensor System Low Frequency Active Sonar in the Hawaii Range Complex from August 2013 through August 2014 (NMFS 2013).

Species	Hawaii North	Hawaii South
Blue Whale	14	4
Fin Whale	7	4
Western Pacific Gray Whale	0	0
Humpback Whale	10	2
Sperm Whale	208	48
Main Hawaiian Island Insular False Killer Whale	2	2
Hawaiian Monk Seal	9	4

Thus far, the combination of geographic constraints, operating protocols, monitoring measures, and shut-down procedures appear to have prevented most threatened and endangered species of marine mammal and sea turtles from being exposed to SURTASS LFA sonar at received levels exceeding 180 dB. Further, they have prevented these species from being exposed in areas that are critical to their ecology, critical to large portions of their populations, or both. The Navy proposes to continue using these measures and they are likely to perform as well in the future as they have performed thus far. Therefore, based on the evidence available, most marine animals are likely to be exposed to received levels of LFA sonar at or below 180 dB. The SURTASS LFA activities are consulted on by NMFS separately from HSTT activities considered here.

Southern California Range Complex- The U.S. Navy has been conducting training exercises 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 Navy estimates that it currently conducts about eight major training exercises, seven integrated exercises, and numerous unit-level training exercises and maintenance exercise on the Southern California Range Complex each year. In total, training exercises 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 exercises in its 2008 EIS, we would expect about 14,000 instances in which endangered or threatened marine mammals would be exposed to Navy training exercises 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 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 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 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 exercises 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 exercises 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 been behaviorally harassed each year as a result of being exposed to underwater detonations associated with training exercises 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 exercises 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.

5.3.11 Deep Water Ambient Noise

Urick (1983) provided a discussion of the ambient noise spectrum expected in the deep ocean. Shipping, seismic activity and weather are primary causes of deep-water ambient noise. Noise

levels between 20 and 500 Hz appear to be dominated by distant shipping noise that usually exceeds wind-related noise. Above 300 Hz, the level of wind-related noise might exceed shipping noise. Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500 to 50,000 Hz. The frequency spectrum and level of ambient noise can be predicted fairly accurately for most deep-water areas based primarily on known shipping traffic density and wind state (wind speed, Beaufort wind force, or sea state) (Urick 1983). For frequencies between 100 and 500 Hz, Urick (1983) has estimated the average deep water ambient noise spectra to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas. Underwater ambient noise from passive acoustic monitoring within the SOCAL Range Complex has spectral shapes with higher levels at low frequencies(78-86 dB), owing to the dominance of ship noise at frequencies below 100 Hz and local wind and wavesabove 100 Hz (Hildebrand et al. 2012). In addition, there is monthly variation including peak in noise at 15-30 Hz and also 47 Hz related to the presence of blue and fin whale calls (Hildebrand et al. 2012).

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.

5.3.12 Seismic Surveys

Numerous seismic surveys have been undertaken through the action area and its surrounding region over the past 35 years (Figure 2). Although this is a long time period, listed marine mammals and sea turtles are long-lived individuals whose experience likely includes prior exposure to seismic sound sources (both in the action area as well as in the broader Pacific Ocean) that could lead to habituation, sensitization, or other changes to future exposure based upon prior experience.

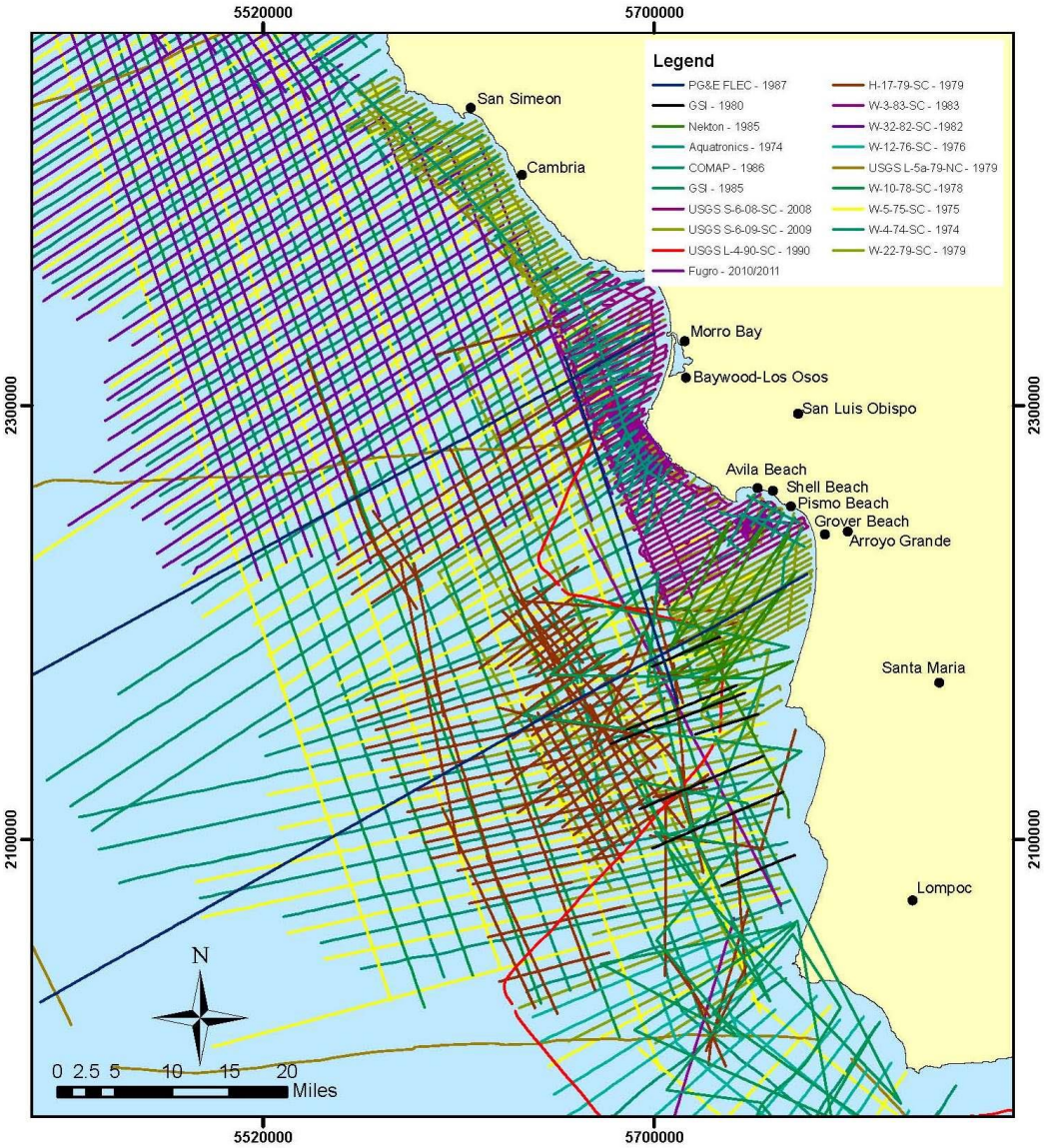

Figure 2. Seismic surveys north of the Navy's Southern California operating area.

There is little information available to us as to what response individuals have to future exposure to seismic sources compared to prior experience. Based upon the little information available to us for marine mammals, if prior exposure produces a learned response, then this response would likely be similar to or less than prior responses to other stressors where either the individual experienced a stress response associated with the novel stimuli and responded behaviorally as a consequence (such as moving away and reduced time budget for activities otherwise undertaken) (Andre and Jurado 1997a; André et al. 1997; Gordon et al. 2006). We do not believe sensitization would occur based upon the lack of severe responses previously observed in marine

mammals, sea turtles, and fishes exposed to seismic sounds that would be expected to produce a more intense, frequent, and/or earlier response to subsequent exposures.

5.3.13 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. That workshop produced several recommendations for addressing 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 Hawaii 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 2000a; Corkeron 1995; Erbe 2002b; Félix 2001;

Magalhaes et al. 2002; Richter et al. 2003a; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams et al. 2002b). 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.

5.3.14 Scientific Research

Scientific research permits issued by the NMFS currently authorize studies listed species in the North Pacific Ocean, some of which extend into portions of the action area for the proposed project. Authorized research on ESA-listed whales includes close vessel and aerial approaches, biopsy sampling, tagging, ultrasound, and exposure to acoustic activities, and breathe sampling. Research activities involve non-lethal "takes" of these whales by harassment, with none resulting in mortality. Sea turtle research includes capture, handling, restraint, tagging, biopsy, blood sampling, lavage, ultrasound, and tetracycline injection. Lethal take of male Hawaiian monk seals has been authorized in specific instances of mobbing; the removal of specific individuals involved in the mobbing, is expected to preserve the health and life of female and young individuals that will provide greater contributions to the survival and recovery of the species as a whole. Table 30 describes the cumulative number of takes for each listed species in the action area authorized in scientific research permits.

Table 30. Authorized takes of listed whales, pinnipeds, and sea turtles in the Pacific Ocean under the Endangered Species Act and the Marine Mammal Protection Act.

Species	2009-2014 lethal take	2009-2014 sub-lethal take
Blue Whale	0	107,785
Fin Whale	0	154,771
Western North Pacific Gray Whale	0	0
Sei Whale	0	41,745
Humpback Whale	0	372,260
North Pacific Right Whale	0	5,762
Sperm Whale	0	142,700
Main Hawaiian Island Insular False Killer Whale	0	9,195
Guadalupe Fur Seal	0	1,125
Hawaiian Monk Seal	142	23,437
Green Turtle	0	7,545

Hawksbill Turtle	0	1,085
Leatherback Turtle	0	1,178
Loggerhead Turtle	0	519
Olive Ridley Turtle	0	2,198

5.4 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 reasonably foreseeable future because of their small population sizes (on the order of 50 individuals) and low population growth rates. Relationships between 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 in the action area 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 the Hawaiian Archipelago and Southern California have only been subjected to limited levels of scientific investigation. As a result, the consequences of these activities on threatened and endangered marine mammals remain uncertain.

Our knowledge of the distribution and abundance of populations of endangered and threatened marine animals in the Hawaiian Archipelago varies widely. We have a better understanding of the distribution and abundance of humpback whales, Hawaiian monk seals, and the Hawaiian population of green turtles than of any of the other endangered or threatened species that occur in the Hawaiian Islands. For example, there is still almost no information on the distribution and number of blue, fin, and sei whales that occur in the Hawaiian Islands and temporal trends in

their abundance; without that information, it would be impossible to determine if these population are increasing or not. Our understanding of the at-sea distribution and abundance of green turtles from the Eastern Tropical Pacific, hawksbill, leatherback, loggerhead, and olive ridley sea turtles remains very limited and primarily consists of information from their interactions with commercial fisheries in the Hawaiian Islands.

Few of the anthropogenic phenomena in the Hawaiian Archipelago or Southern California Range Complex that represent risks to whales in the HSTT Study Area 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 Hawaiian and Southern California waters. The second line of evidence consists of reports that suggest that the response of whales to many of the anthropogenic activities in the Hawaiian Archipelago 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. (1992), Clapham and Mattila (1993), Clapham (1993) concluded that close approaches for biopsy samples or tagging did 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 zero to

2,000 meters away during which whales swam more slowly, but spent more time submerged. Watkins et al. (1981c) 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 Hawaii. 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 (Malme et al. 1983; Richardson et al. 1985b). 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 approximately 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 (2004b) 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 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 2004b; Frid 2003; Frid and Dill 2002; Gill and Sutherland 2001; Harrington and Veitch 1992; Lima and Dill. 1990; Romero and Wikelski 2002). These responses manifest themselves as stress responses (in which an animal perceives human activity as a 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; Müllner et al. 2004), and the death of individual animals (Daan et al. 1996; Feare 1976).

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 and the increased number of humpback whales that are reported to occur in the Hawaiian Islands. In the 1980s, the size of the North Pacific humpback whale population was estimated to range from 1,407 to 2,100 (Baker 1985; Baker and Herman 1987; Darling and Morowitz 1986). 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 Jr 2001). The most recent estimate places the current population of humpback whales in the North Pacific Ocean at about 18,300 whales, not counting calves and population growth trajectories (Calambokidis et al. 2008). Almost half of the humpback whales that were estimated to occur in wintering areas, or about 8,000 humpback whales, occupy the Hawaiian Islands during the winter months. Despite small numbers that are entangled in fishing gear in the action area, this increase in the number of humpback whales suggests that the activities these whales are exposed to in the Hawaiian Islands have not prevented these whales from increasing their numbers in the action area, although we do not know if more humpback whales might have used the action area in the absence of those stressors. The information that is available does not allow us to reach similar conclusions for the other endangered or threatened cetaceans in the action area.

Similarly, despite continued declines in the Northwest Hawaiian Islands, the increasing rate at which monk seals are sighted in the main Hawaiian Islands and the increased number of pups born in the main Hawaiian Islands suggests that the stress regime created by the activities discussed in this Environmental Baseline is not having a negative impact on these seals. In the case of monk seals, however, increases in their occurrence in the main Hawaiian Islands may

represent a re-distribution from the Northwest Hawaiian Islands, which would imply that environmental conditions may merely be worse in the Northwest Hawaiian Islands.

The stress regime created by the activities discussed in this Environmental Baseline continues to have a serious and adverse impact on leatherback and loggerhead turtles. For several years, NMFS biological opinions have established that the leatherback and loggerhead turtles 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 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 green, hawksbill, leatherback, and loggerhead 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, loss of their nesting habitat, and climate change. The limited data available suggests that hawksbill, leatherback and loggerhead 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 for leatherback and loggerhead turtles. The number of individuals of both 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.

At small population sizes, populations experience higher extinction probabilities because of their population size, because stochastic sexual determination leaves them with all males or all females (which occurred to the heath hen and dusky seaside sparrow just before they became extinct), or because the loss of individuals with high reproductive success has a disproportionate effect on the rate at which the population declines (Coulson et al. 2006).

Blue, fin, humpback, and sperm whales in the HSTT Study Area, appear to be increasing in population size or, at least, their population sizes do not appear to be declining, despite their continued exposure to the direct and indirect effects of the activities discussed in the Environmental Baseline. Although we do not have information on other measures of the demographic status of these species (for example, age structure, gender ratios, or the distribution of reproductive success) that would facilitate a more robust assessment of the probable impact of the Environmental Baseline, we infer from their increasing abundance that the Environmental Baseline, which includes ongoing U.S. Navy military readiness activities, is not currently preventing their population size from increasing.

6 EFFECTS OF THE ACTION ON SPECIES AND DESIGNATED CRITICAL HABITAT

6.1 Stressors Associated with the Proposed Action

The stressors (risks) to ESA-listed species that we analyzed based on the training exercises and testing activities the U.S. Navy proposes to conduct in the HSTT Study Area are:

1. The risk of disturbance from aircraft, surface vessels, underwater vehicles, torpedoes, targets, and seafloor devices;
2. The risk of death or injury from collision (i.e., ship strike) with surface vessels, underwater vehicles, torpedoes, and targets;
3. Risk of death or injury by entanglement or ingestion from by expendable materials and remnants of munitions;
4. Risk of injury or disturbance from electromagnetic devices; and
5. Risk of death, injury, or disturbance from acoustic sources such as active sonar, pile driving, explosions, airguns, and weapon firing.

What follows is a brief description of the stressors listed above. More information on each stressor is presented in the FEIS/OEIS. Following the descriptions, we present the results of our exposure analyses, followed by the results of our response analyses.

6.1.1 Disturbance from Vessels and Aircraft

Studies have shown that vessels and aircraft presence and operation can result in changes in behavior of cetaceans (Arcangeli and Crosti 2009; Holt et al. 2009; Luksenburg and Parsons 2009; Noren et al. 2009; Patenaude et al. 2002; Richter et al. 2006; Richter et al. 2003a; Smultea et al. 2008). The combination of the physical presence of a surface vessel and the underwater noise generated by the vessel, or an interaction between the two may result in behavioral modifications of animals in the vicinity of the vessel or submarine (Goodwin and Cotton. 2004; Lusseau 2006)(Sims et al. 2012). Most studies are opportunistic and have only ascertained the short-term response to vessel sound and vessel traffic (Magalhaes et al. 2002; Richardson et al. 1995b; Watkins 1981c); however, the long-term and cumulative implications of ship sound on marine mammals is largely unknown. Several authors suggest that the noise generated by the vessels is probably an important contributing factor to the responses of cetaceans to the vessels (Blane and Jaakson 1994; Evans et al. 1992; Evans et al. 1994).

Based on sea turtle sensory biology (Bartol et al. 1999; Ketten and Bartol 2005; Ketten and Bartol 2006; Lenhardt et al. 1994; Ridgway et al. 1969), sound from low flying aircraft could be heard by a sea turtle at or near the surface. Turtles might also detect low flying aircraft via visual cues such as the aircraft's shadow. Hazel et al. (2007) suggested that green turtles rely more on visual cues than auditory cues when reacting to approaching water vessels. This suggests that sea turtles might not respond to aircraft overflights based on noise alone.

Most of the activities the U.S. Navy proposes to conduct involve some level of activity from surface vessels or submarines. The number of Navy vessels in the HSTT Study Area varies based on training and testing schedules. Most activities include either one or two vessels, with an average of one vessel per activity, and last from a few hours up to two weeks. Multiple ships, however, can be involved with major training events. Vessel movement and the use of in-water devices as part of the proposed action would be concentrated in portions of the Study Area within Southern California, naval installations at San Diego and Pearl Harbor, and on instrumented underwater ranges. Vessels used as part of the Proposed Action include ships (e.g., aircraft carriers, surface combatants), support craft, and submarines ranging in size from 5 to over 300 meters. The U.S. Navy Fact Files on the World Wide Web (http://www.navy.mil/navydata/fact.asp) provide the latest information on the quantity and specifications of the vessels operated by the Navy.

Many of the activities the U.S. Navy proposes to conduct in the HSTT Study Area involve some level of activity from aircraft that include helicopters, maritime patrols, and fighter jets. 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 and sea turtles.

6.1.2 Risk of Death or Injury from Collision (Ship Strike)

The movement of surface and subsurface vessels in waters that also might be occupied by endangered or threatened marine mammals and sea turtles pose collision or ship strike hazards to those species. Pinnipeds in general appear to suffer fewer impacts from ship strikes than do cetaceans. This may be due, at least in part, to the large amount of time they spend on land (especially when resting and breeding), and their high maneuverability in the water. Ship strikes are known to injure and kill sea turtles (Work et al. 2010b). Stranding networks that keep track of sea turtles that wash up dead or injured have consistently recorded vessel propeller strikes as a cause or possible cause of death (Chaloupka et al. 2008b).

Given the speeds at which these vessels are likely to move, they pose some risk of collisions between these ships and marine mammals or sea turtles (although the risks of striking sea turtles is smaller than the risks of striking endangered marine mammals). Large Navy ships generally operate at speeds in the range of 10 to 15 knots, and submarines generally operate at speeds in the range of 8 to 13 knots. Small craft (for purposes of this discussion, less than 40 ft. [12 m] in length), which are all support craft, have much more variable speeds (dependent on the mission). While these speeds are representative of most events, some vessels need to operate outside of

these parameters. For example, to produce the required relative wind speed over the flight deck, an aircraft carrier vessel group engaged in flight operations must adjust its speed through the water accordingly. Conversely, there are other instances such as launch and recovery of a small rigid hull inflatable boat, vessel boarding, search, and seizure training events or retrieval of a target when vessels would be dead in the water or moving slowly ahead to maintain steerage. There are a few specific events including high speed tests of newly constructed vessels such as aircraft carriers, amphibious assault ships and the joint high speed vessel (which will operate at an average speed of 35 knots) where vessels would operate at higher speeds.

The number of Navy vessels in the Study Area at any given time varies and is dependent on local training or testing requirements. Most activities include either one or two vessels and may last from a few hours up to two weeks. Vessel movement as part of the Proposed Action would be widely dispersed throughout the Study Area, but more concentrated in portions of the Study Area near ports, naval installations, and range complexes.

In-water devices are unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles, unmanned undersea vehicles, and towed devices. These devices are self-propelled and unmanned or towed through the water from a variety of platforms, including helicopters and surface ships. In-water devices are generally smaller than most Navy vessels ranging from several inches to about 15 m.

These devices can operate anywhere from the water surface to the benthic zone. Certain devices do not have a realistic potential to strike living marine resources because they either move slowly through the water column (e.g. most unmanned undersurface vehicles) or are closely monitored by observers manning the towing platform (e.g. most towed devices).

6.1.3 Risk from Military Expended Materials

Expended materials pose risks for entanglement, ingestion, and release of chemicals, metals or other synthetics materials. Military expended materials include: (1) all sizes of non-explosive practice munitions, (2) fragments from high explosive munitions, and (3) expended materials other than ordnance, such as sonobuoys, ship hulks, expendable targets and unrecovered aircraft stores (fuel tanks, carriages, dispensers, racks, or similar types of support systems on aircraft).

While disturbance or strike from any material as it falls through the water column is possible, it is not likely because the objects will slow in velocity as they sink toward the bottom and can be avoided by highly mobile organisms.

Entanglements can result in death or injury of marine mammals and sea turtles (Moore et al. 2009; Van Der Hoop et al. 2012). Decellerator/parachutes are used with some expended materials (flares, sonobuoys). Decelerator/parachutes used during the proposed activities range in size from 18 to 48 in. (46 to 122 cm). The vast majority of expended decelerator/parachutes are

small (18 in.) cruciform shaped decelerators used with sonobuoys. These have short attachment lines and upon water impact may remain at the surface for 5 to 15 seconds before the decelerator/parachute and its housing sink to the seafloor. Entanglement of a marine mammal in a decelerator/parachute assembly at the surface or within the water column would be unlikely, since it would have to land directly on an animal, or an animal would have to swim into it before it sinks, and the majority of these are relatively small

Many of the activities the U.S. Navy plans to conduct in the HSTT Study Area include firing of a variety of weapons; the use of explosive and non-explosive practice munitions such as (but not limited to) bombs, small arms ammunition, medium caliber cannons, and missiles; and the use of other military expended materials including targets, marine markers, flares, and chaff may present ingestion risks to ESA-listed species. The Navy would expend the following types of materials that could become ingestion stressors during training exercises and testing activities in the Study Area: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, fragments from targets, chaff, flare casings (including plastic end caps and pistons), and parachutes. Other military expended materials such as targets, large-caliber projectiles, intact training and testing bombs, guidance wires, 55-gallon drums, sonobuoy tubes, and marine markers are too large for marine organisms to consume and are not discussed further in this opinion.

Several different types of materials other than munitions are expended at sea during training exercises and testing activities including targets, chaff, and flares. At-sea targets are usually remotely-operated airborne, surface, or subsurface traveling units, most of which are designed to be recovered for reuse. However, if they are used during activities that utilize high-explosives then they may result in fragments. Expendable targets that may result in fragments would include air-launched decoys, surface targets (such as marine markers, paraflares, cardboard boxes, and 10 ft. diameter red balloons), and mine shapes. Most target fragments would sink quickly to the seafloor. Floating material, such as Styrofoam, may be lost from target boats and remain at the surface for some time.

6.1.4 Risk from Electromagnetic Devices and Lasers

Naval devices that will produce an electromagnetic field are towed or unmanned mine countermeasure systems. The electromagnetic field is produced to simulate a vessel's magnetic field. In an actual mine clearing operation, the intent is that the electromagnetic field would trigger an enemy mine designed to sense a vessel's magnetic field. The majority of devices involved in the proposed activities would be towed or unmanned mine warfare systems that mimic the electromagnetic signature of a vessel passing through the water. None of the devices include any type of electromagnetic "pulse." An example of a representative device is the Organic Airborne and Surface Influence Sweep that would be used by an unmanned surface craft at sea. The Organic Airborne and Surface Influence Sweep works by emitting an electromagnetic

field and mechanically generated underwater sound to simulate the presence of a ship. The sound and electromagnetic signature cause nearby mines to detonate.

Normandeau et al. (2011) reviewed available information on electromagnetic and magnetic field sensitivity of marine organisms (including marine mammals) for impact assessment of offshore wind farms for the Department of Interior and concluded there is no evidence to suggest any magnetic sensitivity for sea lions, fur seals, or sea otters (Normandeau et al. 2011). However, Normandeau et al. (2011) concluded there was behavioral, anatomical, and theoretical evidence indicating cetaceans sense magnetic fields. Most of the evidence in this regard is indirect evidence from correlation of sighting and stranding locations suggesting that cetaceans may be influenced by local variation in the earth's magnetic field (Hui 1984; Kirschvink 1990 (Klinowska 1985; Walker et al. 1992). Results from one study in particular showed that long-finned and short-finned pilot whales, striped dolphin, Atlantic spotted dolphin, Atlantic white-sided dolphin, fin whale, common dolphin, harbor porpoise, sperm whale, and pygmy sperm whale were found to strand in areas where the earth's magnetic field was locally weaker than surrounding areas (negative magnetic anomaly) (Kirschvink 1990). Results also indicated that certain species may be able to detect total intensity changes of only 0.05 microtesla (Kirschvink et al. 1986). This gives insight into what changes in intensity levels some species are capable of detecting, but does not provide experimental evidence of levels to which animals may physiologically or behaviorally respond.

Fin, humpbacks, and sperm whales have shown positive correlations with geomagnetic field differences. Although none of the studies have determined the mechanism for magneto-sensitivity, the suggestion from these studies is that whales can sense the Earth's magnetic field and may use it to migrate long distances. Cetaceans appear to use the Earth's magnetic field for migration in two ways: as a map by moving parallel to the contours of the local field topography, and as a timer based on the regular fluctuations in the field allowing animals to monitor their progress on this map (Klinowska 1990). Cetaceans do not appear to use the Earth's magnetic field for directional information (Klinowska 1990).

Impacts to marine mammals associated with electromagnetic fields are dependent on the animal's proximity to the source and the strength of the magnetic field. Electromagnetic fields associated with naval training exercises and testing activities are relatively weak (only 10 percent of the earth's magnetic field at 79 ft.), temporary, and localized. Once the source is turned off or moves from the location, the electromagnetic field is gone. A marine mammal would have to be present within the electromagnetic field (approximately 656 ft. [200 m] from the source) during the activity in order to detect it.

Sea turtles use geomagnetic fields to navigate at sea, and therefore changes in those fields could impact their movement patterns (Lohmann and Lohmann 1996; Lohmann et al. 1997). Turtles in all life stages orient to the earth's magnetic field to position themselves in oceanic currents; this

helps them locate seasonal feeding and breeding grounds and to return to their nesting sites (Lohmann and Lohmann 1996; Lohmann et al. 1997). Experiments show that sea turtles can detect changes in magnetic fields, which may cause them to deviate from their original direction (Lohmann and Lohmann 1996; Lohmann et al. 1997). For example, Lohmann and Lohmann (1996) found that loggerhead hatchlings tested in a magnetic field of 52,000 nanoteslas swam eastward, and when the field was decreased to 43,000 nanoteslas, the hatchlings swam westward. Sea turtles also use nonmagnetic cues for navigation and migration, and these additional cues may compensate for variations in magnetic fields. Experimental studies show that hatchlings and juvenile turtles are sensitive to the earth's natural magnetic field and they can distinguish magnetic inclination in different places during their migration routes (Lohmann 1991; Luschi et al. 2007). Sea turtle can distinguish magnetic differences lighter than 9 mT (Lohmann et al. 1999; 2001).

If located in the immediate area (within about 650 ft. [200 m]) where electromagnetic devices are being used, sea turtles could deviate from their original movements. The electromagnetic devices used in training exercises and testing activities are not expected to cause more than a short-term behavioral disturbance to sea turtles because of the: (1) relatively low intensity of the magnetic fields generated (0.2 microtesla at 200 m [656.2 ft.] from the source), (2) very localized potential impact area, and (3) temporary duration of the activities (hours). Impacts of exposure to electromagnetic stressors are not expected to result in substantial changes to an individual's behavior, growth, survival, annual reproductive success, lifetime reproductive success (fitness), or species recruitment, and are not expected to result in population-level impacts.

The kinetic energy weapon (commonly referred to as the rail gun) is under development and will likely be tested and eventually used in training events aboard surface vessels, firing non-explosive projectiles at sea-based targets. The system uses stored electrical energy to accelerate the projectiles, which are fired at supersonic speeds over great distances. The system charges for two minutes, and fires in less than a second; therefore, any electromagnetic energy released would be done so over a very short period. Also, the system would likely be shielded so as not to affect shipboard controls and systems. The amount of electromagnetic energy released from this system would likely be low and contained on the surface vessel.

The Navy proposes to test the kinetic energy weapon on vessels off the Pacific Missile Range Facility in the Hawaii Range Complex. This kinetic energy weapon would generate and electromagnetic field (within the railgun barrel) to launch a projectile. Because the electromagnetic field is produced within the kinetic energy weapon barrel, ESA-listed species would not be exposed to the electromagnetic field. Therefore, we do not analyze the risk of kinetic energy weapon use further in this opinion.

Laser devices can be organized into two categories: (1) low energy lasers and (2) high energy lasers. Low energy lasers are used to illuminate or designate targets, to guide weapons, and to

detect or classify mines. High energy lasers are used as weapons to disable surface targets. No high energy lasers would be used in the Study Area as part of the Proposed Action, and are not discussed further.

Within the category of low energy lasers, the highest potential level of exposure would be from an airborne laser beam directed at the ocean's surface. An assessment on the use of low energy lasers by the Navy determined that low energy lasers, have an extremely low potential to impact marine biological resources (Swope 2010). The assessment determined that the maximum potential for laser exposure is at the ocean's surface, where laser intensity is greatest (Swope 2010). As the laser penetrates the water, 96 percent of a laser beam is absorbed, scattered, or otherwise lost (Ulrich 2004). Based on the parameters of the low energy lasers and the behavior and life history of major biological groups, it was determined the greatest potential for impact would be to the eye of a marine mammal or sea turtle. However, an animal's eye would have to be exposed to a direct laser beam for at least 10 seconds or longer to sustain damage. Swope (2010) assessed the potential for damage based on species specific eye/vision parameters and the anticipated output from low energy lasers and determined that no animals were predicted to incur damage. Zorn et al. (Zorn et al. 2000) conducted an analysis of the sensitivity ratio was calculated for each species using the ratio of the irradiance at the retina of the marine mammal to the irradiance at the retina of humans. The sensitivity ratio was used to suggest exposure limits for the various species. They concluded that because the human eye is more sensitive than either the cetacean or pinniped eye, that laser energies that are eye-safe for humans will also be safe for marine mammals, and higher laser irradiances may be permissible if illumination of humans is avoided (Zorn et al. 2000). Therefore, low energy lasers are not analyzed further in this document as a stressor to marine mammals.

This section evaluates the potential for sea turtles to be impacted by lasers used during training exercises and testing activities in the Study Area. Lasers used as part of proposed training exercises and testing activities would be low-energy lasers used for mine detection and targeting. While all points on a sea turtle's body would have roughly the same probability of laser exposure, only eye exposure is of concern for low-energy lasers. Any heat that the laser generates would rapidly dissipate due to the large heat capacity of water and the large volume of water in which the laser is used. There is no suspected effect due to heat from the laser beam. Eye damage to sea turtles is unlikely because eye damage depends on wavelength with exposures of greater than 10 seconds. With pulse durations less than 10 seconds, combined with the laser platform movement and animal motion, exposures of more than 10 seconds would not be possible. Furthermore, 96 percent of a laser beam projected into the ocean is absorbed, scattered, or otherwise lost (Guenther et al. 1996). Therefore, the use of low-energy lasers is discounted from the analysis of impacts on sea turtles.

6.1.5 Risk from Acoustic Sources

The addition of sound to the marine environment is recognized as a risk to by the scientific community (Payne 1971), that could possibly harm marine mammals or significantly interfere with their normal activities (National Research Council 2005). Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging (National Research Council 2003; National Research Council 2005), there are many unknowns in assessing impacts such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al. 2007; Southall et al. 2007).

Non-impulsive Sound Sources

Sonar and other non-impulsive sound sources emit sound waves into the water to detect objects, safely navigate, and communicate. Most systems operate within specific frequencies (although some harmonic frequencies may be emitted at lower sound pressure levels). Other sources of non-impulsive noise include acoustic communications, sonar used in navigation, and other sound sources used in testing.

Most use of active acoustic sources involves a single unit or several units (ship, submarine, aircraft, or other platform) employing a single active sonar source in addition to sound sources used for communication, navigation, and measuring oceanographic conditions. Anti-submarine warfare activities may also use an acoustic target or an acoustic decoy.

Anti-Submarine Warfare Sonar

Sonar used in anti-submarine warfare is deployed on many platforms and operated in various ways. Anti-submarine warfare active sonar is usually mid-frequency (1–10 kHz) because mid-frequency sound balances sufficient resolution to identify targets and distance within which threats can be identified.

- Ship tactical hull-mounted sonar contributes the largest portion of overall non-impulsive sound. Duty cycle can vary from about a ping per minute to continuously active. Sonar can be wide ranging in a search mode or highly directional in a track mode.
- A submarine's mission revolves around its stealth; therefore, a submarine's mid-frequency sonar is used infrequently because its use would also reveal a submarine's location.
- Aircraft-deployed, mid-frequency, anti-submarine warfare systems include omnidirectional dipping sonar (deployed by helicopters) and omnidirectional sonobuoys (deployed from various aircraft), which have a typical duty cycle of several pings per minute.

- Acoustic decoys that continuously emulate broadband vessel sound or other vessel acoustic signatures may be deployed by ships and submarines.
- Torpedoes use directional high-frequency sonar when approaching and locking onto a target. Practice targets emulate the sound signatures of submarines or repeat received signals.

Most anti-submarine warfare events occur more than 12 nm from shore and within areas of the HSTT Study Area designated for anti-submarine warfare activities.

Most events occur over a limited area and are completed in less than one day, often within a few hours. Multi-day anti-submarine warfare events requiring coordination of movement and effort between multiple platforms with active sonar over a larger area occur less often. The multi-day events constitute a large portion of the overall non-impulsive underwater noise that would be created by Navy activities. For example, the largest event, a composite training unit exercise, would have periods of concentrated, near-continuous anti-submarine warfare sonar use by several platforms during a several-week period.

Mine Warfare Sonar

Sonar used to locate mines and other small objects is typically high frequency, which provides higher resolution. Mine detection sonar is deployed at variable depths on moving platforms to sweep a suspect mined area (towed by ships, helicopters, or unmanned underwater vehicles). Mid-frequency hull mounted sonar can also be used in an object detection mode known as "Kingfisher" mode. Mine detection sonar use would be concentrated in areas where practice mines are deployed, typically in water depths less than 200 ft. (61 m). Most events usually occur over a limited area and are completed in less than one day, often within a few hours.

Other Active Acoustic Sources

Active sound sources used for navigation and obtaining oceanographic information (e.g., depth, bathymetry, and speed) are typically directional, have high duty cycles, and cover a wide range of frequencies, from mid frequency to very high frequency. These sources are similar to the navigation systems on standard large commercial and oceanographic vessels. Sound sources used in communications are typically high frequency or very high frequency. These sound sources could be used by vessels during most activities and while transiting in the Study Area.

Use of Sonar During Training and Testing

Most non-impulsive sound sources are used in offshore areas, some use would occur nearshore in inland waters such as bays, at pierside, or during transit in and out of port. These activities include sonar testing and maintenance, object detection/mine counter measures, swimmer detection sonar used pierside in Pierside Integrated Swimmer Defense, and navigation.

Most non-impulsive sound stressors associated with testing events, and about half of non-impulsive sound stressors associated with training events, involve a single unit or several units (ship, submarine, aircraft, or other platform) employing a single active sonar source in addition to sound sources used for communication, navigation, and measuring oceanographic conditions. Anti-submarine warfare activities may also use an acoustic target or an acoustic decoy. These events usually occur over a limited area and are completed in less than one day, often within a few hours.

Multiday anti-submarine warfare events requiring coordination of movement and effort between multiple platforms with active sonar over a larger area occur less often, but constitute a large portion of overall non-impulsive underwater noise imparted by Navy activities. Approximately half of the non-impulsive sound stressors generated during training events occur during multiplatform anti-submarine warfare events. One event of this type, the submarine commander's course training event, occurs up to two times per year in the Hawaii Range Complex.

Impulsive Sound Sources

Impulsive sound sources are largely those that involve at-sea explosions and secondarily from swimmer defense airguns. The shock wave and blast noise from explosions are of concern to marine animals. Depending on the intensity of the shock wave and size and depth of the animal, an animal can be injured or killed. Further from the blast, an animal may suffer non-lethal physical effects. Outside of these zones of death and physical injuries, marine animals may experience hearing related effects with or without behavioral responses.

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).

Explosives

Explosive detonations during training exercises and testing activities are associated with high-explosive ordnance, including bombs, missiles, and naval gun shells; torpedoes, mines, demolition charges, and explosive sonobuoys. Most explosive detonations during training exercises and testing activities involving the use of high-explosive ordnance, including bombs, missiles, and naval gun shells, would occur in the air or near the water's surface. Explosives associated with torpedoes and explosive sonobuoys would occur in the water column; mines and demolition charges could occur near the surface, in the water column, or the ocean bottom. Most detonations would occur in waters greater than 200 ft. (61 m) in depth, and greater than 3 nm from shore, although mine warfare, demolition, and some testing detonations could occur in

shallow water close to shore. Detonations associated with Anti-Submarine Warfare would typically occur in waters greater than 600 ft. (182.9 m) depth.

Explosives in the water introduce loud, impulsive, broadband sounds into the marine environment. Three source parameters influence the effect of an explosive: (1) the weight of the explosive warhead, (2) the type of explosive material, and (3) the detonation depth. The net explosive weight, the explosive power of a charge expressed as the equivalent weight of TNT, accounts for the first two parameters. The properties of explosive detonations are discussed in the FEIS/OEIS.

In general, explosive events would consist of a single explosion or multiple explosions over a short period. During training, all large, high-explosive bombs would be detonated near the surface over deep water. Bombs with high-explosive ordnance would be fused to detonate on contact with the water. Other detonations would occur near but above the surface upon impact with a target; these detonations are conservatively assumed to occur at a depth of 1 m (3.3 ft.) for purposes of analysis. Detonations of projectiles during anti-air warfare would occur far above the water surface.

Since most explosive sources used in military activities are munitions that detonate essentially upon impact, the effective source depths are quite shallow and, therefore, the surface-image interference effect can be pronounced. This effect would reduce peak pressures and impacts near the water surface.

Noise associated with weapons firing and the impact of non-explosive practice munitions could happen at any location within the Study Area but generally would occur at locations greater than 12 nm from shore for safety reasons. These training exercises and testing activities would occur in areas of the HSTT Study Area designated for anti-surface warfare and similar activities as well as in the Transit Corridor during ship transits between the Hawaii and Southern California Range Complexes. Testing activities involving weapons firing noise would be those events involved with testing weapons and launch systems. These activities would also take place throughout the Study Area primarily in the same locations as the training activities occur, but with fewer events taking place in the Transit Corridor.

The firing of a weapon may have several components of associated noise. Firing of guns could include sound generated by firing the gun (muzzle blast), vibration from the blast propagating through a ship’s hull, and sonic booms generated by the projectile flying through the air. Missiles and targets would produce noise during launch. In addition, the impact of non-explosive practice munitions at the water surface can introduce sound into the water.

Pile Driving

Construction during training of the elevated causeway system, a temporary pier allowing offloading of supply ships, would require pile driving and pile removal. This training activity would occur four times per year at the Silver Strand Training Complex. The length of the pier, and therefore the number of piles required, would be determined by the distance from shore to the appropriate water depth for ship off-loading. Construction of the elevated causeway system would involve intermittent impact pile driving of 24-inch (in.), uncapped, steel pipe piles over approximately two weeks. Crews work 24 hours a day and can drive approximately eight piles in that period. Each pile takes about 10 minutes to drive. When training events that use the elevated causeway system are complete, the structure would be removed, using vibratory methods over approximately six days. Crews can remove about 14 piles per 24-hour period, each taking about 6 minutes to remove.

Impact pile driving creates repetitive impulsive sound. An impact pile driver generally operates in the range of 36 to 50 blows per minute. Vibratory pile driving creates a nearly continuous sound made up of a series of short duration rapid impulses at a much lower source level than impact pile driving. The sounds are emitted both in the air and in the water.

Swimmer Defense Airguns

Swimmer defense airguns would be used for pierside integrated swimmer defense testing at pierside locations at Naval Base San Diego. Pierside integrated swimmer defense testing involves a limited number of impulses from a small airgun in inland waters around Navy piers. Airguns would be fired a limited number of times (up to 100) during each activity at an irregular interval as required for the testing objectives. These areas adjacent to Navy pierside integrated swimmer defense testing are industrialized, and the waterways carry a high volume of vessel traffic in addition to Navy vessels using the pier.

Underwater impulses would be generated using small (approximately 60 cubic inch [in.3]) airgun, which are essentially a stainless steel tube charged with high-pressure air via a compressor. An impulsive sound is generated when the air is almost instantaneously released into the surrounding water, an effect similar to popping a balloon in air. Generated impulses would have short durations, typically a few hundred milliseconds. The root-mean-squared sound pressure level and sound exposure level at a distance 1 m from the airgun would be approximately 200–210 dB re 1 µPa and 185–195 dB re 1 µPa2-s, respectively. Swimmer defense airguns lack the strong shock wave and rapid pressure increase that would be expected from explosive detonations.

6.2 Exposure Analysis

Our exposure analyses are designed to determine whether listed resources are likely to co-occur with the direct and indirect beneficial and adverse effects of actions and the nature of that co-occurrence. In this step of our analyses, we try to identify the number, age (or life stage), and

gender of the individuals that are likely to be exposed to one or more of the stressors produced by or associated with an Action and the populations or subpopulations those individuals represent.

6.2.1 Exposure to Vessels and Aircraft

We did not estimate the number of endangered or threatened species that are likely to be exposed to vessels independent of the number of individual exposures to acoustic sources that might occur as the result of the training exercises and testing activities in the HSTT Study Area. We assume that any individuals of the endangered or threatened marine mammals and sea turtles that occur in the Action Area during the training exercises and testing activities may be exposed to visual and acoustic stimuli associated with vessel traffic and related activities (see the Exposure to Acoustic Sources section below).

We did not estimate the number of endangered or threatened species that are likely to be exposed to aircraft traffic — during take-offs and landings and at altitudes low enough for the sounds of their flight to be salient below the ocean's surface — independent of the number of individuals that might be exposed to active sonar associated with those exercises (primarily because the data we would have needed to support those analyses were not available). Nevertheless, we assume that any individuals of the endangered or threatened species that occur in the Action Area during training exercises and testing activities that involve aircraft are likely to be exposed to acoustic stimuli associated with aircraft traffic.

Many unit-level training exercises and testing activities do not involve aircraft traffic, involve less traffic when they involve traffic at all, have shorter duration, and affect much more localized areas than major exercises, so fewer ESA-listed species would be exposed to aircraft traffic during these smaller activities.

6.2.2 Exposure to Collision (Ship Strike)

To estimate the number of ESA-listed animals that may be exposed to the risk of ship strike, we explored several exposure estimation methods. The Navy conducted an analysis that it included in the FEIS/OEIS based on the history of ship strikes in the HSTT Study Area. Additionally, NMFS requested the Navy conduct an exposure analysis using the NAEMO results. However, the Navy indicated to NMFS that the NAEMO was not the suitable tool to do this and felt that the historic ship strike data based on real-world events would be more precise (see discussion below).

The Navy estimated the number of potential vessel strikes by assessing the probability of hitting individuals of different species of large whales that occur in the HSTT Study Area. The Navy considered unpublished ship strike data compiled and provided by NMFS' Southwest Regional Office and Pacific Island Regional Office, unpublished Navy ship strike information collected by the Navy, and information on the trends in the amount of vessel traffic related to its training

exercises and testing activities in the HSTT Study Area. Specifics regarding this analysis is provided in the Navy's ESA consultation request package (Navy 2012b). Based on the Navy's analysis naval vessels could potentially collide with 15 large whales over the five year period of the proposed MMPA rule.

NMFS's requested an estimation of the number of close encounters the Navy could have had with large whales in the Navy's operating areas in Southern California. Based on this request, the Navy developed a quantitative approach to estimate close encounters based on the numbers of large whales sighted within 200 yards during major training exercises and testing activities from 2009-2012.

Applicable data include whether the animal sighted was a whale, how many were sighted, the range at which they were sighted, and the hours of effort spent looking. Whales sighted less than 200 yards from the vessel were considered a close encounter for the purposes of the analysis. By dividing the total number of close encounters observed each year by the hours of effort spent looking during that year, an annual close encounter rate can be estimated. The annual encounter rates were then averaged to get an overall initial encounter rate.

The following assumptions were made regarding the sighting data used for this analysis:

- All whales sighted were ESA-listed large whale species (blue, fin, humpback, sei, or sperm whales); in reality, some of the whale sightings may be of non-listed Bryde's whales, gray whales, or minke whales. (Fin and blue whales are the listed whales with the greatest presence within the Navy's range complex portion of Southern California; humpback whales are seasonally the most common listed whale in Hawaii).
- All whale sightings were within 200 yards of the vessel.
- Probability of detection within the 200 yd range is one, meaning that all whales that were available to be seen were sighted by Navy lookouts or bridge crew.
- Encounter rate does not differ based on season, time of day, specific geographic area, or species.

The approach entails determining a large whale encounter rate (using 2009-2012 data with caveats), adjusting for species-specific sightability using NMFS generated g(0) values, and then estimating a future encounter rate using total vessels training at-sea based on average number of days at-sea per quarter. Using this approach, a close encounter rate exposure estimate of 50 large whales per year was developed.

The very small percentage of Western North Pacific Gray Whales among gray whales in the HSTT Study Area, the seasonal nature of that occurrence, and the overall low probability of ship strike, lead us to conclude that the probability of a collision involving a Western North Pacific gray whale in the HSTT Study Area is discountable.

The rarity of ship strikes involving pinnipeds combined with the Navy's established operating policies and procedure intended to reduce interactions of Navy assets and listed species, leads NMFS to assume that the exposure risk of collision from surface vessels or submarines is small enough to be discountable.

Sea turtles are vunerable to vessel collisions because they regularly surface to breathe and often rest at or near the surface. Stranding networks that keep track of sea turtles that wash up dead or injured have consistently recorded vessel propeller strikes as a cause or possible cause of death (Chaloupka et al. 2008b). From San Diego County turtle stranding data maintained by NMFS, for the period 1988-2008 there were a total of nine sea turtle strikes. All reported strikes were to green turtles, and four of the strikes were within San Diego Bay (National Marine Fisheries Service Southwest Region Stranding Database 2010). However, we do not have sufficient information to estimate how many sea turtles might be exposed to this stressor, and we assume that turtles in close enough proximity to be at risk of permanent threshold shift would also be vunerable to ship strike.

6.2.3 Exposure to Expended Materials

We did not estimate the number of endangered or threatened species that are likely to be exposed to expended materials independent of the number of individual exposures to acoustic sources that might occur as the result of the training exercises and testing activities in the HSTT Study Area. We assume that some individuals of the endangered or threatened marine mammals and sea turtles that occur in the Action Area during the training exercises and testing activities would be exposed to expended materials associated with training exercises and testing activities (see the *Exposure to Active Sonar* section below).

6.2.4 Exposure to Acoustic Sources

Prior to the initiation of formal ESA consultation, we worked with the Navy as it developed a new modeling approach to estimate the number of marine mammals that might be exposed to acoustic stressors during its training exercises and testing activities. This effort culminated in the Navy's Acoustic Effects Model (NAEMO). Below we provide a brief description of the NAEMO; a more expansive description is provided in the Navy's FEIS/OEIS.

Navy Acoustic Effects Model - The Navy developed a set of software tools and compiled data for estimating acoustic effects on marine mammals without consideration of behavioral avoidance or Navy's standard mitigations. These databases and tools collectively form the Navy Acoustic Effects Model (NAEMO). The NAEMO improves upon previous modeling efforts in several ways. First, unlike earlier methods that modeled acoustic sources individually, the NAEMO has the capability to run all sources within a scenario simultaneously, providing a more realistic depiction of the potential effects of an activity. Second, previous models calculated sound received levels within set volumes of water and spread animals uniformly across the volumes; in the NAEMO, animats (virtual animals) are distributed non-uniformly based on

higher resolution species-specific density, depth distribution, and group size, and animats serve as dosimeters, recording energy received at their location in the water column. Third, a fully three-dimensional environment is used for calculating sound propagation and animat exposure in the NAEMO, rather than a two-dimensional environment where the worst case sound pressure level across the water column is always encountered. Additionally, NAEMO expands upon previous modelling efforts by incorporating Type II frequency weighting functions, a behavioural response function, and developing estimates from a new density function, the Navy Marine Species Density Database (NMSDD). Finally, current efforts incorporate site-specific bathymetry, sound speed profiles, wind speed, and bottom properties into the propagation modeling process rather than the flat-bottomed provinces used during earlier modeling (NUWC 2012). The following paragraphs provide an overview of the NAEMO process and its more critical data inputs.

Using the best available information on the predicted density of marine mammals in the area being modeled from the Navy Marine Species Density Database (NMSDD), the NAEMO derives an abundance (total number of individuals) and distributes the resulting number of animats into an area bounded by the maximum distance that energy propagates out to a criterion threshold value (energy footprint). For example, for non-impulsive sources, all animats that are predicted to occur within a range that could receive sound pressure levels greater than or equal to 120 dB sound pressure level are distributed. These animats are distributed based on density differences across the area, the group (pod) size, and known depth distributions (dive profiles) (see Marine Species Modeling Team 2012b) for a discussion of animal dive profiles in detail). Animats change depths every 4 minutes but do not otherwise mimic actual animal behaviors, such as avoidance or attraction to a stimulus (horizontal movement), or foraging, social, or traveling behaviors.

Schecklman et al. (2011) argue that static distributions underestimate acoustic exposure compared to a model with fully three-dimensionally moving animals. However, their static method is different from the NAEMO in several ways. First, they distribute the entire population at depth with respect to the species-typical depth distribution histogram, and those animats remain static at that position throughout the entire simulation. In the NAEMO, animats are placed horizontally dependent on non-uniform density information, and then move up and down over time within the water column by integrating species-typical depth distribution information. Second, for the static method they calculate acoustic received level for designated volumes of the ocean and then sum the animats that occur within that volume, rather than using the animats themselves as dosimeters, as in the NAEMO. Third, Schecklman et al. (2011) ran 50 iterations of the moving distribution to arrive at an average number of exposures, but because they rely on uniform horizontal density (and static depth density) only a single iteration of the static distribution is realized. In addition to moving the animats vertically, the NAEMO overpopulates the animats over a non-uniform density and then resamples the population a number of times to

arrive at an average number of exposures as well. Tests comparing fully moving distributions and static distributions with vertical position changes at varying rates were compared during development of the NAEMO. For position updates occurring more frequently than every 5 minutes, the number of estimated exposures was similar between the NAEMO and the fully moving distribution; however, computational time was much longer for the fully moving distribution.

The NAEMO calculates the likely propagation for various levels of energy (sound or pressure) resulting from each non-impulse or impulse source used during a training or testing event. This is done by taking into account the actual bathymetric relief and bottom types (e.g., reflective), and estimated sound speeds and sea surface roughness at an event's location. Platforms (such as a ship using one or more sound sources) are modeled as moving across an area whose size is representative of what would normally occur during a training or testing scenario. The model uses typical platform speeds and event durations. Moving source platforms either travel along a predefined track or move along straight-line tracks from a random initial course, reflecting at the edges of a predefined boundary. Static sound sources are stationary in a fixed location for the duration of a scenario. Modeling locations were chosen based on historical data where activities have been ongoing and in an effort to include as much environmental variation within the HSTT Study Area as is reasonably available and can be incorporated into the model.

The NAEMO then records the energy received by each animat within the energy footprint of the event and calculates the number of animats having received levels of energy exposures that fall within defined impact thresholds.

Predicted effects on the animats within a scenario are then tallied and the highest order effect (based on severity of criteria; e.g., permanent threshold shift over temporary threshold shift) predicted for a given animat is assumed. Each scenario or each 24-hour period for scenarios lasting greater than 24 hours is independent of all others, and therefore, the same individual marine animal could be impacted during each independent scenario or 24-hour period. In few instances, although the activities themselves all occur within the HSTT Study Area, sound may propagate beyond the boundary of the Study Area. Any exposures occurring outside the boundary of the Study Area are counted as if they occurred within the Study Area boundary. The NAEMO provides the initial estimated impacts on marine species with a static horizontal distribution.

Model Assumptions- There are limitations to the data used in the model, and the results must be interpreted within these context. While the most accurate data and input assumptions have been used in the modeling, when there is a lack of definitive data to support an aspect of the modeling, modeling assumptions believed to overestimate the number of exposures have been chosen:

- Animats are modeled as being underwater, stationary, and facing the source and therefore always predicted to receive the maximum sound level (i.e., no porpoising or pinnipeds' heads above water). Some odontocetes have been shown to have directional hearing, with best hearing sensitivity facing a sound source and higher hearing thresholds for sounds propagating towards the rear or side of an animal (Mooney et al. 2008; Popov and Supin 2009; Kastelein et al. 2005).
- Animats do not move horizontally (but change their position vertically within the water column), which may overestimate physiological effects such as hearing loss, especially for slow moving or stationary sound sources in the model.
- Animats are stationary horizontally and therefore do not avoid the sound source, unlike in the wild where animals would most often avoid exposures at higher sound levels, especially those exposures that may result in permanent threshold shift.
- Animats are assumed to receive the full impulse of the initial positive pressure wave due to an explosion, although the impulse-based thresholds (onset mortality and onset slight lung injury) assume an impulse delivery time adjusted for animal size and depth. Therefore, these impacts are overestimated at farther distances and increased depths.
- Multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating the temporary or permanent hearing loss, because there are not sufficient data to estimate a hearing recovery function for the time between exposures.
- Mitigation measures that are implemented during many training exercises and testing activities were not considered in the model. In reality, sound-producing activities would be reduced, stopped, or delayed if marine mammals are detected within the mitigation zones around sound sources.

An animal is considered "exposed" to a sound if the received sound level at the animal's location is above the low-amplitude acoustic threshold below which meaningful biological responses are not anticipated (120 dB) within a similar frequency band. There are two primary types of source classes: impulsive and non-impulsive. To conduct an exposure analysis, the acoustic sources were divided into categories (bins) based on sound characteristics. Impulsive bins are based on the net explosive weight of the munitions or explosive devices or the source level for air and water guns. Non-impulsive acoustic sources are grouped into bins based on the frequency, source level, and when warranted, the application in which the source would be used. The following factors further describe the considerations associated with the development of non-impulsive source bins:

Frequency of the non-impulsive source:

- Low-frequency sources operate below 1 kilohertz (kHz)
- Mid-frequency sources operate at and above 1 kHz, up to and including 10 kHz

- High-frequency sources operate above 10 kHz, up to and including 100 kHz
- Very high-frequency sources operate above 100 kHz but below 200 kHz

Source level of the non-impulsive source:

- Greater than 160 dB, but less than 180 dB
- Equal to 180 dB and up to 200 dB
- Greater than 200 dB

Application in which the source would be used:

- How a sensor is employed supports how the sensor's acoustic emissions are analyzed
- Factors considered include pulse length (time source is on); beam pattern (whether sound is emitted as a narrow, focused beam or, as with most explosives, in all directions); and duty cycle (how often or how many times a transmission occurs in a given time period during an event).

The Navy provided NMFS with output values as "unprocessed" or "raw" exposure estimates. That is the estimated number of animats exposed to acoustic sources at received levels above 120 dB.

For this consultation, we considered exposure estimates from the NAEMO at several output points. First, the total number of ESA-listed species (animats) that would be exposed to acoustic sources prior to the application of a dose-response curve or criteria. We term these the "unprocessed" estimates. This estimate is the number of times individual animats or animals are likely to be exposed to the acoustic environment that is a result of training exercises and testing activities, regardless of whether they are "taken" as a result of that exposure. In most cases, the number of animals "taken" by an action would be a subset of the number of animals that are exposed to the action because (1) in some circumstances, animals might not respond to an exposure and (2) some animals may respond negatively to an exposure without that response constituting a form of "take" (for example, some physiological stress responses only have fitness consequences when they are sustained and would only constitute a "take" as a result of cumulative exposure).

A second set of exposure estimates of listed species were generated and "processed" using dose-response curves and criteria for temporary and permanent threshold shift developed by the Navy and NMFS Permits Division (Navy 2013b). Neither sets of exposure estimates, the unprocessed or processed, consider standard mitigation actions that the NMFS Permits Division would require under the MMPA rule to avoid marine mammals or that the Navy proposes for marine mammals, nor did the estimates consider any avoidance responses that might be taken by individual animals once they sense the presence of Navy vessels or aircraft.

Lastly, the U.S. Navy applied a third step of incorporated species specific avoidance and mitigation to derive the Navy's final MMPA take request. To account for mitigation measures, the acoustic analysis assumes a portion of the model-predicted mortalities or injuries would not occur if an animal at the water surface would likely be observed during those activities with Lookouts or other mitigation measures(Navy 2013f).

The Navy used mitigation effectiveness and sightability to partially account for the implementation of mitigation. The mitigation effectiveness is considered over two regions of an event's mitigation zone: (1) the range to onset mortality closer to the explosion and (2) range to onset permanent threshold shift. The model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness x Sightability, g(0)]; these animals are instead assumed to be present within the range to injury and range to temporary threshold shift, respectively. During an activity with a series of explosions (not concurrent multiple explosions), an animal is expected to exhibit an initial startle reaction to the first detonation followed by a behavioral response after multiple detonations. At close ranges and high sound levels approaching those that could cause permanent threshold shift, avoidance of the area around the explosions is the assumed behavioral response for most cases.

The ranges to permanent threshold shift for each functional hearing group for a range of explosive sizes (single detonation) are provided in the FEIS/OEISs. Animals not observed by Lookouts within the ranges to permanent threshold shift at the time of the initial couple of explosions are assumed to experience permanent threshold shift; however, animals that exhibit avoidance reactions beyond the initial range to permanent threshold shift are assumed to move away from the expanding range to permanent threshold shift effects with each additional explosion. Additionally, odontocetes have been demonstrated to have directional hearing, with best hearing sensitivity facing a sound source. An odontocete avoiding a source would receive sounds along a less sensitive hearing axis, potentially reducing impacts. Because the NAEMO does not account for avoidance behavior, the model-estimated effects are based on unlikely behavior that animals would remain in the vicinity of potentially injurious sound source and stay oriented to face the source. Therefore, only the initial exposures resulting in model-estimated permanent threshold shift are counted in the applied mitigation values, with the remaining model-estimated permanent threshold shift added to the temporary threshold shift value due to avoidance. This is why the values below for behavior responses or temporary threshold shift estimates increase and estimates of permanent threshold shift or other unjuries are lowered.

The analysis presented in this opinion considers all three exposure estimates on an annual basis. Specific numbers of takes presented in this opinion in some cases may vary from the numbers of takes in the referenced documents, such as the FEIS and associated technical reports, due to differences as a result of rounding issues associated with the different analysis used in this opinion.

Blue Whale

As decribed above we provide three exposure estimates for blue whales, unprocessed estimate, processed estimate, and an applied mitigation estimate.

Unprocessed Estimate - The model output estimates that blue whales will be exposed to sonar and other non-impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 97,942 blue whale exposure events annually to non-impulsive sounds at levels between 120 and 156 dB SPL and 9,068 blue whale exposure events annually to non-impulsive acoustic sources at levels between 157 and 216 dB SPL. No exposures to non-impulsive sounds are expected above 217 dB SPL. Approximately 103,758 of these exposures will occur in the Southern California areas, 3,054 will be in areas around Hawaii, and 198 will be in HSTT transit lane (Table 31).

Table 31. Activities that result in the highest percentages of blue whales unprocessed exposures to non-impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Blue Whale Exposures						
Helo ASW tracking			*23%*			
MPA ASW tracking	*38%*		*17%*			
Unmanned vehicle development	*18%*		*9%*			
Countermeasure testing		*100%*				
Sonobuoy lot testing	*13%*					
TRACKEX/TORPEX-surface				*37%*	*60%*	*43%*
TRACKEX/TORPEX-subsurface					*11%*	*13%*
Surface ship sonar maintenance					*18%*	
Undersea warfare exercise						*8%*
COMPTUEX				*32%*		
Joint task force exercise				*10%*		

The activities that are the largest contributors to non-impulsive exposure for blue whales in Southern California Range Complex are such due to the combination of the high number of each of these activities in Southern California Range Complex, the involvement of sonar in these training exercises and testing activities, and the relatively high density of blue whales in the areas where the training exercises and testing activities will occur.

Relatively few activities (and number of instances in which activities occur) take place in the Hawaii Range Complex and the transit lane, which explains the relatively low number of exposures in those areas, along with the relatively low density of blue whales here compared to Southern California Range Complex. As in Southern California Range Complex, the major contributors are activities that involve the use of sonar and activity frequency is greater than other activities in this area.

The model estimates that blue whales will be exposed to explosions and other impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 2,943 blue whale exposure events annually at sound levels between 120 and 156 dB SPL and 1,665 blue whale exposure events annually to impulsive acoustic sources at levels between 157 and 229 dB SPL. Approximately 4,434 of these exposures are predicted to occur in the Southern California areas, 173 are predicted to be in the areas around Hawaii, and one is predicted to be in the HSTT Study Area transit lane (Table 32).

Table 32. Activities that result in the highest percentages of blue whales unprocessed exposures to impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing Activities			Training exercises		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Blue Whale Exposures						
Missile (A-S)				*10%*		*14%*
Helo ASW tracking	21%					
MPA ASW tracking	*24%*		*21%*			
BOMBEX (A-S)						*29%*
TRACKEX/TORPEX - MPA extended echo ranging sonobuoy				*65%*		*22%*
Countermeasure testing			*32%*			
GUNEX (S-S)-ship-medium caliber					*65%*	
GUNEX (S-S)-ship-large caliber					*35%*	
Explosive torpedo testing			*21%*			
Missile exercise	*34%*					
Mine neutralization-EOD				*7%*		

The activities that are the largest contributors to impulsive exposure for blue whales in Southern California Range Complex are large contributors due to the large sound fields that the activities produce in the marine environment and the relatively high density of blue whales in the Southern California Range Complex.

Few impulsive activities (and number of instances in which activities occur) take place in the HSTT Study Area transit lane along with the relatively low density of blue whales here compared to Southern California Range Complex result in few exposures.

Blue whale density is relatively low in the Hawaii Range Complex and relatively little testing occurs here, which explains the relatively small proportion of exposures here compared to Southern California Range Complex. As in Southern California Range Complex, the major contributors here result from the large sound fields produced by the activities and the frequency of these activities.

Processed Estimates - The processed NAEMO results for non-impulsive acoustic source generate 1,788 instances of blue whales exposed to received levels that would cause them to respond with behaviors that NMFS would classify as harassment (as that term is defined for the purposes of military readiness activities under the Marine Mammal Protection Act of 1972) during training exercises and 125 during testing activities. In addition, there would be another 2,421 instances in which blue whales could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during training exercises and 303 during testing activities. There would be 116 instances in which blue whales could accumulate energy sufficient to result in permanent shifts in hearing sensitivity during training exercises and one blue whale during testing activities.

The processed NAEMO results for impulsive acoustic sources generate two instances of blue whales exposed to receive levels that cause them to respond with behaviors that NMFS would classify as harassment during training exercises and one from testing activities. In addition, there will be another three instances in which blue whales could accumulate energy sufficient to result in temporary shifts in hearing sensitivity from training exercises and one from testing activities. One blue whale could accumulate energy sufficient to result in permanent shift in hearing sensitivity during training exercises and zero from testing activities. No blue whales would experience GI tract or lung injury, and no blue whales would be killed during either training exercises or testing activities.

Applied Mitigation - After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of blue whales that could experience behavioral responses due to non-impulsive acoustic sources during training exercises is 1,786, the number of animals that would be expected to experience temporary threshold shift increased to 2,535, and zero blue whales would be expected to experience permanent threshold shift.

The estimated number of blue whales that could experience behavioral responses due to impulsive acoustic sources during training exercises is one, the number of animals that would be expected to experience temporary threshold shift increased to three, and zero blue whales would be expected to experience permanent threshold shift during training exercises.

After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of blue whales that could experience behavioral responses due to non-impulsive acoustic sources during testing activities was 124, the number of animals that would be expected to experience temporary threshold shift is 303, and zero blue whales would experience permanent threshold shift, GI tract or lung injury, and zero blue whale would be killed. The estimated number of blue whales that could experience behavioral responses due to impulsive acoustic sources during testing activities is one. Zero blue whales would experience temporary or permanent threshold shift, GI tract or lung injury, or be killed.

Fin Whale

As decribed previously we provide three exposure estimates for fin whales, unprocessed estimate, processed estimate, and an applied mitigation estimate.

Unprocessed Estimate - The model output estimates that fin whales will be exposed to sonar and other non-impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 44,231 fin whale exposure events annually to non-impulsive sounds at levels between 120 and 156 dB SPL and 3,437 fin whale exposure events annually to non-impulsive acoustic sources at levels between 157 and 210 dB SPL. No exposures to non-impulsive sounds are expected above 211 dB SPL. Approximately 38,397 of these exposures will occur in the Southern California areas, 2,937 will be in areas around Hawaii, and 6,333 will be in HSTT transit lane (Table 33).

Table 33. Activities that result in the highest percentages of fin whales unprocessed exposures to non-impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Fin Whale						
Helo ASW tracking	*20%*					
MPA ASW tracking	*17%*		*39%*			
Unmanned vehicle development	*11%*		*16%*			
Countermeasure testing		*100%*				
Sonobuoy lot testing			*14%*			
TRACKEX/TORPEX-surface				*36%*	*59%*	*44%*
TRACKEX/TORPEX-subsurface				*13%*	*13%*	*15%*
Surface ship sonar maintenance					*17%*	
Rim of the Pacific exercise						*9%*
COMPTUEX				*36%*		

The activities that are the largest contributors to non-impulsive exposure for fin whales in Southern California Range Complex are large contributors due to the combination of the large number of each of these activities in Southern California Range Complex, the normal involvement of significant acoustic energy output into the marine environment. The relatively high density of fin whales in the Hawaii Range Complex transit lane and the prevalvence of certain activities here are the basis for TORPEX activities constituting a large majority of exposures to fin whales here. Relatively little testing occurs in the Southern California Range Complex, which explains the relatively small number of exposures here compared to Southern California Range Complex, although fin whale density here is generally higher here than in Southern California Range Complex where exposure numbers are higher. As in Southern California Range Complex, the major contributors are activities that regularly discharge acoustic energy into the marine environment and activity frequency is greater than most other activities in this area.

The model estimates that fin whales will be exposed to explosions and other impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 1,067 fin whale exposure events annually at sound

levels between 120 and 156 dB SPL and 661 fin whale exposure events annually to impulsive acoustic sources at levels between 157 and 219 dB SPL. Approximately 1,551 of these exposures are predicted to occur in the Southern California areas, 164 are predicted to be in the areas around Hawaii, and 13 are predicted to be in the HSTT Study Area transit lane (Table 34).

Table 34. Activities that result in the highest percentages of fin whales unprocessed exposures to impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Fin Whale						
Missile Exercise (A-S)				*12%*		*14%*
MPA ASW tracking	*18%*		*22%*			
Helo ASW tracking	*17%*					
Missile testing (A-S)	*39%*					
Countermeasure testing			*30%*			
BOMBEX (A-S)				*61%*		*27%*
TRACKEX/TORPEX-MPA extended echo ranging sonobuoy						*23%*
GUNEX (S-S)-ship-large calibre					*30%*	
GUNEX (S-S)-ship-medium calibre					*70%*	
GUNEX (A-S)-mine neutralization-EOD				*8%*		
Explosive torpedo testing			*21%*			

The activities that are the largest contributors to impulsive exposure for fin whales in Southern California Range Complex are large contributors due to the large sound fields that the activities produce in the marine environment here. Few impulsive activities (and number of instances in which activities occur) take place in the transit lanes, which explains why there are few exposures here even though fin whale density is relatively high compared to Southern California Range Complex. Relatively little testing occurs in the Hawaii Range Complex, which explains the relatively small number of exposures here compared to Southern California Range Complex. As in Southern California Range Complex, the major contributors here result from the large sound fields produced by the activities and the frequency of these activities is greater than most other impulsive activities in the Hawaii Range Complex.

Processed Estimates - The processed NAEMO results for non-impulsive acoustic source generate 703 instances of fin whales exposed to received levels that cause them to respond with behaviors that NMFS would classify as harassment (as that term is defined for the purposes of the Marine Mammal Protection Act of 1972) during training exercises and 57 during testing activities. In addition, there would be another 986 instances in which fin whales could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during training exercises and 169 during testing activities. There would be 32 instances in which fin whales could accumulate energy sufficient to result in permanent shifts in hearing sensitivity during training exercises and zero during testing activities.

The processed NAEMO results for impulsive acoustic sources generate one instance of a fin whale exposed to receive levels that cause them to respond with behaviors that NMFS would classify as harassment during training exercises and none during testing activities. In addition, there would be one instance in which a fin whale could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during training exercises and one during testing activities. No fin whales are expected to accumulate energy sufficient to result in permanent shift in hearing sensitivity from either training exercises or testing activities. No fin whales would experience GI tract or lung injury, and no fin whales would be killed from either training or testing activities.

Applied Mitigation - After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of fin whales that could experience behavioral responses due to non-impulsive acoustic sources during training exercises is 701. In addition, there would be another 1,018 instances in which fin whales could accumulate energy sufficient from non-impulsive sources to result in temporary shifts in hearing sensitivity during training exercises. There would be zero instances in which fin whales could accumulate energy sufficient to result in permanent shifts in hearing sensitivity during training exercises.

The estimated number of fin whales that could experience behavioral responses due to impulsive acoustic sources during training exercises is zero, the number of animals that would be expected to experience temporary threshold shift is one, and zero fin whales would be expected to experience permanent threshold shift during training exercises.

After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of fin whales that could experience behavioral responses due to non-impulsive acoustic sources during testing activities was 56, the number of animals that would be expected to experience temporary threshold shift is 169, and zero fin whales would experience permanent threshold shift, GI tract or lung injury, and zero fin whales would be killed.

The estimated number of fin whales that could experience behavioral responses due to impulsive acoustic sources during testing activities is zero. The number of animals that would be expected to experience temporary threshold shift also zero. Further, zero fin whales are expected to experience permanent threshold shift, GI tract or lung injury or be killed.

Western North Pacific Gray Whale

The Navy did not have sufficient information to distinguish between ESA-listed western north Pacific gray whales and unlisted eastern north Pacific gray whales at the time they ran the NAEMO. Following reports of several listed western north Pacific gray whales along the west coast of the United States, we made a request to the Navy to evaluate the likelihood of of the proposed training exercises and testing activities to affect western north Pacific gray whales.

Evaluating the likely occurance of western north Pacific gray whales in the HSTT Study Area we determine that it is possible that a western north Pacific gray whale would transit southbound and northbound through the SOCAL Range Complex portion of the HSTT Study Area. Mate and Urban-Ramirez (2003) documented a northbound coastal migration route for a satellite tagged gray whale with the exception of the offshore leg between Mexico and the Channel Islands. This offshore route through the SOCAL Range Complex is consistent with previous studies showing both a near shore migration route for gray whales and an offshore route that passes east and west of San Clemente Island (Dohl et al. 1981 as summarized in Bonnell and Dailey 1993, Sumich and Show 2011). Average transit rate reported by Mate and Urban-Ramirez was 5.2 km/hr. Therefore, expected residence within the SOCAL Range Complex would be on the order of hours to days during each of the southbound and northbound legs of gray whale migrations.

To estimate the number of western north Pacific gray whales that would be exposed to active sonar and other acoustic sources, the Navy propotionally allocated the eastern north Pacific gray whale estimate based on the Weller et al (2013) estimate of western north Pacific gray whales along the U.S. West Coast of 23 animals and the estimated eastern north Pacific gray whale population of 19,126 (Carretta et al. 2013) such that 23/19,126=0.12 percent. Using that allocation the following processed estimates and applied mitigation estimates were calculated (cite memo).

<u>Processed Estimates</u> - The proportional allocation by the Navy did not distinguish between non-impulsive and impulsive acoustic sources. Combined, the Navy estimates that there would be three instances of western north Pacific gray whales exposed to received levels that would cause them to respond with behaviors that NMFS would classify as harassment during training exercises and zero during testing activities. In addition, there would be another seven instances in which north Pacific gray whales could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during training exercises and two during testing activities. There would be zero instances in which north Pacific gray whales could accumulate energy sufficient to result in

permanent shifts in hearing sensitivity during training exercises or testing activities (Navy 2013e).

Applied Mitigation - After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of western north Pacific gray whales that could experience behavioral responses due to non-impulsive acoustic sources during training exerises is three. Seven western north Pacific gray whales could experience temporary threshold shift due to non-impulsive acoustic sources during training exercises. Zero north Pacific gray whales would be expected to experience permanent threshold shift or other injury during training exercises (Navy 2013e).

The estimated number of western north Pacific gray whales that could experience behavioral responses from impulsive acoustic sources during training exercises is one. Zero western north Pacific gray whales could experience temporary threshold shift during training exercises. Zero would experience permanent threshold shift, GI tract or lung injury, and zero western north Pacific gray whale would be killed during training exercises.

After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of western north Pacific gray whales that could experience behavioral responses due to non-impulsive acoustic sources during testing activities was zero. The number of animals that would be expected to experience temporary threshold shift from non-impulsive acoustic sources during testing activities is two. Zero western north Pacific gray whales would experience permanent threshold shift or be killed during testing activities.

The estimated number of western north Pacific gray whales that could experience behavioral responses, temporary threshold shift of permanent threshold shift due to impulsive acoustic sources during testing activities is zero.

Humpback Whale

As decribed previously we provide three exposure estimates for humpback whales, unprocessed estimate, processed estimate, and an applied mitigation estimate.

Unprocessed Estimate - The model output estimates that humpback whales will be exposed to sonar and other non-impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 185,275 humpback whale exposure events annually to non-impulsive sounds at levels between 120 and 156 dB SPL and 13,541 humpback whale exposure events annually to non-impulsive acoustic sources at levels between 157 and 210 dB SPL. No exposures to non-impulsive sounds are expected above 211 dB SPL. Approximately 29,163 of these exposures will occur in the

Southern California areas, 169,383 will be in areas around Hawaii, and 270 will be in HSTT transit lane (Table 35).

Table 35. Activities that result in the highest percentages of humpback whales unprocessed exposures to non-impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Humpback Whale						
Helo ASW tracking			*15%*			
MPA ASW tracking	*40%*		*20%*			
Unmanned vehicle development			*13%*			
Countermeasure testing		*100%*				
ASW mission package testing	*16%*					
TRACKEX/TORPEX-surface				*36%*	*58%*	*25%*
TRACKEX/TORPEX-subsurface					*12%*	
Surface ship sonar maintenance					*18%*	
Undersea warfare exercise						*9%*
COMPTUEX				*33%*		
Submarine navigation						*24%*
Sonobuoy lot testing	*14%*					
Joint task force exercise				*13%*		

The activities that are the largest contributors to non-impulsive exposure for humpback whales in Southern California Range Complex are large contributors due to the combination of the large number of each of these activities in Southern California Range Complex, the seasonal presence of humpback whales here, and the normal involvement of significant acouistic energy output into the marine environment. The relatively low density of humpback whales in the Hawaii Range Complex transit lane and the prevalvence of certain activities here are the basis for TRACKEX/TORPEX activities constituting a large majority of exposures to humpback whales here. Relatively little testing occurs in the Hawaii Range Complex but humpback whale density here is generally higher here than in Southern California Range Complex. As in Southern California Range Complex, the major contributors are activities that regularly discharge acoustic energy into the marine environment and activity frequency is greater than most other activities in this area. Areas of high humpback whale density in the HRC were discussed earlier in this document.

Because humpback whales migrate to the north in the summer, impacts are predicted only for the cool season in the HSTT Study Area. While the humpback breeding areas around Hawaii are important, major training exercises involving mid-frequency active sonar in the humpback breeding areas are rare and infrequent.

The model estimates that humpback whales will be exposed to explosions and other impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 5,972 humpback whale exposure events annually at sound levels between 120 and 156 dB SPL and 1,133 humpback whale exposure events annually to impulsive acoustic sources at levels between 157 and 219 dB SPL. Approximately 900 of these exposures are predicted to occur in the Southern California areas, 6,204 are predicted to be in the areas around Hawaii, and 30 are predicted to be in the HSTT Study Area transit lane (Table 36).

The activities that are the largest contributors to impulsive exposure for humpback whales in Southern California Range Complex are large contributors due to the large sound fields that the activities produce in the marine environment here. Few impulsive activities (and number of instances in which activities occur) take place in the Hawaii Range Complex transit lane, which explains the few number of exposures here, although humpback whale density is relatively low compared to Southern California Range Complex. Relatively little testing occurs in the Hawaii Range Complex, but humpback whale density is seasonally much higher than in other areas, resulting in a larger number of exposures here than in Southern California Range Complex. As in Southern California Range Complex, the major contributors here result from the large sound fields produced by the activities and the frequency of these activities is greater than most other impulsive activities in the Hawaii Range Complex.

Table 36. Activities that result in the highest percentages of humpback whales unprocessed exposures to impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Humpback Whale						
Missile exercise (A-S)				*11%*		*20%*
Missile testing (A-S)	*30%*		*15%*			
MPA ASW tracking	*22%*		*38%*			
MCM mission package testing			*15%*			
Helo ASW tracking	*19%*					
BOMBEX (A-S)				*58%*		*33%*
TRACKEX/TORPEX - MPA extended echo ranging sonobuoy						*27%*
GUNEX (S-S)-ship-large calibre					*87%*	
GUNEX (S-S)-ship-medium calibre					*13%*	
Mine neutralization-EOD				*9%*		

Processed Estimates - The processed NAEMO results for non-impulsive acoustic source generate 3,300 instances of humpback whales exposed to received levels that cause them to respond with behaviors that NMFS would classify as harassment during training exercises and 273 during testing activities. In addition, there would be another 5,912 instances in which humpback whales could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during training exercises and 640 during testing activities. There would be 64 instances in which humpback whales could accumulate energy sufficient to result in permanent shifts in hearing sensitivity during training exercises and four humpback whales during testing activities.

The processed NAEMO results for impulsive acoustic sources generate one instance of a humpback whale exposed to received levels that cause it to respond with behaviors that NMFS would classify as harassment during training exercises and zero during testing activities. In addition, there will be another one instance in which humpback whales could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during training exercises and seven during testing activities. No humpback whales are expected to accumulate energy sufficient to result in permanent shift in hearing sensitivity from either training exercises or testing activities.

No humpback whales would experience GI tract or lung injury, and no humpback whales would be killed during either training exercises or testing activities.

Applied Mitigation - After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of humpback whales that could experience behavioral responses due to non-impulsive acoustic sources during training exercises is 3,299 and 272 during testing activities. The estimated number of humpback whales that could accumulate energy sufficient to result in temporary shifts in hearing sensitivity due to non-impulsive acoustic sources was 5,974 during training exercises and 649 during testing activities. Zero humpback whales would be expected to experience permanent threshold shift from either training exercises or testing activities from non-impulsive acoust sources.

After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of humpback whales that could experience behavioral responses due to impulsive acoustic sources during training exercises is zero. Zero animals could be expected to experience temporary threshold shift, permanent threshold shift, GI tract or lung injury, or would be killed.

The estimated number of humback whales that could experience behavioral responses due to impulsive acoustic sources during testing activities is zero, the number of animals that would be expected to experience temporary threshold shift is six. Zero humpback whales would be expected to experience permanent threshold shift or be killed during either training exercises or testing activities.

Sei Whale

As decribed previously we provide three exposure estimates for sei whales, unprocessed estimate, processed estimate, and an applied mitigation estimate.

Unprocessed Estimate - The model output estimates that sei whales will be exposed to sonar and other non-impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 9,674 sei whale exposure events annually to non-impulsive sounds at levels between 120 and 156 dB SPL and 949 sei whale exposure events annually to non-impulsive acoustic sources at levels between 157 and 210 dB SPL. No exposures to non-impulsive sounds are expected above 211 dB SPL. Approximately 3,496 of these exposures will occur in the Southern California areas, 6,895 will be in areas around Hawaii, and 232 will be in HSTT transit lane (Table 37).

Table 37. Activities that result in the highest percentages of sei whales unprocessed exposures to non-impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Sei Whale						
Helo ASW tracking			*17%*			
MPA ASW tracking	*30%*		*18%*			
Unmanned vehicle development	*16%*		*13%*			
Countermeasure testing		*100%*				
ASW mission package testing	*16%*					
TRACKEX/TORPEX-surface				*38%*	*60%*	*40%*
TRACKEX/TORPEX-subsurface					*12%*	*13%*
Surface ship sonar maintenance					*17%*	
Rim of the Pacific exercise						*10%*
COMPTUEX				*27%*		
Joint task force exercise				*14%*		

The activities that are the largest contributors to non-impulsive exposure for sei whales in Southern California Range Complex are large contributors due to the combination of the large number of each of these activities in Southern California Range Complex, the seasonal and generally low presence of sei whales here, and the normal involvement of significant acoustic energy output into the marine environment. The prevalvence of certain activities in the Hawaii Range Complex transit lane are the basis for TRACKEX/TORPEX activities constituting a large majority of exposures to sei whales here. Relatively little testing occurs in the Hawaii Range Complex but sei whale density here is generally higher here than in Southern California Range Complex. As in Southern California Range Complex, the major Hawaii Range Complex contributors are activities that regularly discharge acoustic energy into the marine environment and activity frequency is greater than most other activities in this area.

The model estimates that sei whales will be exposed to explosions and other impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 362 sei whale exposure events annually at sound levels between 120 and 156 dB SPL and 145 sei whale exposure events annually to impulsive acoustic sources at levels between 157 and 210 dB SPL. Approximately 228 of these exposures

are predicted to occur in the Southern California areas, 278 are predicted to be in the areas around Hawaii, and 1 is predicted to be in the HSTT Study Area transit lane (Table 38).

Table 38. Activities that result in the highest percentages of sei whales unprocessed exposures to impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Sei Whales						
Missile exercise (A-S)				*12%*		*19%*
MPA ASW tracking			*30%*			
Helo ASW tracking	*21%*					
Missile testing (A-S)	*25%*					
Sonobuoy lot acceptance testing	*19%*					
BOMBEX (A-S)				*51%*		*29%*
TRACKEX/TORPEX - MPA extended echo ranging sonobuoy						*25%*
GUNEX (S-S)-ship-large calibre					*29%*	
GUNEX (S-S)-ship-medium calibre					*71%*	
Countermeasure testing			*24%*			
Explosive torpedo testing			*18%*			
Mine neutralization-EOD				*17%*		

The activities that are the largest contributors to impulsive exposure for sei whales in Southern California Range Complex are large contributors due to the large sound fields that the activities produce in the marine environment here. Few impulsive activities (and number of instances in which activities occur) take place in the Hawaii Range Complex transit lane, which explains the few number of exposures here, although sei whale density is relatively low compared to Southern California Range Complex. Relatively little testing occurs in the Hawaii Range Complex, but sei whale density is seasonally high in this area, resulting in a roughly equivalent number of exposures compared to Southern California Range Complex. As in Southern California Range Complex, the major contributors here result from the large sound fields produced by the activities and the frequency of these activities is greater than most other impulsive activities in the Hawaii Range Complex.

Processed Estimates - The processed NAEMO results for non-impulsive acoustic source generate 227 instances of sei whales exposed to received levels that cause them to respond with behaviors that NMFS would classify as harassment during training exercises and 17 during testing activities. In addition, there would be another 388 instances in which sei whales could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during training exercises and 36 during testing activities. There would be 18 instances in which sei whales could accumulate energy sufficient to result in permanent shifts in hearing sensitivity during training exercises and zero sei whales during testing activities.

The processed NAEMO results for impulsive acoustic sources generate zero instances of a sei whale exposed to received levels that cause it to respond with behaviors that NMFS would classify as harassment during training exercises and zero during testing activities. In addition, there were no instances in which sei whales could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during either training exercises or testing activities. No sei whales are expected to accumulate energy sufficient to result in permanent shift in hearing sensitivity from either training exercises or testing activities No sei whales would experience GI tract or lung injury, and no sei whales would be killed for training or testing activities.

Applied Mitigation - After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of sei whales that could experience behavioral responses due to non-impulsive acoustic sources during training exercises was 226 and 16 during testing activities. The estimated number of sei whales that could accumulate energy sufficient to result in temporary shifts in hearing sensitivity due to non-impulsive acoustic sources was 404 during training exercises and 35 during testing activities. Zero sei whales would be expected to experience permanent threshold shift from either training exercises or testing activities.

After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of sei whales that could experience behavioral responses due to impulsive acoustic sources was zero for both training exercises and testing activities. Zero sei whales would be expected to experience temporary threshold shift, permanent threshold shift, GI tract or lung injury, or would be killed for both training exercises and testing activities.

Sperm Whale

As decribed previously we provide three exposure estimates for sperm whales, unprocessed estimate, processed estimate, and an applied mitigation estimate.

Unprocessed Estimate - The model output estimates that sperm whales will be exposed to sonar and other non-impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 111,383 sperm

whale exposure events annually to non-impulsive sounds at levels between 120 and 156 dB SPL and 7,304 sperm whale exposure events annually to non-impulsive acoustic sources at levels between 157 and 210 dB SPL. No exposures to non-impulsive sounds are expected above 211 dB SPL. Approximately 65,554 of these exposures will occur in the Southern California areas, 52,208 will be in areas around Hawaii, and 926 will be in HSTT transit lane (Table 39).

Table 39. Activities that result in the highest percentages of sperm whales unprocessed exposures to non-impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Sperm Whale						
Helo ASW tracking			*14%*			
MPA ASW tracking	*41%*		*24%*			
Unmanned vehicle development	*15%*		*12%*			
Countermeasure testing		*100%*				
TRACKEX/TORPEX-surface				*38%*	*60%*	*38%*
TRACKEX/TORPEX-subsurface					*13%*	*16%*
Surface ship sonar maintenance					*15%*	
ASW mission package testing	*17%*					
COMPTUEX				*33%*		
Submarine navigation exercise						*10%*
Joint task force exercise				*12%*		

The activities that are the largest contributors to non-impulsive exposure for sperm whales in Southern California Range Complex are large contributors due to the combination of the large number of each of these activities in Southern California Range Complex, the high sperm whale density, and the normal involvement of significant acoustic energy output into the marine environment. The prevalvence of certain activities in the Hawaii Range Complex transit lane are the basis for TRACKEX/TORPEX activities constituting a large majority of exposures to sperm whales here. As in Southern California Range Complex, the major Hawaii Range Complex contributors are activities that regularly discharge acoustic energy into the marine environment and activity frequency is greater than most other activities in this area.

The model estimates that sperm whales will be exposed to explosions and other impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 1,681 sperm whale exposure events annually at sound levels between 120 and 156 dB SPL and 1,822 sperm whale exposure events annually to impulsive acoustic sources at levels between 157 and 219 dB SPL. Approximately 1,393 of these exposures are predicted to occur in the Southern California areas, 2,101 are predicted to be in the areas around Hawaii, and 10 are predicted to be in the HSTT Study Area transit lane (Table 40).

Table 40. Activities that result in the highest percentages of sperm whales unprocessed exposures to impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Sperm Whale						
Missile exercise (A-S)				*12%*		*11%*
MPA ASW tracking	*27%*		*33%*			
Helo ASW tracking	*22%*					
Missile testing (A-S)	*21%*					
BOMBEX (A-S)				*57%*		*23%*
TRACKEX/TORPEX - MPA extended echo ranging sonobuoy						*37%*
GUNEX (S-S)-ship-large caliber					*25%*	
GUNEX (S-S)-ship-medium caliber					*75%*	
MCM mission package testing			*26%*			
Sinking exercise				*8%*		
Countermeasure testing			*14%*			

The activities that are the largest contributors to impulsive exposure for sperm whales in Southern California Range Complex are large contributors due to the large sound fields that the activities produce in the marine environment here. Few impulsive activities (and number of instances in which activities occur) take place in the Hawaii Range Complex transit lane, which explains the few number of exposures here. Relatively little testing occurs in the Hawaii Range Complex. As in Southern California Range Complex, the major contributors here result from the

large sound fields produced by the activities and the frequency of these activities is greater than most other impulsive activities in the Hawaii Range Complex.

Processed Estimates - The processed NAEMO results for non-impulsive acoustic source generate 3,151 instances of sperm whales exposed to received levels that cause them to respond with behaviors that NMFS would classify as harassment during training exercises and 140 during testing activities. In addition, there would be another 183 instances in which sperm whales could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during training exercises and 123 during testing activities. There would be zero instances in which sperm whales could accumulate energy sufficient to result in permanent shifts in hearing sensitivity during training exercises and three sperm whales during testing activities.

he processed NAEMO results for impulsive acoustic sources generate zero instances of a sperm whale exposed to receive levels that cause it to respond with behaviors that NMFS would classify as harassment during training exercises and zero during testing activities. Also there will be zero instances in which sperm whales could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during either training exercises or testing activities. No sperm whales are expected to accumulate energy sufficient to result in permanent shift in hearing sensitivity from either training exercises or testing activities No sperm whales would experience GI tract or lung injury, and no sperm whales would be killed from either training exercises or testing activities.

Applied Mitigation - After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of sperm whales that could experience behavioral responses due to non-impulsive acoustic sources during training exercises was 3,150 and 140 during testing activities. The estimated number of sperm whales that could accumulate energy sufficient to result in temporary shifts in hearing sensitivity due to non-impulsive acoustic sources was 182 during training exercises and 124 during testing activities. Zero sperm whales would be expected to experience permanent threshold shift from either training exercises or testing activities.

After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of sperm whales that could experience behavioral responses due to impulsive acoustic sources during training exercises and testing activities remained at zero. Zero sperm whales would experience permanent threshold shift, GI tract or lung injury, and no sperm whale would be killed.

Main Hawaiian Islands Insular False Killer Whales

The NAEMO output for false killer whales included multiple stocks; only one of which is listed under the ESA, the main Hawaiian Islands Insular false killer whales. As such, to estimate the number of ESA-listed false killer whales may be affected by the proposed action we prorated the

values based on the proportional estimates of whales from each stock. Per previous sections we provide three exposure estimates for main Hawaiian Island Insular false killer whales, unprocessed estimate, processed estimate, and an applied mitigation estimate.

Unprocessed Estimate - The model output estimates that MHI insular false killer whales will be exposed to sonar and other non-impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 1,337 false killer whale (7 percent of 19,101) exposure events annually to non-impulsive sounds at levels between 120 and 156 dB SPL and 98 MHI insular false killer whale exposure events annually to non-impulsive acoustic sources at levels between 157 and 210 dB SPL. Zero exposures to non-impulsive sounds are expected above 211 dB SPL. All of these exposures are predicted to occur in the areas around Hawaii (Table 41). The major HRC contributors are activities that regularly discharge acoustic energy into the marine environment and activity frequency is greater than most other activities in this area.

Table 41. Activities that result in the highest percentages of unprocessed exposures of false killer whales to non-impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
False Killer Whale						
Helo ASW tracking			*15%*			
MPA ASW tracking			*14%*			
Submarine sonar testing/maintenance			*16%*			
TRACKEX/TORPEX-surface						*44%*
TRACKEX/TORPEX-subsurface						*14%*
Undersea warfare exercise						*10%*

The model estimates that MHI insular false killer whales will be exposed to explosions and other impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 42 MHI insular false killer whale exposure events annually at sound levels between 120 and 156 dB SPL and 10 MHI insular false killer whale exposure events annually to impulsive acoustic sources at levels between 157 and 216 dB SPL. All of these exposures are predicted to occur in the areas around Hawaii (Table 42).

The major contributors in the Hawaii Range Complex result from the large sound fields produced by the activities and the frequency of these activities is greater than most other

impulsive activities in the Hawaii Range Complex. In addition, these activities are generally closer to shore, which overlaps the distribution of Main Hawaiian Islands Insular false killer whales more than other activities.

Table 42. Activities that result in the highest percentages of false killer whales unprocessed exposures to impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
False Killer Whale						
Missile exercise (A-S)						*19%*
MPA ASW tracking			*35%*			
Explosive torpedo testing			*21%*			
Countermeasure testing			*17%*			
BOMBEX (A-S)						*30%*
TRACKEX/TORPEX - MPA extended echo ranging sonobuoy						*24%*

Processed Estimates - The processed NAEMO results for non-impulsive acoustic sources generate 46 instances of MHI insular false killer whales exposed to received levels that cause them to respond with behaviors that NMFS would classify as harassment during training exercises and two during testing activities. In addition, there would be another three instances in which MHI insular false killer whales could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during training exercises and two during testing activities. There would be zero instances in which MHI insular false killer whales could accumulate energy sufficient to result in permanent shifts in hearing sensitivity during either training exercises or testing activities.

The processed NAEMO results for impulsive acoustic sources generate zero instances of a MHI insular false killer whale exposed to received levels that cause it to respond with behaviors that NMFS would classify as harassment during either training exercises or testing activities. In addition, there were zero instances in which MHI insular false killer whales could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during either training exercises or testing activities. No MHI insular false killer whales are expected to accumulate energy sufficient to result in permanent shift in hearing sensitivity from either training exercises or testing activities No MHI insular false killer whales would experience GI tract or lung injury, and no MHI insular false killer whales would be killed from either training exercises or testing activities.

Applied Mitigation - After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of MHI insular false killer whales that could experience behavioral responses due to non-impulsive acoustic sources during training exercises remained at 46 during training exercises and two during testing activities. The estimated number of MHI insular false killer whales that could accumulate energy sufficient to result in temporary shifts in hearing sensitivity due to non-impulsive acoustic sources remained at three during training exercises and two during testing activities. No MHI insular false killer whales would be expected to experience permanent threshold shift from either training exercises or testing activities.

After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of MHI insular false killer whales that could experience behavioral responses due to impulsive acoustic sources remained at none, and the number of animals that would be expected to experience temporary threshold shift was also none for either training exercises or testing activities. No MHI insular false killer whales would experience permanent threshold shift, GI tract or lung injury, and no MHI insular false killer whale would be killed from either training exercises or testing activities.

Guadalupe Fur Seal

As decribed previously for most of the whale species we provide three exposure estimates for Guadalupe fur seals; unprocessed estimate, processed estimate, and an applied mitigation estimate.

Unprocessed Estimate - The model output estimates that Guadalupe fur seals will be exposed to sonar and other non-impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 86,022 Guadalupe fur seal exposure events annually to non-impulsive sounds at levels between 120 and 156 dB SPL and 6,649 Guadalupe fur seal exposure events annually to non-impulsive acoustic sources at levels between 157 and 216 dB SPL. No exposures to non-impulsive sounds are expected above 214 dB SPL. Approximately 91,286 of these exposures will occur in the Southern California areas, zero will be in areas around Hawaii, and 1,385 will be in HSTT transit lane (Table 43).

Table 43. Activities that result in the highest percentages of Guadalupe fur seals unprocessed exposures to impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Guadalupe fur seals						
ASW mission package testing	*19%*					
MPA ASW tracking	*36%*					
Unmanned vehicle development	*15%*					
Countermeasure testing		*100%*				
TRACKEX/TORPEX-surface				*36%*	*64%*	
TRACKEX/TORPEX-subsurface					*9%*	
Surface ship sonar maintenance					*16%*	
COMPTUEX				*32%*		
Joint task force exercise				*12%*		

The major Southern California Range Complex contributors are activities that regularly discharge acoustic energy into the marine environment and activity frequency is greater than most other activities in this area. However, as the species' density is greater closer to shore, activities that tend to be undertaken closer to shore also tend to expose Guadalupe fur seals more than activities that tend to be more offshore or wide-ranging in nature. Eight non-impulsive exposures intense enough that they are expected to result in temporary threshold shift, permanent threshold shift, or other pathological effects are anticipated from training exercises, most from COMPTUEX and lesser contributions from surface TRACKEX/TORPEX. None are expected to produce permanent threshold shift or other pathological effects and all would occur in Southern California Range Complex (Table 44).

Table 44. Activities that result in the highest percentages of Guadalupe fur seals unprocessed exposures to non-impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Guadalupe Fur Seal						
Missile exercise (A-S)				*15%*		
MPA ASW tracking	*18%*					
Missile testing (A-S)	*36%*					
Helo ASW tracking	*16%*					
BOMBEX (A-S)				*56%*		
GUNEX (S-S)-ship-large caliber					*30%*	
GUNEX (S-S)-ship-medium caliber					*70%*	
Sinking exercise				*7%*		

The major Southern California Range Complex contributors are activities that regularly discharge acoustic energy into the marine environment and activity frequency is greater than most other activities in this area. However, as the species' density is greater closer to shore, activities that tend to be undertaken closer to shore also tend to expose Guadalupe fur seals more than activities that tend to be more offshore or wide-ranging in nature.

Processed Estimates - The processed NAEMO results for non-impulsive acoustic sources generate 2,596 instances of Guadalupe fur seals exposed to received levels that cause them to respond with behaviors that NMFS would classify as harassment during training exercises and 270 during testing activities. In addition, there would be another seven instances in which Guadalupe fur seals could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during training exercises and zero during testing activities. There would be one instance in which Guadalupe fur seals could accumulate energy sufficient to result in permanent shifts in hearing sensitivity during training exercises and zero Guadalupe fur seals during testing activities.

The processed NAEMO results for impulsive acoustic sources generate zero instance of a Guadalupe fur seal exposed to received levels that cause it to respond with behaviors that NMFS would classify as harassment during training exercises and zero during testing activities. In addition, there will be zero instances in which Guadalupe fur seals could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during either training exercises or testing activities. No Guadalupe fur seals are expected to accumulate energy sufficient to result

in permanent shift in hearing sensitivity from either training exercises or testing activities. One Guadalupe fur seal during training exercises and one instance during testing activities of animals that would experience GI tract or lung injury. No Guadalupe fur seals would be killed from either training exercises or testing activities.

Applied Mitigation - After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of Guadalupe fur seals that could experience behavioral responses due to non-impulsive acoustic sources during training exercises was 2,596 and 269 during testing activities. The estimated number of Guadalupe fur seals that could accumulate energy sufficient to result in temporary shifts in hearing sensitivity due to non-impulsive acoustic sources was seven during training exercises and zero during testing activities. Zero Guadalupe fur seals would be expected to experience permanent threshold shift from either training exercises or testing activities.

After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of Guadalupe fur seals that could experience behavioral responses due to impulsive acoustic sources from either training exercises or testing activities was zero. Zero Guadalupe fur seals would experience permanent threshold shift or slight lung injury, GI tract injury, or be killed.

Hawaiian Monk Seal

As decribed previously for most of the whale species we provide three exposure estimates for Hawaiian monk seals; unprocessed estimate, processed estimate, and an applied mitigation estimate.

Unprocessed Estimate - The model output estimates that Hawaiian monk seals will be exposed to sonar and other non-impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 23,328 Hawaiian monk seal exposure events annually to non-impulsive sounds at levels between 120 and 156 dB SPL and 2,628 Hawaiian monk seal exposure events annually to non-impulsive acoustic sources at levels between 157 and 201 dB SPL. Zero exposures to non-impulsive sounds are expected above 202 dB SPL. None of these exposures will occur in the Southern California or transit lane areas (Table 45).

Table 45. Activities that result in the highest percentages of Hawaiian monk seals unprocessed exposures to non-impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Hawaiian Monk Seal						
Submarine sonar maintenance						*44%*
Non-explosive torpedo testing			*15%*			
Unmanned vehicle development			*11%*			
AUV AT/FP mine countermeasures			*38%*			
TRACKEX/TORPEX-surface						*22%*
Undersea warfare exercise						*8%*

The major Hawaii Range Complex contributors are activities that regularly discharge acoustic energy into the marine environment and activity frequency is greater than most other activities in this area. However, as the species' density is greater closer to shore, activities that tend to be undertaken closer to shore also tend to expose Hawaiian monk seals more than activities that tend to be more offshore or wide-ranging in nature. No non-impulsive exposures intense enough that they are expected to result in temporary threshold shift, permanent threshold shift, or other pathological effects are anticipated from testing or training exercises.

Table 46. Activities that result in the highest percentages of Hawaiian monk seal unprocessed exposures to impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Hawaiian Monk Seal						
Missile exercise (A-S)						*28%*
Mine neutralization-EOD						*10%*
MPA ASW tracking			*18%*			
Missile testing (A-S)			*41%*			
BOMBEX (A-S)						*40%*
Explosive torpedo testing			*13%*			

The major impulsive Hawaii Range Complex contributors are activities that regularly discharge acoustic energy into the marine environment and activity frequency is greater than most other activities in this area. However, as the species' density is greater closer to shore, activities that tend to be undertaken closer to shore also tend to expose Hawaiian monk seals more than activities that tend to be more offshore or wide-ranging in nature.

Processed Estimates - The processed NAEMO results for non-impulsive acoustic sources generate 845 instances of Hawaiian monk seals exposed to received levels that cause them to respond with behaviors that NMFS would classify as harassment during training exercises and 179 during testing activities. In addition, there would be another 443 instances in which Hawaiian monk seals could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during training exercises and 168 during testing activities. There would be five instances in which Hawaiian monk seals could accumulate energy sufficient to result in permanent shifts in hearing sensitivity during training exercises and 14 Hawaiian monk seals during testing activities.

The processed NAEMO results for impulsive acoustic sources generate one instance of a Hawaiian monk seal exposed to received levels that cause it to respond with behaviors that NMFS would classify as harassment during training exercises and zero during testing activities. In addition, there will be one instance in which Hawaiian monk seals could accumulate energy sufficient to result in temporary shifts in hearing sensitivity during training exercises and zero during testing activities. No Hawaiian monk seals would experience permanent shifts in hearing sensitivity, experience GI tract or lung injury, or would be killed from either training or testing activities.

Applied Mitigation - After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of Hawaiian monk seals that could experience behavioral responses due to non-impulsive acoustic sources during training exercises was 845 and 178 during testing activities. The estimated number of Hawaiian monk seals that could accumulate energy sufficient to result in temporary shifts in hearing sensitivity due to non-impulsive acoustic sources was 446 during training exercises and 180 during testing activities. Zero Hawaiian monk seals would be expected to experience permanent threshold shift from either training exercises or testing activities.

After considering mitigation actions that will be implemented by the Navy plus those measures that will satisfy the requirements of the MMPA, the estimated number of Hawaiian monk seals that could experience behavioral responses due to impulsive acoustic sources during training exercises remained at zero, one Hawaiian monk seal would be expected to experience temporary threshold shift. Zero Hawaiian monk seals would experience permanent threshold shift, GI tract or lung injury, and zero Hawaiian monk seal would be killed from either training exercises or testing activities.

Sea Turtles

Information regarding the abundance and distribution of the five sea turtle species was not sufficient to allow the NAEMO to estimate exposures by species. To assess turtle exposures the Navy combined all of the species into a single category they termed "Pacific Turtle Guild" and we are calling "Pacific Sea Turtles." In other words, green, hawksbill, loggerhead, leatherback, and olive ridley turtles were all included as a group to account for open ocean occurrences of sea turtle species in all life stages. All species density distributions matched the expected distributions from published literature and NMFS stock assessments.

A quantitative analysis of impacts on a species requires data on the abundance and concentration of the species population in the impacted area. The most appropriate metric for this type of analysis is density, which is the number of animals present per unit area. There is no single source of density data for every area of the world, species, and season because of the fiscal costs, resources, and effort involved in providing survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the Study Area, the Navy compiled data from several sources. To compile and structure the most appropriate database of marine species density data, the Navy developed a protocol to select the best available data sources based on species, area, and time (season). The resulting Geographic Information System database called the Navy Marine Species Density Database includes seasonal density values for every marine mammal and sea turtle species present within the Study Area (U.S. Department of the Navy 2011). All species density distributions matched the expected distributions from published literature and the NMFS stock assessments.

The NAEMO used sea turtle density data as an input in their original temporal and spatial resolution. Seasons are defined as winter (December through February), spring (March through May), summer (June through August), and fall (September through November). The density grid cell spatial resolution varied, depending on the original data source used. Where data sources overlap, there might be a sudden increase or decrease in density due to different derivation methods or survey data utilized. This is an artifact of attempting to use the best available data for each geographic region. Any attempt to smooth the datasets would either increase or decrease adjacent values, and would have inflated the error of those values.

Green Turtle – Southern California Range Complex

Green turtles are only regularly expected within the southern part of San Diego Bay where a semi-resident population of about 50-60 green turtles reside. Given a reasonably accurate subpopulation count and known distribution within the Bay, an acceptable green sea turtle density estimate was derived specifically for San Diego Bay only. For offshore waters from the San Diego coast through the SOCAL range complex out to the Patton Escarpment, there are no sea turtle sighting data from which to estimate density. This includes either published or unpublished NMFS data, or from ongoing Navy funded surveys.

Navy has been funding visual surveys from the coast of Southern California out to approximately 100 nm from 2008 through 2013. As summarized through 2012, over 870 hours of effort was made and 43,500 nm of survey effort completed. To date, not a single sea turtle visual sighting has been made. These surveys, one of which was done exclusively by NMFS SWFSC, are able to sight small surfaced and submerged animals such as sharks, ocean sunfish, and fish schools, and have been demonstrated to sight sea turtles in other areas where turtles are more common such as Hawaii. While there are some sea turtle stranding records in Southern California, and possibly some unpublished sea turtle satellite tracks through parts of the Navy's range, the Navy would assert that biologically speaking, the Navy's range complex is not a significant sea turtle habitat for any species.

Therefore, for the SOCAL portion of HSTT, the only sea turtle density available was for green turtle within San Diego Bay. As decribed previously for other species, we provide three exposure estimates for green turtles; an unprocessed estimate, processed estimate, and an applied mitigation estimate.

Unprocessed Estimate - The model output estimates that green turtles will be exposed to sonar and other non-impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 2,536 green turtle exposure events annually to non-impulsive sounds at levels between 120 and 156 dB SPL and 103 green turtle exposure events annually to non-impulsive acoustic sources at levels between 157 and 177 dB SPL. No exposures to non-impulsive sounds are expected above 178 dB SPL (Table 47). All modelled exposures will occur in Southern California, specifically in San Diego Bay.

Table 47. Activities that result in the highest percentages of green turtle unprocessed exposures to non-impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Green Turtle						
TRACKEX/TORPEX-surface				*79%*		
Extended echo ranging sonobuoy				*21%*		
Surface ship sonar testing and maintenance	*4%*					
Fixed AT/FP mine countermeasures	*37%*					
AUV AT/FP mine countermeasures	*51%*					

The major Southern California Range Complex contributors are activities that regularly discharge acoustic energy into the marine environment where activity frequency is greater than most other activities in this area. In this case, only certain activities occur in San Diego Bay and these are the only activities that can expose green turtles to acoustic sources. There are no non-impulsive exposures anticipated to result in temporary threshold shift, permanent threshold shift, or other pathological effects from training exercises. However, three are expected from testing activities stemming from the pierside integrated swimmer defense airgins. None of the exposures are expected to produce permanent threshold shift or pathological effects.

The model estimates that green turtles will be exposed to explosions and other impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 136 green turtle exposure events annually at sound levels between 120 and 156 dB SPL and zero green turtle exposure events annually to impulsive acoustic sources at levels over 157 dB SPL (Table 48). All modelled exposures are predicted to occur in Southern California, specifically San Diego Bay.

Table 48. Activities that result in the highest percentages of green turtle unprocessed exposures to impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Green Turtles						
Pierside integrated swimmer defense	*100%*					
BOMBEX (A-S)				*100%*		

The major Southern California Range Complex contributors are activities that regularly discharge acoustic energy into the marine environment and where activity frequency is greater than most other activities in this area. In this case, only certain activities occur in San Diego Bay and these are the only activities that can expose green turtles to the proposed activities. There are no non-impulsive exposures anticipated to result in temporary threshold shift, permanent threshold shift, or other pathological effects from training or testing activities

Processed Estimates - The processed NAEMO results for non-impulsive acoustic sources generate zero instances of green turtles exposed to received levels that cause them to respond with behaviors that NMFS would classify as harassment, zero instances of accumulated energy sufficient to result in temporary shift in hearing sensitivity, and zero instances of

accumulation of energy sufficient to result in permanent shift in hearing sensitivity from training exercises. There will be 529 instances in which green turtles could accumulate energy sufficient to result in temporary shifts in hearing sensitivity and 28 green turtles that could accumulate energy sufficient to result in permanent shift in hearing sensitivity from testing activities.

The processed NAEMO results for impulsive acoustic sources generated zero instances of green turtles exposed to received levels that cause them to respond with behaviors that NMFS would classify as harassment from either training or testing activities. In addition, there will be zero instances in which green sea turtles could accumulate energy sufficient to result in temporary shifts in hearing sensitivity, or could accumulate energy sufficient to result in permanent shift in hearing sensitivity from either training exercises testing activities. No green turtles would experience GI tract or lung injury, and no green turtles would be killed from either training or testing activities.

Applied Mitigation - After considering mitigation actions that will be implemented by the Navy, the estimated number of green turtles that could experience temporary threshold shift due to non-impulsive acoustic sources during training exercises remained at zero. Zero green turtles would be expected to experience permanent threshold shift, or be killed from either training exercises or testing activities.

After considering mitigation actions that will be implemented by the Navy, the estimated number of green turtles that could experience temporary threshold shift due to impulsive acoustic sources during training exercises remained at zero, the number of animals that would be expected to experience permanent threshold shift is zero, and zero green turtles would experience GI tract or lung injury, and no green turtles would be killed.

After considering mitigation actions that will be implemented by the Navy plus those proposed to be mandatory under the MMPA rule, the estimated number of green turtles that could experience temporary threshold shift due to non-impulsive acoustic sources during testing activities is 616, the number of animals that would be expected to experience permanent threshold shift is 97. Zero green turtles would be killed.

The estimated number of green turtles that could experience temporary threshold shift due to impulsive acoustic sources during testing activities is zero. Zero green turtles would be expected to experience permanent threshold shift, GI tract or lung injury, and no green turtles would be killed.

Pacific Sea Turtles-Hawaii Range Complex and Transit Lane

As decribed previously we provide three exposure estimates for Pacific sea turtles; unprocessed estimate, processed estimate, and an applied mitigation estimate.

Unprocessed Estimate - The model output estimates that Pacific sea turtles will be exposed to sonar and other non-impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 24,901 Pacific sea turtle exposure events annually to non-impulsive sounds at levels between 120 and 156 dB SPL and 184 Pacific sea turtle exposure events annually to non-impulsive acoustic sources at levels between 157 and 189 dB SPL (Table 49). No exposures to non-impulsive sounds are expected above 190 dB SPL. All of these exposures will occur in the areas around Hawaii and the transit lane.

Table 49. Activities that result in the highest percentages of Pacific sea turtle unprocessed exposures to non-impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Pacific Sea Turtles						
ASW mission package testing			*23%*			
MPA ASW tracking			*40%*			
Unmanned vehicle development			*26%*			
Undersea warfare exercise						*37%*
Extended echo ranging sonobuoy						*23%*
Rim of the Pacific exercise						*31%*

The major Hawaii Range Complex contributors are activities that regularly discharge acoustic energy into the nearshore marine environment and where activity frequency is greater than most other activities in this area. In this case, only certain activities occur in areas in and near Pearl Harbor (where Pacific sea turtle density is relatively high versus very low density estimates in all other Hawaii Range Complex locations) and these are the only activities that can expose Pacific sea turtles to acoustic stressors. Three non-impulsive exposures are expected to result in temporary threshold shift from training exercises, but none are expected to produce permanent threshold shift or other pathological injuries. These exposures stem from RIMPAC and undersea warfare exercises. One may result from testing activities due to ASW mission package testing. No permanent threshold shift or pathological effects are expected from this exposure.

The model estimates that Pacific sea turtles will be exposed to explosions and other impulsive acoustic stressors associated with training exercises and testing activities throughout the year. The NAEMO provided an unprocessed estimate of 9,088 Pacific sea turtle exposure events annually at sound levels between 120 and 156 dB SPL and 12,961 Pacific sea turtle exposure

events annually to impulsive acoustic sources at levels between 157 and 237 dB SPL (Table 50). All of these exposures are predicted to occur in the areas around Hawaii.

Table 50. Activities that result in the highest percentages of Pacific sea turtle unprocessed exposures to impulsive acoustic sources in the Hawaii-Southern California Training and Testing Study Area.

	Testing			Training		
Species-largest contributors to exposure	**SOCAL**	**Transit Lane**	**HRC**	**SOCAL**	**Transit Lane**	**HRC**
Pacific Sea Turtles						
Missile exercise (A-S)						*10%*
MPA ASW tracking			*28%*			
Explosive torpedo testing			*16%*			
Missile testing (A-S)			*27%*			
BOMBEX (A-S)						*18%*
Mine neutralization-EOD						*60%*

The major Hawaii Range Complex contributors are activities that regularly discharge acoustic energy into the nearshore marine environment and where activity frequency is greater than most other activities in this area. In this case, only certain activities (particularly mine neutralization) occur in nearshore areas (where sea turtle density is relatively high versus very low density estimates in all other Hawaii Range Complex locations) and these are the only activities that can expose Pacific sea turtles to the acoustic sources.

Processed Estimates - The processed NAEMO results for non-impulsive acoustic source generate zero instances of Pacific sea turtles exposed to received levels that cause them to respond with behaviors that NMFS would classify as harassment harassment from either training exercises or testing activities. In addition, there will be another 261 instances in which Pacific sea turtles could accumulate energy sufficient to result in temporary shift in hearing sensitivity from training exercises and 77 Pacific sea turtles from testing activities. Four Pacific sea turtles could accumulate energy sufficient to result in permanent shift in hearing sensitivity from training exercises and no animals from testing activities.

The processed NAEMO results for impulsive acoustic source generated 728 instances of Pacific sea turtles exposed to received levels that cause them to respond with behaviors that NMFS would classify as harassment from training exercises and 56 from testing activities. In addition, there will be another 166 instances in which Pacific sea turtles could accumulate energy sufficient to result in temporary shifts in hearing sensitivity from training exercises and one from testing activities. There could be 44 Pacific sea turtles that could accumulate energy sufficient to result in permanent shift in hearing sensitivity from training exercises and five from testing

activities. No Pacific sea turtles would experience GI tract injuries from either training or testing activities. There could be 13 slight lung injuries from training exercises and one from testing activities. Five Pacific sea turtles could be killed by training exercises and none killed by testing activities.

Applied Mitigation - After considering mitigation actions that will be implemented by the Navy, the estimated number of Pacific sea turtles that could experience behavioural changes due to non-impulsive acoustic sources during training exercises is 412. Zero Pacific sea turtles would be expected to experience temporary threshold shift, permanent threshold shift, or be killed.

After considering mitigation actions that will be implemented by the Navy, the estimated number of Pacific sea turtles that could experience temporary threshold shift due to impulsive acoustic sources during training exercises is 182, the number of animals that would be expected to experience permanent threshold shift also remained at 21, and zero Pacific sea turtles would experience GI tract, 13 would experience lung injury, and four Pacific sea turtles would be killed.

After considering mitigation actions that will be implemented by the Navy, the estimated number of Pacific sea turtles that could experience temporary threshold shift due to non-impulsive acoustic sources during testing activities is 400, the number of animals that would be expected to experience permanent threshold shift is zero. Zero Pacific sea turtles would be killed.

The estimated number of Pacific sea turtles that could experience temporary threshold shift due to impulsive acoustic sources during testing activities is one. Five Pacific sea turtles would be expected to experience permanent threshold shift, GI tract or lung injury, and no Pacific sea turtles would be killed.

6.3 Sources of Exposures of ESA-listed Species during Training Exercises

The NAEMO model output (based on unprocessed estimates) indicates that four types of training exercises accounted for the majority of exposures to non-impulsive sound sources (Table 51) and five types of exercises comprise the majority of the exposures to impulsive acoustic sources (Table 52).

Table 51. Proportion of unprocessed exposure estimate to non-impulsive sound sources from specific training exercises in the Hawaii-Southern California Training and Testing Study Area.

	Exercise Type			
Species	**Composite Training Unit**	**Submarine Navigation**	**Tracking/Torpedo – Surface**	**Undersea Warfare**
Blue Whale	40%		35%	
Fin Whale	33%		40%	
Humpback Whale		20%	38%	
Sei Whale	13%	11%	40%	
Sperm Whale	23%		38%	
MHI Insular False Killer Whale			54%	19%
HI Monk Seal		64%	14%	
Guadalupe Fur Seal	38%		37%	
Green Turtle				
Pacific Sea Turtles				78%

Table 52. Proportion of unprocessed exposure estimate to impulsive sound sources from specific training exercises Hawaii-Southern California Training and Testing Study Area.

	Exercise Type			
Species	**Bombing Air-to-Sea**	**Firing at Sea**	**Mine Neutralization – EOD**	**Tracking/Torpedo MPA Extended Echo Ranging Sonobuoy**
Blue Whale	69%			
Fin Whale	65%		18%	
Humpback Whale	23%	26%		
Sei Whale	49%		23%	
Sperm Whale	26%			34%
MHI Insular False Killer Whale	37%			
HI Monk Seal	22%		49%	
Guadalupe Fur Seal	65%		21%	
Green Turtle			93%	
Pacific Sea Turtles				

Training Exercises that contribute to Non-impulsive Exposures

Four types of training exercises result in the vast majority of the exposures of ESA-listed species to non-impulsive acoustic sources (Table 51). They are composite training unit, submarine navigation tracking/torpedo – surface, and undersea warfare exercises; each of these is described briefly below.

Composite Training Unit Exercise: These training exercises occur during an integration phase for Navy personel. They are considered a major range event. For the carrier strike group, this exercise integrates the aircraft carrier and carrier air wing with surface and submarine units in a challenging operational environment. For the expeditionary strike group/amphibious readiness group, this exercise integrates amphibious ships with their associated air wing, surface ships, submarines, and the Marine Expeditionary Unit. Live-fire operations that may take place during Composite Training Unit Exercise include long-range air strikes, Naval Surface Fire Support, and surface-to-air, surface-to-surface, and air-to-surface missile exercises. The 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.

Each Strike Group performs a rehearsal called Composite Training Unit Exercise before deployment. Prior to the Composite Training Unit Exercise, each ship and aircraft in the strike group trains in their specialty. The Composite Training Unit Exercise is an intermediate-level strike group exercise designed to forge the group into a cohesive fighting team. Composite Training Unit Exercise is normally conducted during a 1 to 3 week period 6 to 8 weeks before Joint Task Force Exercise and consists of an 18 day schedule of event driven exercise, and a 3 day Final Battle Problem.

These exercises occur in the Southern California Operating Area and Point Mugu Sea Range (overlap area only). Acoustic sources during these exercises include mid-frequency hull-mounted sonar (MF1, MF2, MF3), helicopter dipping sonar (MF4), sonobuoy (MF5), high duty cycle variable depth sonar (MF12), multistatic active coherent sonobuoy (ASW2),mid-frequency acoustic countermeasure (ASW3, high-frequency hull-mounted sonar (HF1), explosive sonobuoys (E4); vessel noise, aircraft noise.

Submarine Navigation: Submarine crews train to operate sonar for navigation. The ability to navigate using sonar is critical for object detection while transiting in and out of port during periods of reduced visibility. Submarine Navigation training exercises conducted while transiting in and out of port are done so while surfaced, with bridge watches and a single lookout. Sonar in use is high frequency submarine sonar system (HF1); hull-mounted mid-frequency sonar (MF3).

Primary location(s) where this training occurs within the HSTT Study Area are Hawaii Range Complex: Pearl Harbor Channel and virtual channel south of Pearl Harbor and Southern California Range Complex: Subase Point Loma and seaward virtual channel.

Tracking Exercise/Torpedo Exercise – Surface: These exercises are when surface ships search, detect, and track threat submarines to determine a firing position to launch a torpedo and attack the submarine.

A surface vessel operates at slow speeds while employing hull mounted and/or towed array sonar. Passive or active sonar is employed depending on the type of threat submarine, the tactical situation, and environmental conditions. The target for this exercise is a MK-39 Expendable Mobile Anti-Submarine Warfare Training Target, MK-30 Recoverable Training Target, or live submarine.

Tracking exercise/torpedo exercise – surface could occur anywhere throughout the Hawaii-Southern California Training and Testing Study Area. This exercise may involve a single ship, or be undertaken in the context of a coordinated larger exercise involving multiple aircraft, ships, and submarines, including a major range event.

The tracking exercise becomes a torpedo exercise when the ship launches an exercise torpedo. The exercise torpedo is recovered by helicopter or small craft. The preferred range for this exercise is an instrumented underwater range, but it may be conducted in other operating areas depending on training requirements and available assets.

These occur in the Hawaii Range Complex: Hawaii Operating Area (including Barking Sands Underwater Range Extension; Barking Sands Tactical Underwater Range; Shallow Water Training Range) and in the Southern California Range Complex: Southern California Operating Areas, Point Mugu Sea Range (overlap area only).

Acoustic sources during this training exercise include mid-frequency sonar (ASW1), mid-frequency acoustic countermeasure (ASW3, ASW4), high-frequency sonar (HF1), hull mounted sonar (MF1, MF2, MF3, MF11), helicopter dipping sonar (MF4), sonobuoys (MF5), high duty cycle variable depth sonar (MF12), lightweight torpedo (TORP1), vessel noise.

Undersea Warfare: Elements of the anti-submarine warfare tracking exercise combine in an exercise of multiple air, surface, and subsurface units, over a period of 4 days during undersea warfare exercises. No explosive ordnance is used. Sonobuoys are released from aircraft, and active and passive sonar is used.

Undersea Warfare Exercise is conducted up to five times annually. Undersea Warfare Exercise is an assessment based anti-submarine warfare exercise conducted by Expeditionary Strike Groups and Carrier Strike Groups while in transit from the west coast of the United States to the Western Pacific Ocean. Undersea Warfare Exercise can involve more than one Carrier Strike Group or Expeditionary Strike Group formation. This training occurs in the Hawaii Operating Area.

Acoustic sources include mid-frequency, high-frequency sonar, sonobuoys, high-frequency acoustic modems, and dipping sonar (MF1, MF2, MF3, MF4, MF5, MF6, ASW2, ASW4), aircraft noise.

Training Exercises that contribute to Impulsive Exposures

Four types of training exercises result in the vast majority of the exposures of ESA-listed species to non-impulsive acoustic sources (Table 52). They are bombing air-to-sea, firing at sea, mine neutralization – EOD, tracking/torpedo MPA, and extended echo ranging sonobuoy exercises; each of these is described briefly below.

Bombing Air-to-Sea: Bombing exercises involve fixed-wing aircrews delivering bombs against surface targets. Fixed-wing aircraft conduct a bombing exercise against stationary floating targets (e.g.: MK-58 smoke buoy). An aircraft clears the area, deploys a smoke buoy or other floating target, and then delivers high explosive or non-explosive practice munitions bomb(s) on the target. A range boat may be used to deploy targets for an aircraft to attack.

Exercises for strike fighters typically involve a flight of two aircraft delivering unguided or guided munitions that may be either high explosive or non-explosive practice munitions. The following munitions may be employed by strike fighter aircraft in the course of the bombing exercise: Unguided munitions: Non explosive Sub Scale Bombs (MK-76 and BDU-45); explosive and non-explosive general purpose bombs (MK-80 series); MK-20 Cluster Bomb (explosive, non-explosive). Precision-guided munitions: Laser-guided bombs (explosive, non-explosive); Laser-guided Training Rounds (non-explosive); Joint Direct Attack Munition (explosive, non-explosive). These activities will take place in Hawaii Range Complex: Hawaii Operating Area Southern California Range Complex and in Southern California Anti-Submarine Warfare Range T-3, T 4, T-5, Mine Training Range 2, Shore Bombardment Area. These training exercises also occur in the HSTT Transit Corridor.

Bombing Exercise (Air-to-Ground) Bombing exercise involves training of strike fighter aircraft delivery of ordnance against land targets in day or night conditions. Bombing exercise involves training of strike fighter aircraft delivery of ordnance against land targets in day or night conditions. The bombing exercise may involve close air support training in direct support of and in close proximity to forces on the ground, such as Navy or Marine forces engaged in training exercises on land, and may include the use of targeting laser. Fixed-wing strike fighter aircraft use Targeting laser systems to deliver non-explosive MK-76, BDU-45, and BDU-45 on land targets. These exercises generally last 1 to 2 hours and occur in the Hawaii Range Complex around Kaula Island.

Mine Neutralization – Explosive Ordnance Disposal exercises involve Navy divers, typically explosive ordnance disposal personnel, which disable threat mines with explosive charges to create a safe channel for friendly vessels to transit.

Personnel detect, identify, evaluate, and neutralize mines in the water with an explosive device and may involve detonation of one or more explosive charges from 10 to 60 pounds of TNT equivalent. These operations are normally conducted during daylight hours for safety reasons. Time delay fuses may be used for these events.

These activities will take place in the Hawaii Range Complex: Puuloa Underwater Range, Marine Corps Base Hawaii, Marine Corps Training Area Bellows, Barbers Point Underwater Range, Naval Inactive Ship Maintenance Facility, Lima Landing, Ewa Training Minefield; the Southern California Range Complex: Northwest Harbor, Horse Beach Cove, Southern California Anti-submarine Warfare Range, Shallow Water Training Range, in Special Warfare Training Area, Offshore waters; and Silver Strand Training Complex: Boat Lanes 1-14. The majority of EOD UNDET occur nearshore within the Silver Strand Training Complex. Northwest Harbor is more used by Naval Special Warfare. Offshore UNDETs are rare.

6.4 Sources of Exposures of ESA-listed Species during Testing Activities

The NAEMO model output (based on unprocessed estimates) indicates that five types of testing activities accounted for the majority of exposures to non-impulsive sound sources (Table 53) and four types of training exercises accounted for the majority of exposures to impulsive sound sources (Table 52).

Table 53. Proportion of unprocessed exposure estimate to non-impulsive sound sources from specific testing activities Hawaii-Southern California Training and Testing Study Area.

	Testing Activity				
Species	Combat System Ship Qualification Trials: USW	AUV AT/FP Mine Counter Measures	Counter Measure Testing	ASW Mission Package Testing	Unmanned Vehicle Development and Payload Testing
Blue Whale				31%	15%
Fin Whale			24%	19%	15%
Humpback Whale	24%		16%		
Sei Whale			14%	21%	15%
Sperm Whale	11%		10%	20%	
MHI Insular False Killer Whale	24%		13%		
HI Monk Seal	17%	22%			
Guadalupe Fur Seal			11%	35%	12%
Green Turtle Pacific Sea Turtles		21%		36%	22%

Table 54. Proportion of unprocessed exposure estimate to impulsive sound sources from testing activities Hawaii-Southern California Training and Testing Study Area.

	Testing Activity			
Species	**Anti-submarine Tracking Test - Helo**	**Anti-submarine Tracking Test - MPA**	**Air-to-Surface Missile Test**	**Sonobuoy Lot Acceptance Test**
Blue Whale	20%	35%	21%	
Fin Whale	23%	28%	23%	
Humpback Whale	29%	27%		
Sei Whale	23%	28%		23%
Sperm Whale	19%	36%		
MHI Insular False Killer Whale	34%	32%		
HI Monk Seal	19%		21%	
Guadalupe Fur Seal		34%	24%	
Green Turtle				
Pacific Sea Turtles	33%	20%		

Testing Activities that contribute to Non-impulsive Exposures

Five types of testing activities result in the vast majority of the exposures of ESA-listed species to non-impulsive acoustic sources (Table 53). They are combat system ship qualification trials: USW, AUV AT/FP mine counter measures, counter measure testing, ASW mission package testing, unmanned vehicle development and payload testing; each of these is described briefly below.

Combat System Ship Qualification Trial – Undersea Warfare to test a vessel's ability to track and engage undersea targets. Undersea warfare events are comprised of a series of tracking and firing exercises. The events ensure the operability of the undersea warfare suite and its interface with the Light Airborne Multi-Purpose System helicopter. Approximately one week of in-port training precedes exercises on an instrumented underwater range, where vessel's force becomes familiar with operation and maintenance of the undersea warfare system. Personnel then demonstrate the capability to establish the data link between the helicopter and vessel's undersea warfare system. Platforms used include surface combatant vessels and rotary wing aircraft. Systems involved are surface ship sonar, underwater communication systems, sonobuoys, and missile systems. Non-explosive torpedoes are used against motorized autonomous targets (e.g., Expendable Mobile Anti-Submarine Warfare Training Target). These tests generally occur over one week in the Hawaii Range Complex at the Pacific Missile Range Facility and in the Southern California Range Complex.

AUV AT/FP Mine Counter Measures - Autonomous undersea vehicle shallow water mine countermeasure testing is focused on the testing of unmanned undersea vehicles with mine hunting sensors in marine environments in and around rocky outcroppings. Anti-terrorism/force protection mine countermeasures testing are focused on mine countermeasure missions in confined areas between piers and pilings. It provides training to Navy personnel on how to deploy, detect, and defend against mine systems and underwater improvised explosive devices. Platform used include Autonomous Undersea Vehicle Systems with mine hunting sensors, synthetic aperture sonar (e.g., SAS1, SAS2, SAS3) and typically occur over five days of daily operations for 6 hours per day. These testing activities occur in the Hawaii Range Complex near Oahu, Hawaii and in the Southern California Range Complex at San Diego Bay, Camp Pendleton Amphibious Assault Area, San Clemente Island Operating Areas, and Silver Strand Training Complex.

Counter Measure Testing - Countermeasure testing of systems that would detect, localize, and track incoming weapons. At-sea testing of the Surface Ship Torpedo Defense systems including towed acoustic systems, torpedo warning systems, and countermeasure subsystems. Some countermeasure scenarios would employ non-explosive or explosive torpedoes against targets released by secondary platforms (e.g., helicopter or submarine). While surface vessels are in transit, countermeasure systems will be used to identify false alert rates.

Platforms involved in these testing activities include aircraft carrier, surface combatant, submarine, fixed-wing aircraft with countermeasure systems and lightweight torpedoes (non-explosive and explosive) targeting torpedo test vehicles. Testing generally take up to 7 days and occur in the Transit Corridor, Hawaii Range Complex, and Southern California Range Complex.

ASW Mission Package Testing - Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines. Vessels conduct detect-to-engage operations against modern diesel-electric and nuclear submarines using airborne and surface assets (both manned and unmanned). Active and passive acoustic systems are used to detect and track submarine targets, culminating in the deployment of lightweight torpedoes to engage the threat. Surface combatant vessels (e.g., Littoral Combat Ship); rotary-wing aircraft, and submarines use systems: Surface ship sonar, helicopter deployed sonar, active sonobuoys, and torpedo sonar. Event duration is approximately 1 to 2 weeks, with 4 to 8 hours of active sonar use with intervals of non-activity in between. These tests occur in the Southern California Range Complex.

Unmanned Vehicle Development And Payload Testing - Vehicle development involves the production and upgrade of new unmanned platforms on which to attach various payloads used for different purposes. Platforms can include unmanned underwater vehicles, unmanned surface vehicles, and unmanned aerial systems. Payload testing assesses various systems that can be incorporated onto unmanned platforms for mine warfare, bottom mapping, and other missions.

Tests range from basic remote control and autonomous navigation tests to deployment and activation of onboard systems which may include hydrodynamic instruments, launchers, and recovery capabilities. These vehicles are capable of expanding the communication and surveillance capabilities of submarines, surface vessels, and terrestrial commands. Event duration for unmanned vehicles with traditional propulsion typically lasts up to 40 hours and occur in the Hawaii Range Complex and the Southern California Range Complex.

Testing Activities that contribute to Impulsive Exposures

Four types of testing activities result in the vast majority of the exposures of ESA-listed species to non-impulsive acoustic sources (Table 54). They are anti-submarine tracking testing – helo, anti-submarine tracking testing – MPA, ATS missile testing, and sonobuoy lot acceptance testing; each of these is described briefly below.

Anti-Submarine Tracking Testing – Helo - This testing is similar to the training event, Anti-Submarine Tracking Exercise–Helicopter. The test evaluates the sensors and systems used to detect and track submarines and to ensure that helicopter systems used to deploy the tracking systems perform to specifications. Helicopter evaluates the sensors and systems used to detect and track submarines and to ensure that platform systems used to deploy the tracking systems perform to specifications. Typically, one MH-60R helicopter conducts Anti-Submarine testing using the AN/AQS-22 dipping sonar, tonal sonobuoys (e.g., AN/SSQ-62), passive sonobuoys (e.g., AN/SSQ-53D/E), or explosive sonobuoys (e.g., mini sound-source seeker buoys). Targets (e.g., MK-39 Expendable Mobile Anti-Submarine Warfare Training Target or MK-30) may also be employed during an Anti-Submarine event. If available, tests may be conducted using a submarine as the target. This activity would be conducted in shallow or deep waters and could initiate from a land base or from a surface ship. Helicopter Anti-Submarine tests are intended to evaluate the sensors and systems used to detect and track submarines and to ensure that platform systems used to deploy the tracking systems perform to specifications. Some Anti-Submarine Helicopter Tracking Test could be conducted as part of an Anti-Submarine Tracking Coordinated Event with Fleet training activities. Each testing event lasts for about 2 flight hours and events occur in the Hawaii Range Complex and in the Southern California Operating Area.

Anti-Submarine Tracking Testing – MPA - Similar to an Anti-Submarine Warfare Tracking Exercise-Maritime Patrol Aircraft this testing activity evaluates the sensors and systems used to detect and track submarines and to ensure that platform systems used to deploy the tracking systems perform to specifications and meet operational requirements. P-3 or P-8A fixed-wing aircraft conduct Anti-Submarine Warfare testing using tonal sonobuoys (e.g., AN/SSQ-62 DICASS), explosive sonobuoys (e.g., AN/SSQ-110 Improved Extended Echo Ranging), passive sonobuoys (e.g., AN/SSQ-53), torpedoes (e.g., MK-46), smoke devices (e.g., MK-58), SUS devices (e.g., MK-61 SUS), missiles (e.g., harpoons), and chaff. Targets (e.g., MK-39 Expendable Mobile Anti-Submarine Warfare Training Target) may also be employed during an

Anti-Submarine Warfare scenario. This activity would be conducted in deep waters and could initiate from a land base or from a surface ship. Some Anti-Submarine Warfare Maritime Patrol Aircraft Tracking Test could be conducted as part of a Coordinated Event with Fleet training activities. These testing activities generally involve 4 to 6 flight hours/event. They occur in the Hawaii Operating Area and the Southern California Operating Area.

Air-to-Surface Missile Testing - Missile testing includes various missiles (e.g., standard missiles, Water Piercing Missile Launch) fired from submarines and surface combatants. These testing activities generally take 1 to 2 hours and occur in the Hawaii Range Complex: Pacific Missile Range Facility and the Southern California Range Complex. Acoustic stressors from this testing activity include weapons firing noise and vessel noise.

Sonobuoy Lot Acceptance Testing - Sonobuoys are deployed from surface vessels and aircraft to verify the integrity and performance of a lot or group of sonobuoys in advance of delivery to the Fleet for operational use. Lot acceptance testing would occur for the following types of sonobuoys: AN/SSQ-62 DICASS, AN/SSQ-110 Improved Extended Echo Ranging, AN/SSQ-125 MAC, MK-61 SUS, MK-64 SUS, MK-82 SUS, MK-84 SUS, and Mini Source. Some sonobuoys are high explosive. These testing activities generally take 6 flight hours per event and occur in the Southern California Operating Area.

6.5 Response Analysis

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

6.5.1 Potential Responses to Vessels and Aircraft

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Amaral and Carlson 2005; Au and Perryman 1982; Au and Green 2000a; Bain et al. 2006; Bauer 1986; Bejder et al. 1999; Bejder and Lusseau. 2008; Bejder et al. 2009; Bryant et al. 1984; Corkeron 1995; Erbe 2002b; Félix 2001; Goodwin and Cotton 2004; Lemon et al. 2006; Lusseau 2003; Lusseau 2006; Magalhaes et al. 2002; Nowacek et al. 2001; Richter et al. 2003a; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams et al. 2002b; Wursig et al. 1998). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994; Evans et al. 1992; Evans et al. 1994). These studies

suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

Based on the suite of studies of cetacean behavior to vessel approaches (Au and Perryman 1982; Bain et al. 2006; Bauer and Herman 1986; Bejder et al. 1999; Bejder et al. 2006a; Bejder et al. 2006b; Bryant et al. 1984; Corkeron 1995; David 2002; Felix 2001; Goodwin and Cotton 2004; Hewitt 1985; Lusseau 2003; Lusseau 2006; Magalhaes et al. 2002; Nowacek et al. 2001; Richter et al. 2006; Richter et al. 2003b; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams and Ashe 2007; Williams et al. 2002b; Wursig et al. 1998) (Acevedo 1991b) (Acevedo 1991, Aguilar de Soto et al. 2006, Arcangeli and Crosti 2009, Au and Green 2000, Christiansen et al. 2010, Erbe 2002, Williams et al. 2009, Christiansen et al. 2010, Noren et al. 2009, Stensland and Berggren 2007, Stockin et al. 2008), the set of variables that help determine whether marine mammals are likely to be disturbed by surface vessels include:

1. *Number of vessels*. The behavioral repertoire marine mammals have used to avoid interactions with surface vessels appears to depend on the number of vessels in their perceptual field (the area within which animals detect acoustic, visual, or other cues) and the animal's assessment of the risks associated with those vessels (the primary index of risk is probably vessel proximity relative to the animal's flight initiation distance) (Sims et al. 2012).

   Below a threshold number of vessels (which probably varies from one species to another, although groups of marine mammals probably share sets of patterns), studies have shown that whales will attempt to avoid an interaction using horizontal avoidance behavior. Above that threshold, studies have shown that marine mammals will tend to avoid interactions using vertical avoidance behavior, although some marine mammals will combine horizontal avoidance behavior with vertical avoidance behavior (Bryant et al. 1984; David 2002; Kruse 1991; Lusseau 2003; Nowacek et al. 2001; Stensland and Berggren 2007; Williams and Ashe 2007);

2. *The distance between vessel and marine mammals* when the animal perceives that an approach has started and during the course of the interaction (Au and Perryman 1982; David 2002; Hewitt 1985; Kruse 1991; Lundquist et al. 2012; Lusseau 2003; Tseng et al. 2011);

3. *The vessel's speed and vector* (David 2002);

4. *The predictability of the vessel's path*. That is, cetaceans are more likely to respond to approaching vessels when vessels stay on a single or predictable path (Acevedo 1991a; Angradi et al. 1993; Browning and Harland. 1999; Lusseau 2003; Lusseau 2006; Williams et al. 2002a) than when it engages in frequent course changes (Evans et al. 1994; Lusseau 2006; Williams et al. 2002a);

5. *Noise associated with the vessel* (particularly engine noise) and the rate at which the engine noise increases (which the animal may treat as evidence of the vessel's speed) (David 2002; Lusseau 2003; Lusseau 2006; Polagye et al. 2011);
6. *The type of vessel* (displacement versus planing), which marine mammals may be interpret as evidence of a vessel's maneuverability (Goodwin and Cotton 2004);
7. *The behavioral state of the marine mammals* (David 2002; Lusseau 2003; Lusseau 2006; Wursig et al. 1998). For example, Würsig et al. (Wursig et al. 1998) concluded that whales were more likely to engage in avoidance responses when the whales were milling or resting than during other behavioral states.

Most of the investigations reported that animals tended to reduce their visibility at the water's surface and move horizontally away from the source of disturbance or adopt erratic swimming strategies (Corkeron 1995; Lundquist et al. 2012; Lusseau 2003; Lusseau 2004; Nowacek et al. 2001; Van Parijs and Corkeron 2001; Williams et al. 2002a; Williams et al. 2002b). In the process, their dive times increased, vocalizations and jumping were reduced (with the exception of beaked whales), individuals in groups move closer together, swimming speeds increased, and their direction of travel took them away from the source of disturbance (Baker and Herman 1989; Edds and Macfarlane 1987; Evans et al. 1992; Kruse 1991). Some individuals also dove and remained motionless, waiting until the vessel moved past their location. Most animals finding themselves in confined spaces, such as shallow bays, during vessel approaches tended to move towards more open, deeper waters (Kruse 1991). We assume that this movement would give them greater opportunities to avoid or evade vessels as conditions warranted.

Although most of these studies focused on small cetaceans (for example, bottlenose dolphins, spinner dolphins, spotted dolphins, harbor porpoises, beluga whales, and killer whales), studies of large whales have reported similar results for fin and sperm whales (David 2002). Baker et al. (1983) reported that humpbacks in Hawaii responded to vessels at distances of 2 to 4 km. Richardson et al. (1985a) reported that bowhead whales (*Balaena mysticetus*) swam in the opposite direction of approaching seismic vessels at distances between 1 and 4 km and engage in evasive behavior at distances under 1 km. Fin whales also responded to vessels at a distance of about 1 km (Edds and Macfarlane 1987). A study by Lundquist (2012) on dusky dolphins concluded that disturbance to tour vessel traffic may interrupt social interactions, and postulated that those disturbances may carry energetic costs, or otherwise affect individual fitness. However, they were unable to determine if such disturbances were likely to cause long-term harm.

Some cetaceans detect the approach of vessels at substantial distances. Finley et al. (1990) reported that beluga whales seemed aware of approaching vessels at distances of 85 km and began to avoid the approach at distances of 45-60 km. Au and Perryman (1982) studied the behavioral responses of eight schools of spotted and spinner dolphins (*Stenella attenuata* and *S.*

longirostris) to an approaching ship (the NOAA vessel Surveyor: 91.4 meters, steam-powered, moving at speeds between 11 and 13 knots) in the eastern Pacific Ocean (10°15 N lat., 109°10 W long.). They monitored the response of the dolphin schools to the vessel from a Bell 204 helicopter flying a track line ahead of the ship at an altitude of 366 – 549 meters (they also monitored the effect of the helicopter on dolphin movements and concluded that it had no observable effect on the behavior of the dolphin schools). All of the schools continuously adjusted their direction of swimming by small increments to continuously increase the distance between the school and the ship over time. The animals in the eight schools began to flee from the ship at distances ranging from 0.9 to 6.9 nm. When the ship turned toward a school, the individuals in the school increased their swimming speeds (for example, from 2.8 to 8.4 knots) and engaged in sharp changes in direction.

Hewitt (1985) reported that five of 15 schools of dolphin responded to the approach of one of two ships used in his study and none of four schools of dolphin responded to the approach of the second ship (the first ship was the NOAA vessel *David Starr Jordan*; the second ship was the Surveyor). Spotted dolphin and spinner dolphins responded at distances between 0.5 to 2.5 nm and maintained distances of 0.5 to 2.0 nm from the ship while striped dolphins allowed much closer approaches. Lemon et al. (2006) reported that bottlenose dolphin began to avoid approaching vessels at distances of about 100 m.

Würsig et al. (1998) studied the behavior of cetaceans in the northern Gulf of Mexico in response to survey vessels and aircraft. They reported that Kogia species and beaked whales (ziphiids) showed the strongest avoidance reactions to approaching ships (avoidance reactions in 11 of 13 approaches) while spinner dolphins, Atlantic spotted dolphins, bottlenose dolphins, false killer whales, and killer whales either did not respond or approached the ship (most commonly to ride the bow). Four of 15 sperm whales avoided the ship while the remainder appeared to ignore its approach.

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

Pirotta et al. (Pirotta et al. 2012b) concluded that observed changes could potentially correspond to a restriction in the movement of groups, a period of more directional travel, a reduction in the number of individuals clicking within the group, or a response to changes in prey movement.

The study on dusky dolphins conducted by Lundquist et al. (Lundquist et al. 2012) concluded that disturbance to tour vessel traffic may interrupt social interactions, by they were only able to postulate that those disturbances may carry energetic costs, or otherwise affect individual fitness. They were unable to determine if such disturbances were likely to cause long-term harm.

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 (NRC 2003b). Recent regional decreases in commercial ship traffic and associated underwater noise can also occur based on changing economic conditions (McKenna et al. 2012a). Commercial fishing vessels, cruise ships, transport boats, recreational boats, and aircraft, all contribute sound into the ocean (NRC 2003b). 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, or tonal, and sound pressure levels at a source will vary according to speed, burden, capacity and length (Richardson et al. 1995b)(Kipple and Gabriele 2007; McKenna et al. 2012b). 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. Source levels for 593 container ship transits were estimated from long-term acoustic recording received levels in the Santa Barbara shipping channel, and a simple transmission loss model using Automatic Identification System data for source-receiver range (McKenna et al 2013). Ship noise levels could very 5-10 dB depending on transit conditions. Given the sound propagation of low frequency sounds, a large vessel in this sound range can be heard 139-463 kilometers away (Polefka 2004). Hatch et al. (2008) measured commercial ship underwater noise levels and reported average source level estimates (71–141 Hz,root-mean-square pressure re 1 uPa ± SE) for individual vessels ranged from 158 ± 2dB (research vessel) to 186 ± 2dB (oil tanker). McKenna et al (2012b) in a study off Southern California documented differentacoustic levels and spectral shapes observed from different modern ship-types.Most studies of whale interactions with vessels are opportunistic and have only examined the short-term response to vessel sound and vessel traffic (Magalhães et al. 2002, Richardson et al. 1995, Watkins 1981, Noren et al. 2009). The long-term and cumulative implications of ship sound on marine mammals are largely unknown (National Marine Fisheries Service 2012). Clark et al. (Clark et al. 2009) provided a discussion on calculating the cumulative impacts of anthropogenic noise on baleen whales and estimated that in some habitats with high rates of vessel traffic and high levels

of vessel noise, the predicted area over which animals can communicate is routinely reduced to a small proportion (< 20 percent) of what it would be under quiet conditions (Clark et al. 2009).

There are few studies of the responses of marine animals to air traffic and the few that are available have produced mixed results. Some investigators report some responses while others report no responses. 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. Several authors have reported that sperm whales did not react to fixed-wing aircraft or helicopters in some circumstances (Au and Perryman 1982, Clarke 1956, Gambell 1968, Green et al. 1992) and reacted 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). Richardson et al. (1985) reported that bowhead whales responded behaviorally to fixed-wing aircraft that were used in their surveys and research studies when the aircraft were less than 457 meters above sea level; their reactions were uncommon at 457 meters, and were undetectable above 610 meters. They also reported that bowhead whales did not respond behaviorally to helicopter overflights at about 153 meters above sea level.

Smultea et al. (2008) studied the response of sperm whales to low-altitude (233-269 m) flights by a small fixed-wing airplane near Kaua‘i and reviewed data available from other studies. They concluded that sperm whales responded behaviorally to aircraft passes in about 12 percent of encounters. All of the reactions consisted of sudden dives and occurred when the aircraft was less than 360 m from the whales (lateral distance). They concluded that the sperm whales had perceived the aircraft as a predatory stimulus and responded with defensive behavior. In at least one case, Smultea et al. (2008) reported that the sperm whales formed a semi-circular “fan” formation that was similar to defensive formations reported by other investigators.

In a review of aircraft noise effects on marine mammals, Luksenburg and Parsons (2009) determined that the sensitivity of whales and dolphins to aircraft noise may depend on the animals’ behavioral state at the time of exposure (e.g. resting, socializing, foraging or travelling) as well as the altitude and lateral distance of the aircraft to the animals. While resting animals seemed to be disturbed the most, low flying aircraft with close lateral distances over shallow water elicited stronger disturbance responses than higher flying aircraft with greater lateral distances over deeper water (Patenaude et al. 2002, Smultea et al. 2008 in Luksenburg and Parsons (2009).

6.5.2 Likely Responses to Vessels and Aircraft

For surface vessels, the set of variables that help determine whether marine mammals are likely to be disturbed include: (1) the number of vessels in a marine mammal’s perceptual field and the animal’s assessment of the risks associated with those vessels; (2) the distance between vessels and marine mammals; (3) the vessel’s speed and path; (4) the predictability of the vessel’s path; (5) noise associated with the vessel and the rate at which the engine noise increases; (6) the type

of vessel; and (7) the behavioral state of the animal. Because of the number of vessels involved in U.S. Navy training exercises and testing activities, the vessel speed, and the use of course changes as a tactical measure with the associated sounds, the available evidence leads us to expect marine mammals to treat Navy vessels as 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 (for example, Composite Training Unit Exercise, Joint Task Force Exercise/Sustainment Exercise, and Rim of the Pacific exercises), unit- and intermediate-level exercises, and testing activities would represent different stress regimes because of differences in the number of vessels involved, vessel maneuvers, and vessel speeds.

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. We also consider evidence that factors other than received sound level, including the activity state of animals exposed to different sounds, the nature and novelty of a sound, and spatial relations between sound source and receiving animals (i.e., the exposure context) strongly affect the probability of a behavioral response (Ellison et al. 2012).

Cetaceans

We considered the research and reports cited above and conclude that in general blue, fin, humpback, sei, and MHI insular false killer whales are likely to either not react or exhibit an avoidance behavior. 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 of 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). In some instances, the 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.).

Behavioral disruptions of whales result from the presence of vessels or submarines, those disruptions are expected to be temporary. Animals are expected to resume their migration, feeding, or other behaviors with minimal threat to their survival or reproduction. Marine mammals react to vessels in a variety of ways and seem to be generally influenced by the activity the marine mammal is engaged in when a vessel approaches (Richardson et al. 1995b). Some respond negatively by retreating or engaging in antagonistic responses while other animals ignore the stimulus altogether (Terhune and Verboom 1999; Watkins 1986).

We assume that humpback and sperm whales would respond to both any active sonar, and other mid-frequency and low-frequency acoustic cues produced by surface vessels involved in a training exercise or testing activity, and their perception of whether ships are approaching them or moving away when they decide whether or not to avoid the vessels.

Pinnipeds

As with the cetacean species, we would expect Hawaiian monk seals and Guadalupe fur seals to engage in avoidance behavior when surface vessels move toward them. Seals would likely reduce their visibility at the water's surface and move horizontally away from the source of disturbance or adopt erratic swimming strategies. Most animals finding themselves in confined spaces, such as shallow bays, during vessel approaches tended to move towards more open, deeper waters. We assume that this movement would give them greater opportunities to avoid or evade vessels as conditions warranted.

Sea Turtles

Based on the information available, endangered and threatened sea turtles may have a brief startle response, but are most likely to ignore Navy vessels entirely and continue behaving as if the vessels and any risks associated with those vessels did not exist.

6.5.3 Potential Responses to Collision (Vessel Strike)

Worldwide, many cetacean species have been documented to have been hit by transiting surface vessels (Richardson et al. 1995, Laist et al. 2001, Lammers et al. 2003, Jensen and Silber 2003, Félix and Van Waerebeek 2005, Cole et al 2006, Van Waerebeek et al. 2007, Douglas et al. 2008, Félix 2009, Glass et al. 2009, Ritter 2009, Carillo and Ritter 2010. David et al 2011, Pace 2011), and vessel strikes are known to affect large whales within the HSTT Study Area (Lammers et al. 2003, Abramson et al. 2009, Laggner 2009, Berman-Kowalewski et al. 2010). The ability of a ship to detect a marine mammal and avoid a collision depends on a variety of factors, including environmental conditions, ship design, size, speed, and manning, as well as the behavior of the animal. Records of collisions date back to the early 17th century, and the worldwide number of collisions appears to have increased steadily during recent decades (Ritter 2012)(IWC, 2008; Laist et al., 2001).

NMFS Northeast Fisheries Science Center (NEFSC) developed and applied criteria to evaluate reports of human-caused injury and mortality to large whales including ship strikes. They evaluated determinations made for reports received from 2004 - 2008 involving North Atlantic right, humpback, fin, sei, blue, minke, and Bryde's whales observed along the eastern seaboard of the United States and adjacent Canadian Maritimes (Glass et al. 2010). A total of 539 unique large whale events were verified, including carcasses (both beached and at-sea) and live whales. They confirmed 57 (53 percent) ship strikes, and 330 mortality events. Thirty of the ship strikes were fatal. Serious injury was sustained in 2 (4 percent) of the confirmed ship strikes. Six (11 percent) of the ship strike events did not have adequate documentation to determine if serious

injury occurred. Fifteen (26 percent) of the ship strike events were determined to have not caused serious injury or death. Of the 330 confirmed mortalities, 256 (78 percent) lacked sufficient evidence to determine cause of death. Minke whales had the greatest number of entanglement mortalities (n=11); humpback whales had the highest number of serious injury events resulting from entanglements (n=11); fin whales had the greatest number of ship strike mortalities (n=10); and right whales had the only serious injuries (n=2) from ship strikes.

In the event of a ship strike with a whale, researchers have found that the lethality of the collision increases with ship speed (Silber et al. 2010; Vanderlaan and Taggart 2007; Wiley et al. 2011)). Vanderlaan and Taggart (Vanderlaan and Taggart 2007) found the probability of a lethal strike increased from 20 percent to 100 percent at speeds between 9 and 20 knots, and that lethality from ship strike increased most rapidly between 10 and 14 knots. Similar results were reported by Pace and Silber (2005)(Wiley et al. 2011). In addition, Silber et al. (Silber et al. 2010) found that increased vessel speed increased the hydrodynamic draw of vessels that could result in right whales (and likely other species) being pulled towards vessels making them more vulnerable to collisions and increasing the magnitude of impact. Therefore, slowing ship speeds in whale dense areas is a practical mitigation measure to reduce the severity to whales of collisions with ships (Laist et al. 2001; Silber et al. 2010; Vanderlaan and Taggart 2007) (Wiley et al. 2011)(73 FR 198).

6.5.4 Likely Responses to Collision (Vessel Strike)

Although the Navy's operational orders for ships that are underway are designed to prevent collisions between surface vessels participating in naval exercises and any endangered whales that might occur in the action area, these measures, which include additional lookouts and watchstanders on the bridge of ships, requirements for course and speed adjustments to maintain safe distances from whales, and having any ship that observes whales to alert other ships in the area, have historically been effective measures for avoiding collisions between surface vessels and whales in most areas. The Navy in the Southern California Training Range has struck three whales over the last 10 years to include an unknown species in 2006 and two fin whales in 2009.

In the event of a ship strike with a whale, researchers have found that the lethality of the collision increases with ship speed (Silber et al. 2010; Vanderlaan and Taggart 2007; Wiley et al. 2011)). Vanderlaan and Taggart (Vanderlaan and Taggart 2007) found the probability of a lethal strike increased from 20 percent to 100 percent at speeds between 9 and 20 knots, and that lethality from ship strike increased most rapidly between 10 and 14 knots.

In the absence of speed restrictions that would reduce the likelihood and severity of injury from ship strikes, we assume that Navy vessels could operate over the full range of ship speeds. The disparity in size between a large whale weighing over 150 tons and an amphibious assault ship weighing 50,370 tons or a destroyer, the most prevalent type of ship in the U.S. Pacific Fleet surface force, weighing 10,635 tons leads us to conclude that most ship strikes would result in

the death of the struck animal. Based on this, we expect that if an endangered blue, fin, humpback, sei or sperm whale is struck by a Navy vessel that it would die as a result of that collision.

6.5.5 Potential Response to Expendable Materials

Expended materials include fiber optic cables, guidance wires, parachutes, and potentially ingestible materials (munitions, targets, chaff, flares, and parachutes).

Expended materials have the potential to entangle and could be encountered by marine mammals and sea turtles in the HSTT Study Area at the surface, in the water column, or along the seafloor. There has never been a reported or recorded instance of a marine mammal entangled in military expended materials; however, the possibility still exists. Since impacts depend on how a marine mammal encounters and reacts to items that pose an entanglement risk, the following subsections discuss research relevant to specific groups or species. Most documented entanglements along the west coast are marine mammal encounters with fishing gear or other non-military materials that float or are suspended at the surface (Saez et al. 2011).

Fiber optic cables and guidance wires would be in the water column during the training or testing activity and while they sink. Bottom feeding animals have an increased likelihood of encounter because they may find the item and become entangled during feeding long after the training or testing event has occurred. Fiber optic cable is brittle and would be expected to break if kinked, twisted or sharply bent. Thus, the physical properties of the fiber optic cable would not allow the cable to loop, greatly reducing or the likelihood of entanglement of ESA-listed species.

Similar to fiber optic cables, guidance wires may pose an entanglement threat to ESA-listed species either in the water column or after the wire has settled to the sea floor. The likelihood of a marine mammal encountering and becoming entangled in a guidance wire depends on several factors. Since the guidance wire will only be within the water column during the activity and while it sinks (at an estimated rate of 0.7 ft. [0.2 m] per second), the likelihood of a marine mammal encountering and becoming entangled within the water column is very low. It is more likely that a marine mammal would encounter a guidance wire once it had settled on the sea floor. In addition, based on degradation times the guide wires would break down within one to two years and therefore no longer pose an entanglement risk. The length of the guidance wires vary, but greater lengths increase the likelihood that a marine mammal or sea turtle could become entangled. The behavior and feeding strategy of a species can determine whether they may encounter items on the seafloor, where guidance wires will most likely be available.

The chance that an individual animal would encounter expended parachutes is low based on their small size, the distribution of the parachutes expended, the fact that parachute assemblies are designed to sink upon release, and the relatively few animals that feed on the bottom. Parachutes used by the Navy range in size from 18 to 48 in. (46 to 122 cm). The vast majority of expended

decelerator/parachutes are small (18 in.) cruciform shaped decelerators used with sonobuoys. These have short attachment lines and upon water impact may remain at the surface for 5 to 15 seconds before the decelerator/parachute and its housing sink to the seafloor.

The possibility of a sperm whale or Hawaiian monk seal becoming entangled exists when they are feeding on the bottom in areas where parachutes have been expended. This is unlikely as parachutes are used in events that generally occur in deeper waters where these species are not likely to be feeding on the bottom, though even if momentarily entangled, a marine mammal would likely be able to free themselves of the light weight fabric of a parachute. There has never been any recorded or reported instance of a marine mammal becoming entangled in a parachute.

Military expended material is expected to sink to the ocean floor. Mysticete species that feed off the bottom in the areas where activities make use of military expended materials could encounter them. Seasonally present when migrating through the Southern California portion of the HSTT Study Area, gray whale is the only mysticete occurring in the Study Area that regularly feeds at the seafloor, but it does so in relatively shallow water soft sediment seafloor area where these military expended material entanglement stressors are less likely to be present.

Heezen (Heezen 1957) reported two confirmed instances of sperm whales entangled in the slack lengths of telegraph cable near cable repair sites along the seafloor. These whales likely became entangled while feeding along the bottom, as the cables were most often found wrapped around the jaw. Juvenile harbor porpoise exposed to 0.5 in. diameter (13 millimeters [mm] diameter) white nylon ropes in both vertical and horizontal planes treated the ropes as barriers, more frequently swimming under than over them. However, harbor porpoise feeding on fish in the area crossed the ropes more frequently and became less cautious, suggesting that rope poses a greater risk in a feeding area than in a transit area.

Known cases of whale entanglement in fishing gear within the HSTT Study Area are common. Data from NMFS Pacific Science Center indicates in the five years including 2006-2010 on average fisheries observers on have documented 18-21 marine mammals injured and an additional one to two animals dead annually as a result of commercial longline fishing. Since these observations were for a fraction of the fishing effort, the total impact is not known. In addition to commercial fishing in Hawaiian waters, recreational fishery interactions with odontocetes have been documented. In 2006, a spinner dolphin was observed off Oahu entangled in a gill net (National Marine Fisheries Service 2006) but not able to be freed. In 2009, a hooked bottlenose dolphin was observed off Kona (National Marine Fisheries Service 2009) and a hooked spinner dolphin was observed off Maui (National Marine Fisheries Service 2009). Similar longline data from the Southern California portion of the HSTT Study Area are not available.

Walker and Coe (Walker and Coe 1990) provided data on the stomach contents from 16 species of odontocetes, some of which occur or have stranded in Southern California waters with evidence of debris ingestion. Of the ESA-listed species occurring in the Study Area only sperm whales had ingested items (likely incidentally) that do not float and are thus indicative of foraging at the seafloor.

Fur seals (such as the Guadalupe fur seal) appear to be attracted to floating debris and consequently suffer a high rate of entanglement in derelict fishing lines and nets (Derraik 2002) than other pinniped species. Their unique habit of rolling on the surface of the water leads to complex entanglement. A young pup may become so entangled that its body becomes constricted by the material as it grows. Death may occur by strangulation or severing of the arteries (Derraik 2002). Hawaiian monk seals have one of the highest documented entanglement rates of any pinniped species (National Marine Fisheries Service 2010: Stranding Newsletter #16). This most often includes derelict fishing gear including nets, fish line, and fishhooks; there are no known cases of Hawaiian monk seal being entangled in military expended material. The Hawaii Stranding Response Network frequently undertakes dehooking of monk seals (removing embedded fishhooks) and two monk seals are known to have died from entanglement in gill nets; one on Oahu in 2006 (National Marine Fisheries Service 2006) and another on Maui in 2007 (National Marine Fisheries Service 2007; Honolulu Advertiser 2007).

While pinnipeds in the HSTT Study Area feed primarily in the water column, Hawaiian monk seal which occur in the Hawaii Range Complex portion of the HSTT Study Area are opportunistic feeders and also forage on the seafloor. It is unlikely that Hawaiian monk seal would be impacted by entanglement stressors if exposed on the seafloor.

Species that feed at the surface or in the water column include blue, fin, and sei whales. While humpback whales feed predominantly by lunging through the water after krill and fish, there are instances of humpback whales disturbing the bottom in an attempt to flush prey, the northern sand lance (*Ammodytes dubius*)(Hain et al. 1995). Humpback whales are not known to feed while in Hawaiian waters. Humpback whales may forage while present in the Southern California portion of the Study Area although are not likely to forage at the seafloor in this area. Gray whales are also seasonally present when migrating through the Southern California portion of the Study Area. Gray whale is the only mysticete occurring in the Study Area that regularly feeds at the seafloor, but it does so in relatively shallow water and soft sediment areas where ingestion stressors are less likely to be present (fewer activities take place in shallow water and expended materials are more likely to bury in soft sediment and be less accessible). In a comprehensive review of documented ingestion of debris by marine mammals, there are two species of mysticetes (bowhead and minke whale) with records of having ingested debris items that included plastic sheeting and a polythene bag (Laist 1997). Based on the available evidence,

since gray whale and humpback whale are known to forage at the seafloor, it is possible but unlikely they may ingest items found on the seafloor.

Sperm whales are known to incidentally ingest foreign objects while foraging; however, this does not always result in negative consequences to health or vitality (Laist 1997) (Walker and Coe 1990). While this incidental ingestion has led to sperm mortality in some cases, Whitehead (Whitehead 2003b) suggested the scale to which this affects sperm whale populations was not substantial. Sperm whales are recorded as having ingested fishing net scraps, rope, wood, and plastic debris such as plastic bags and items from the seafloor (Walker and Coe 1990).

Training exercises and testing activities involving small- and medium-caliber non-explosive practice munitions would involve the use of small and medium-caliber projectiles that could be encountered by marine mammals or sea turtles. The potential for such an encounter is low based on the patchy distribution of both the projectiles and an animal's feeding habitat. An animal would not likely ingest every projectile it encountered. Furthermore, an animal may attempt to ingest a projectile and then reject it when it realizes it is not a food item. Even ingestion of certain items (hooks), if they do not become embedded in tissue, do not end up resulting in injury or mortality to the individual (Wells et al. 2008). Therefore impacts of non-explosive practice munitions ingestion would be limited to the unlikely event where a marine mammal or sea turtle might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

6.5.6 Likely Responses to Expendable Materials

Military expended materials are generally expected to sink to the ocean floor and therefore pose a risk to individual animals for a relatively short period of time. Although there is a potential for ESA-listed species to encounter military expended material, we cannot determine whether such interactions are probable, given the relatively small number of materials that would be expended during any given training exercise or testing activity, the large geographic area involved, and the relatively low densities of threatened or endangered marine mammals and sea turtles in the HSTT Study Area.

The chance that an individual animal would encounter expended cables or wires is low based on the distribution of both the cables and wires expended and the fact that the wires and cables will sink upon release and that relatively few marine mammals that are likely to feed on the bottom in the deeper waters where these would be expended. It is also unlikely that an animal would get entangled even if it encountered a cable or wire while it was sinking or upon settling to the seafloor. An animal would have to swim through loops or become twisted within the cable or wire to become entangled, and given the properties of the expended cables and wires (low breaking strength and sinking rates).

Entanglement of a marine mammal in a parachute assembly at the surface or within the water column would be unlikely, since the parachute would have to land directly on an animal, or an animal would have to swim into it before it sinks. Once on the seafloor, if bottom currents are present, the canopy may temporarily billow and pose an entanglement threat to marine animals with bottom-feeding habits; however, the probability of a marine mammal encountering a parachute assembly on the seafloor and accidental entanglement in the canopy or suspension lines is unlikely.

Seasonally present when migrating through the Southern California portion of the HSTT Study Area, gray whale is the only mysticete occurring in the Study Area that regularly feeds at the seafloor, but it does so in relatively shallow water soft sediment seafloor area where these military expended material entanglement stressors are less likely to be present.

Walker and Coe (Walker and Coe 1990) provided data on the stomach contents from 16 species of odontocetes, some of which occur or had stranded in Southern California waters with evidence of debris ingestion. Of the listed species occurring in the HSTT Study Area, only a sperm whale had ingested items (likely incidentally) that do not float and are thus indicative of foraging at the seafloor.

The chance that an individual animal would encounter expended parachutes is low based on the distribution of the parachutes expended, the fact that parachute assemblies are designed to sink upon release, and the relatively few animals that feed on the bottom. If a marine mammal did become entangled in a parachute, it could easily become free of the parachute because the parachutes are made of very light-weight fabric.

The possibility of odontocetes (sperm whale, Blainville's beaked whale, Cuvier's beaked whale), and pinnipeds (Hawaiian monk seal) becoming entangled exists when they are feeding on the bottom in areas where parachutes have been expended. This is unlikely as parachutes are used in events that generally occur in deeper waters where these species are not likely to be feeding on the bottom, though even if momentarily entangled, a marine mammal would likely be able to free themselves of the light weight fabric of a parachute. There has never been any recorded or reported instance of a marine mammal becoming entangled in a parachute

Beaked whales use suction feeding to ingest benthic prey and may incidentally ingest other items (Macleod et al. 2003). Both sperm whales and beaked whales are known to incidentally ingest foreign objects while foraging; however, this does not always result in negative consequences to health or vitality (Laist 1997; Walker and Coe 1990). While this incidental ingestion has led to sperm mortality in some cases, Whitehead (Whitehead 2003b) suggested the scale to which this affects sperm whale populations was not substantial. Sperm whales are recorded as having ingested fishing net scraps, rope, wood, and plastic debris such as plastic bags and items from the seafloor (Walker and Coe 1990; Whitehead 2003b).

Recently weaned juveniles, who are investigating multiple types of prey items, may be particularly vulnerable to ingesting non-food items as found in a study of juvenile harbor porpoise (Baird and Hooker 2000). A male pygmy sperm whale reportedly died from blockage of two stomach compartments by hard plastic, and a Blainville's beaked whale (Mesoplodon densirostris) washed ashore in Brazil with a ball of plastic thread in its stomach (Derraik 2002). In a comprehensive review of documented ingestion of debris by marine mammals, odontocetes had the most ingestion records with 21 species represented (Laist 1997). Walker and Coe (Walker and Coe 1990) provided data on the stomach contents from 16 species of odontocetes some of which occur or had stranded in Southern California waters with evidence of debris ingestion. Of these odontocete species, only sperm whale, Blainville's beaked whale, and Cuvier's beaked whale had ingested non-floating items (i.e., stones, concrete, metal, glass) presumably while foraging from the seafloor.

Pinnipeds primarily feed within the water column. In a comprehensive review of documented ingestion of debris by marine mammals, for pinniped in the Study Area, only northern elephant seal are recorded as having ingested Styrofoam cup debris (Laist 1997). Guadalupe fur seal in the Southern California Range Complex portion of the Study Area are unlikely to encounter or ingestion stressors as a result of training exercises and testing activities. Hawaiian monk seals, which occur in the Hawaii Range Complex portion of the Study Area, are opportunistic feeders and also forage on the seafloor. It is unlikely that Hawaiian monk seal would encounter and incidentally or mistakenly consume ingestion stressors resulting from the proposed Navy activities if those items remain exposed on the seafloor.

6.5.7 Potential Response to Acoustic Sources

Our exposure analyses concluded that all of the ESA-listed whale species, the two seal species, and the sea turtle species that occur within the action area would be exposed to active acoustic sources in the HSTT Study Area. Potential responses to that exposure, based on scientific literature, the Navy's assessment, and NMFS Permits Divisions analysis are described below, followed by the likely responses of ESA-listed species to those exposures to acoustic sources.

The information that follows is presented as if endangered or threatened marine animals that occur in the HSTT Study Area would only be exposed to active sonar or sound pressure waves associated with underwater detonations when, in fact, any individuals that occur in the area of a training exercise or testing activity would be exposed to multiple stressors and would be responding to a wide array of cues from their environment including natural cues from other members of their social group, from predators, and other living organisms. However, the information that is available generally focuses on the physical, physiological, and behavioral responses of marine animals to one or two stressors or environmental cues rather than the suite of anthropogenic and natural stressors that most free-ranging animals must contend with in their daily existence. We present the information from studies that investigated the responses of animals to one or two stressors, but we remain aware that we might observe very different results

if we presented those same animals with the suite of stressors and cues they would encounter in the wild.

Injury

For the purposes of this assessment, an injury is physical trauma or damage that is a direct result of an acoustic exposure, regardless of the potential consequences of that injury to an animal. Based on the literature available, active sonar might injure marine animals through two mechanisms: acoustic resonance and noise-induced loss of hearing sensitivity (more commonly-called threshold shift). Direct injury from non-impulsive sound sources, such as sonar, is unlikely due to relatively lower peak pressures and slower rise times than potentially injurious sources such as explosives. In reference to strandings, including those associated with use of sonar, Ketten (2012) has recently summarized, "to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result [of] anthropogenic noise exposures, including sonar, even for the most sensitive auditory tissues."

The relatively little that is known about auditory system trauma in marine mammals resulting from a known sound exposure comes from laboratory studies. A single study spatially and temporally correlated the occurrence of auditory system trauma in humpback whales with the detonation of a 5,000 kilogram (kg) (11,023 lb) explosive (Ketten 2012). The exact magnitude of the exposure in that study was not determined, but it is likely the trauma was caused by the shock wave produced by the explosion. There are few known occurrences of direct auditory trauma in marine mammals exposed to tactical sonar or other non-impulsive sound sources (Ketten 2012). The potential for auditory trauma in marine mammals exposed to impulsive sources (e.g., explosions) is inferred from tests of submerged terrestrial mammals exposed to underwater explosions (Ketten 1995; Richmond et al. 1973; Yelverton et al. 1973).

Direct, non-auditory tissue damage may occur after exposure to high amplitude impulsive sources, such as explosions. Primary blast injury is usually limited to gas- containing structures (e.g., lung and gut) and the auditory system (Craig J.C. and C.W. 1998). Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system, as measured in terrestrial mammals, may consist of pulmonary contusions, pneumothorax, pneumomediastinum, traumatic lung cysts, or interstitial or subcutaneous emphysema (Navy 2013c). These injuries may be fatal depending upon the severity of the trauma. Rupture of the lung may introduce air into the vascular system, possibly producing air emboli that can cause a cerebral infarct or heart attack by restricting oxygen delivery to these organs. Though often secondary in life-threatening severity to pulmonary blast trauma, the gastrointestinal tract can also suffer contusions and lacerations from blast exposure, particularly in air-containing regions of the tract. Potential traumas include hematoma, bowel perforation, mesenteric tears, and

ruptures of the hollow abdominal viscera. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered.

A known occurrence of mortality to a marine mammal due to a U.S. Navy training or testing event involved the use of underwater explosives in March 2011 in nearshore waters off San Diego, California, at the Silver Strand Training Complex. This area has been used for underwater demolitions training for at least three decades without incident. On this occasion, however, a group of long-beaked common dolphins entered the mitigation zone and approximately 1 minute after detonation, three animals were observed dead at the surface; a fourth animal was discovered three days later stranded dead approximately 42 mi. (68 km) to the north of the detonation site. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil and Leger 2011).

Acoustic Resonance

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

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

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

A recent paper by Kvadsheim et al. (2012) explored the risk of decompression sickness (DCS) in several cetacean species. Their model estimates suggest that shallow (killer whales), intermediate (pilot whales) and deep diving whales (sperm whales, Cuvier's beaked whale, and Blainville's beaked whale) all live with high blood and tissue partial pressure nitrogen (PN2) levels, but the deep divers seem to experience the most extreme values. The deep diving sperm whales which respond to mid-frequency active (1-10 kHz) sonar exposure by shallower but still deep diving were found to increase risk of decompression sickness, but not beyond the normal risk range of sperm whales. Further, they found no systematic changes during sonar exposure in the other species, for some animals partial pressure nitrogen level appeared to increase slightly, while for others it decreased. However, the variation increased with dive depth. Their results suggest that all species have naturally occurring high nitrogen levels, with deep diving generally associated with higher end-dive partial pressure nitrogen as compared with shallow diving. A separate study found that specific segments of a marine mammal dive are riskier than others in terms of inducing cardiovascular instability, demonstrating that behaviorally induced variability in the dive response can lead to increased susceptibility to DCS (Williams 2012).

In controlled exposure experiments, sonar exposure caused some changes in dive behavior in killer whales, pilot whales, and beaked whales, but it did not lead to increased risk of decompression sickness. However, in three of eight exposure sessions with sperm whales, animals changed to shallower diving, and in all these cases this seemed to result in an increased risk of decompression sickness, although risk was still within the normal risk range of this species. When a hypothetical removal of the normal dive response (bradycardia and peripheral vasoconstriction), was added to the behavioral response during model simulations, this led to an increased variance in the estimated end-dive nitrogen (N2) levels, but no consistent change of risk. Kvadsheim et al. (Kvadsheim et al. 2012) could not rule out the possibility that a combination of behavioral and physiological responses to sonar have the potential to alter the blood and tissue end-dive nitrogen tension to levels which could cause DCS and formation of in vivo bubbles, but actually observed behavioral responses of cetaceans to sonar in their study, did not imply any significantly increased risk of DCS.

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) reqired by sounds in order to be detected by an individual. 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 temporary threshold shift 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 ESA-listed species, we assume that the frequencies are roughly equivalent to the frequencies of the source.

Acoustic exposures can result in three main forms of noise-induced losses in hearing sensitivity: permanent threshold shift, temporary threshold shift, and compound threshold shift (Ward et al. 1998; Yost 2007). When permanent loss of hearing sensitivity, or permanent threshold shift, occurs, there is physical damage to the sound receptors (hair cells) in the ear that can result in total or partial deafness within a range of frequencies, 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 temporary threshold shift, have focused on sound receptors (hair cell damage) concluding that this form of threshold shift is temporary because hair cell damage is not observed 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) argued that traditional testing of threshold shifts, which have focused on recovery of threshold sensitivities after exposure to noise, would fail to account for acute loss of afferent nerve terminals and chronic degeneration of the cochlear nerve, which would have the effect of permanently reducing an animal's ability to perceive and process acoustic signals. Based on their studies of small mammals, the authors reported that two hours of acoustic exposures produced moderate temporary threshold shifts but caused delayed losses of afferent nerve terminals and chronic degeneration of the cochlear nerve in test animals. They concluded that the reversibility of noise induced threshold shifts, or temporary threshold shift, 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, temporary threshold shift may have more permanent effects on an animal's ability to perceive and process sound than earlier studies would lead us to recognize.

Although the published body of science literature contains numerous theoretical studies and discussion papers on hearing impairments that can occur with exposure to a loud sound, only a few studies provide empirical information on noise-induced loss in hearing sensitivity in marine mammals. Most of the few studies available have reported the responses of captive animals

exposed to sounds in controlled experiments. Schlundt et al. (2000), see also Finneran et al. (2003; 2001) provided a detailed summary of the behavioral responses of trained marine mammals during temporary threshold shift tests conducted at the Navy's SPAWAR Systems Center with 1-second tones. Schlundt et al. (2000), reported on eight individual temporary threshold shift experiments that were conducted in San Diego Bay.

Finneran et al. (2003; 2001) conducted temporary threshold shift experiments using 1-second duration tones at 3 kHz. The test method was similar to that of Schlundt et al. (2000) except the tests were conducted in a pool with a very low ambient noise level (below 50 dB re 1 μPa2/Hz), and no masking noise was used. The signal was a sinusoidal amplitude modulated tone with a carrier frequency of 12 kHz, modulating frequency of 7 Hz, and SPL of approximately 100 dB re 1 μPa. Two separate experiments were conducted. In the first, fatiguing sound levels were increased from 160 to 201 dB SPL. In the second experiment, fatiguing sound levels between 180 and 200 dB re 1 μPa were randomly presented. Richardson et al.(1995b) hypothesized that marine mammals within less than 100 meters of a sonar source might be exposed to mid-frequency active sonar transmissions at received levels greater than 205 dB re 1 Pa which might cause temporary threshold shift. However, there is no empirical evidence that exposure to active sonar transmissions with this kind of intensity can cause permanent threshold shift in any marine mammals; instead the probability of permanent threshold shift has been inferred from studies of temporary threshold shift (see Richardson et al. 1995b). Popov et al conducted TTS experiments with captive beluga whales, using tones with center frequencies ranging from 11.2 to 90 kHz, a level of 165 dB re 1 μPa, and exposure durations from 1 to 30 minutes. The highest TTS with the longest recovery duration was produced by noises of lower frequencies (11.2 and 22.5 kHz). At higher noise frequencies (45 and 90 kHz), the TTS decreased. The TTS effect gradually increased with prolonged exposures ranging from 1 to 30 minutes (Popov et al. 2013).

Despite the extensive amount of attention given to threshold shifts by researchers, environmental assessments conducted by the Navy and seismic survey operators, and its use in permits issued by NMFS Permits Division, it is not certain that threshold shifts are common. Several variables affect the amount of loss in hearing sensitivity: the level, duration, spectral content, and temporal pattern of exposure to an acoustic stimulus as well as differences in the sensitivity of individuals and species. All of these factors combine to determine whether an individual organism is likely to experience a loss in hearing sensitivity as a result of acoustic exposure (Ward et al. 1998; Yost 2007). In free-ranging marine mammals, an animal's behavioral responses to a single acoustic exposure or a series of acoustic exposure events would also determine whether the animal is likely to experience losses in hearing sensitivity as a result of acoustic exposure. Unlike humans whose occupations or living conditions expose them to sources of potentially-harmful noise, in most circumstances, free-ranging animals are not likely to remain in a sound field that contains potentially harmful levels of noise unless they have a compelling reason to do so (for example, if they must feed or reproduce in a specific location). Any behavioral responses that would take an

animal out of a sound field or reduce the intensity of its exposure to the sound field would also reduce the animal's probability of experiencing noise-induced losses in hearing sensitivity.

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

Auditory Masking

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

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

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

The echolocation calls of toothed whales are subject to masking by high frequency sound. Data on human hearing indicates low frequency sound can mask high frequency sounds (i.e., upward masking). Studies on captive odontocetes by Au et al. (Au 1993; Au et al. 1985; Au et al. 1974) indicate that some species may use various processes to reduce masking effects (e.g., adjustments in echolocation call intensity or frequency as a function of background noise conditions). There is also evidence that the directional hearing abilities of odontocetes are useful in reducing masking at the high frequencies these cetaceans use to echolocate, but not at the low-to-moderate frequencies they use for communication (Zaitseva et al. 1980).

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

Francis and Barber (2013) reviewed the literature on noise impacts on wildlife and concluded that whereas intermittent and unpredictable noise is often perceived as a threat, chronic and frequent noise interferes with animals' abilities to detect important sounds. The authors state that these chronic effects can lead to fitness costs associated with compromising predator/prey detection or mating signals, altering temporal or movement patterns and increasing physiological stress.

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

Clark et al. (Clark et al. 2009) developed a methodology for estimating masking effects on communication signals for cetaceans that that vocalize and detect sound at low frequencies, including calculating the cumulative impact of multiple noise sources. For example, their technique calculates that in Stellwagen Bank National Marine Sanctuary, when two commercial vessels pass through a North Atlantic right whale's optimal communication space (estimated as a sphere of water with a diameter of 20 km), that space is decreased by 84 percent. This methodology works primarily for continuous sounds, relies on empirical data on source levels of calls (which is unknown for many species), and requires many assumptions about ancient ambient noise conditions and simplifications of animal behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication.

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Changes to vocal behavior and call structure may result from a need to compensate for an increase in background noise. In cetaceans, vocalization changes have been reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying (Parks 2012).

In the presence of low frequency active sonar, humpback whales have been observed to increase the length of their 'songs' (Fristrup et al. 2003; Miller et al. 2000), possibly due to the overlap in frequencies between the whale song and the low frequency active sonar. North Atlantic right whales have been observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007) as well as increasing the amplitude (intensity) of their calls (Parks et al. 2009). In contrast, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test (Bowles et al. 1994a), although it cannot be absolutely determined whether the inability to acoustically detect the animals was due to the cessation of sound production or the displacement of animals from the area. Humpback whale song in the Stellwagen Bank National Marine Sanctuary was reduced over an 11 day span concurrent with transmissions of an Ocean Acoustic Waveguide Remote Sensing experiment with FM pulses centered at 415, 734 and 949 Hz, approximately 200 km away (Risch et al. 2012). Experimental trials with captive bottlenose dolphins demonstrated that exposure to increased levels of introduced sound led to increased metabolic costs of vocalization, presumably as a result of the dolphins' increased physical effort at vocalization (Holt et al. 2013).

Differential vocal responses in marine mammals have been documented in the presence of seismic survey noise. An overall decrease in vocalization during active surveying has been noted in large marine mammal groups (Potter et al. 2007), while blue whale feeding/social calls increased when seismic exploration was underway (Di Lorio and Clark 2010), indicative of a compensatory response to the increased noise level. Melcon et al. (2012) recently documented that blue whales decreased the proportion of time spent producing certain types of calls when mid-frequency sonar was present. At present it is not known if these changes in vocal behavior corresponded to changes in foraging or any other behaviors.

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

the acoustic cues produced by their predators. Whether or not this is a possibility depends on the duration of the masking/hearing impairment and the likelihood of encountering a predator during the time that predator cues are impeded.

Behavioral Responses

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

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

Southall et al. (2007) synthesized data from many past behavioral studies and observations to determine the severity of behavioral reactions at specific sound levels. While the sound pressure level of the sound source was generally correlated with severity of behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al. 2007). After examining all of the available data, the authors felt that the derivation of thresholds for behavioral response based solely on exposure level was not supported because context of the animal at the time of sound exposure was an important factor in estimating response.

Marine animals have not had the time nor have they experienced the selective pressure necessary to have evolved a behavioral repertoire containing a set of responses specific to active sonar, other 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 respond to active sonar, other stressors associated with naval military readiness activities, or human disturbance generally. An extensive number of studies have established that these animals will invoke the same behavioral responses they would invoke when faced with predation and will make the same ecological considerations when they experience human disturbance that they make when they perceive they have some risk of

predation (Beale and Monaghan 2004b; Frid 2003; Frid and Dill 2002; Gill and Sutherland 2001; Harrington and Veitch 1992; Lima 1998; Romero 2004). Specifically, when animals are faced with a predator or predatory stimulus, they consider the risks of predation, the costs of anti-predator behavior, and the benefits of continuing a pre-existing behavior when deciding which response is most appropriate (Bejder et al. 2009; Gill and Sutherland 2001; Houston et al. 1993; Lima 1998; Lima and Bednekoff 1999; Ydenberg and Dills 1986). Further, animals appear to detect and adjust their responses to temporal variation in predation risks (Lima and Bednekoff 1999; Rodriguez-Prieto et al. 2009).

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

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

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

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

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

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

Marine animals might experience one of these behavioral responses, they might experience a sequence of several of these behaviors (for example, an animal might continue its pre-disturbance behavior for a period of time, then abandon an area after it experiences the consequences of physiological stress) or one of these behaviors might accompany responses such as permanent or temporary loss in hearing sensitivity. The narratives that follow summarize the information available on these behavioral responses.

Behavioral Avoidance of Initial Exposures or Continued Exposure

As used in this opinion, behavioral avoidance refers to animals that abandon an area in which active sonar is being used to avoid being exposed to the sonar (regardless of how long it takes them to return to the area after they have abandoned it), animals that avoid being exposed to the entire sound field produced by active sonar; and animals that avoid being exposed to particular

received levels within a sound field produced by active sonar. Richardson et al. (1979) noted that avoidance reactions are the most obvious manifestations of disturbance in marine mammals. There are few empirical studies of avoidance responses of free-living cetaceans to mid-frequency sonar.

Based on a review of observations of the behavioral responses of 122 minke whales, 2,259 fin whales, 833 right whales, and 603 humpback whales to various sources of human disturbance, Watkins (1986) reported that fin, humpback, minke, and North Atlantic right whales ignored sounds that occurred at relatively low received levels, that had the most energy at frequencies below or above their hearing capacities, or that were from distant human activities, even when those sounds had considerable energies at frequencies well within the whale's range of hearing. Most of the negative reactions that had been observed occurred within 100 m of a sound source or when sudden increases in received sound levels were judged to be in excess of 12 dB, relative to previous ambient sounds. From these observations, we would have to conclude that the distance between marine mammals and a source of sound, as well as the received level of the sound itself, will help determine whether individual animals are likely to respond to the sound and engage in avoidance behavior.

While noting that exposure level alone was not adequate to reliably predict an animal's behavioral response to sound, Southall et al. (2007) determined nonethelessthat in some conditions consistent avoidance reactions were noted at higher sound levels dependent on the marine mammal species or group, allowing conclusions to be drawn. Most low-frequency cetaceans (mysticetes) observed in studies usually avoided sound sources at received levels of greater than or equal to 160 dB re 1 µPa. Published studies of mid-frequency cetaceans analyzed include sperm whales, belugas, bottlenose dolphins, and river dolphins. These groups showed no clear tendency, but for non-impulsive sounds, captive animals tolerated received levels in excess of 170 dB re 1 µPa before showing behavioral reactions, such as avoidance, erratic swimming, and attacking the test apparatus. High-frequency cetaceans (observed from studies with harbor porpoises) exhibited changes in respiration and avoidance behavior at received levels between 90 and 140 dB re 1 µPa, with profound avoidance behavior noted for levels exceeding this. Phocid seals showed avoidance reactions at or below received levels of 190 dB re 1 µPa, thus seals may actually receive levels adequate to produce TTS before avoiding the source. Recent studies with beaked whales have shown them to be particularly sensitive to noise, with animals during 3 playbacks of sound breaking off foraging dives at levels below received levels of 142 dB re 1 µPa, although acoustic monitoring during actual sonar exercises revealed some beaked whales continuing to forage at received levels up to 157 dB re 1 µPa (Tyack et al. 2011).

Nachtigall et al. reported that a captive false killer whale was able to proactively change its hearing sensitivity for protection when a warning sound was provided prior to a more intense sound and that the animal learned to change its hearing sensitivity when warned that a loud

sound was about to arrive. The observed hearing threshold increase was not a result of the unconditioned effect of the loud sound, like TTS, so it was considered to be a manifestation of a conditioned dampening of hearing when the subject anticipated the quick appearance of a loud sound, most likely to protect its hearing (Nachtigall and Supin 2013).

Behavioral Avoidance to Sonar

Houser et al. exposed captive groups of bottlenose dolphins to MFA sonar signals to test behavioral responses at various sound pressure levels. Dose–response functions demonstrated a robust relationship between received SPL and the probability of response and indicated rapid habituation to repetitive exposures with received SPL ≤ 160 dB. No habituation was observed at received SPL ≥ 175 dB re 1 μPa and all dolphins refused to participate in trials when the received SPL = 185 dB re 1 μPa. Results showed that bottlenose dolphins may rapidly habituate to MFA sonar sound exposures below a certain level, particularly if there is food motivation, while abandonment of behaviors increases rapidly at received levels ≥ 175 dB re 1 μPa (Houser et al. 2013). Kastelein et al (2013) tested the behavioral reaction of a captive harbor porpoise to five helicopter dipping sonar signals with different spectra at multiple SPLs. The harbor porpoise displayed a behavioral response (a sudden change in swimming speed or swimming direction during sound emission) to the dipping sonar at received levels of between 124-140 dB re: 1 μPa, depending on the signal (Kastelein et al. 2013). Harbor porpoises are particularly sensitive to sound.

There are several empirical studies of avoidance responses of free-living cetaceans to mid-frequency sonar. Kvadsheim et al. (2007) conducted a controlled exposure experiment in which killer whales that had been fitted with DTAGs (which record acoustic exposure, vocal activity, movement, and orientation) were exposed to mid-frequency active sonar (Source A: was a 1.0 s upsweep 209 dB @ 1 - 2 kHz every 10 seconds for 10 minutes; Source B: was a 1.0 s upsweep 197 dB @ 6 - 7 kHz every 10 s for 10 min). When exposed to Source A, a tagged killer whale and the group it was traveling with did not appear to avoid the source. When exposed to Source B the tagged whales, along with other whales that had been carousel feeding, ceased feeding during the approach of the sonar and moved rapidly away from the source (the received level associated with this response was not reported). When exposed to Source B, Kvadsheim and his co-workers reported that a tagged killer whale seemed to try to avoid further exposure to the sound field by immediately swimming away (horizontally) from the source of the sound; by engaging in a series of erratic and frequently deep dives that seemed to take it below the sound field; or by swimming away while engaged in a series of erratic and frequently deep dives. Although the sample sizes in this study are too small to support statistical analysis, the behavioral responses of the orcas were consistent with the results of other studies. Maybaum (Maybaum 1993) conducted sound playback experiments to assess the effects of mid-frequency active sonar on humpback whales in Hawaiian waters. Specifically, she exposed focal pods to sounds of a 3.3-kHz sonar pulse, a sonar frequency sweep from 3.1 to 3.6 kHz, and a control

(blank) tape while monitoring the behavior, movement, and underwater vocalizations. The two types of sonar signals differed in their effects on the humpback whales, although the whales exhibited avoidance behavior when exposed to both sounds. The whales responded to the pulse by increasing their distance from the sound source and responded to the frequency sweep by increasing their swimming speeds and track linearity.

DeRuiter et al. (2013b) employed DTAGs to record responses of Cuvier's beaked whales to playbacks of MFA sonar and, in the case of one whale, to actual distant sonar exercises. Whales displayed strong avoidance responses to playbacks of received levels 89–127 dB re 1 µPa by ceasing normal fluking and echolocation, then swimming away rapidly and silently, extending both dive duration and subsequent non-foraging interval. Distant sonar exercises (78–106 dB re 1 µPa) did not elicit such responses, reinforcing the suggestion of Southall et al. (2007) that behavioral reactions are likely to be context dependent. Tyack (Tyack 2012) reported that playbacks of 1-2 kHz sonar sounds to a minke whale tagged in Norwegian waters resulted in two clear behavioral changes relative to the baseline observation period: a change in dive behavior and movement away from the source, and a switch to shallow dives and increasing speed when received levels were higher and the source vessel was closer to the whale.

An analysis of the dive behavior of killer whales, long-finned pilot whales and sperm whales exposed to controlled LFA sonar (1-2 kHz) and MFA sonar (6-7 kHz) found behavioral reactions were dependent on species and context. Killer whales conducting deep dives abruptly changed to shallow dives at the onset of LFA sonar, but did not alter their dive pattern when exposed to MFA sonar. Long-finned pilot whales performed fewer deep dives during LFA sonar exposures. Some sperm whales performed shallower and shorter dives and did not vocalize during those dives when exposed to LFA sonar (Sivle et al. 2012).

Several researchers have published papers based on studies conducted in the Tongue of the Ocean (Bahamas) on the AUTEC Range where sonars were in regular use (Claridge and Dunn 2011; Mccarthy et al. 2011; Moretti et al. 2010; Pirotta et al. 2012a; Tyack et al. 2011). An array of stationary bottom-mounted hydrophones at the Range is capable of detecting beaked whales when they echolocate anywhere within the range area.

Tyack et al. (Tyack et al. 2011) used two complementary methods to investigate behavioral responses of beaked whales to sonar on the AUTEC Range: an opportunistic approach that monitored whale responses to multi-day naval exercises involving tactical mid-frequency sonars, and an experimental approach using playbacks of simulated sonar, killer whale sounds, and control sounds to beaked whales tagged with DTAGs. They found that in both exposure conditions beaked whales stopped echolocating during deep foraging dives and moved tens of kilometers away. During actual sonar exercises, most whales stopped foraging as a response to the sonar and moved away to distances of more than 10 km, gradually returning to the center of the range over 2–3 days following cessation of sonar exercises. Playback experiments also

demonstrated a clear reaction to sonar, involving premature cessation of foraging dives, coupled with a prolonged ascent. Playback of killer whale sounds elicited a similar response, followed by a prolonged avoidance response over tens of kilometres. However, beaked whale response to killer whale playbacks occurred at a lower received SPL (138 dB SPL) than the response to sonar playbacks (98 dB SPL), indicating that, at least in this instance, whales do not react to MFA sonars at similar exposure levels as they do predators. The tagged whales responded to the actual sonar exercise and to the killer whale playback with well oriented swimming toward the only deep water exit from the area.

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

Behavioral responses to air guns, vessel noise, and other sound sources

Seismic

Blue and fin whales have occasionally been reported in areas ensonified by airgun pulses; however, there have been no systematic analyses of their behavioral reactions to airguns. Sightings by observers on seismic vessels off the United Kingdom suggest that, at times of good sight-ability, the number of blue, fin, sei, and humpback whales seen when airguns are shooting are similar to the numbers seen when the airguns are not shooting (Stone 1997; Stone 1998; Stone 2000; Stone 2001; Stone 2003). However, fin and sei whale sighting rates were higher when airguns were shooting, which may result from their tendency to remain at or near the surface at times of airgun operation (Stone 2003). The analysis of the combined data from all years indicated that baleen whales stayed farther from airguns during periods of shooting (Stone 2003) . Baleen whales also altered course more often during periods of shooting and more were headed away from the vessel at these times, indicating some level of localized avoidance of seismic activity (Stone 2003). The threshold at which Bowhead whales cease calling when exposed to airgun pulses was found to be near 124 dB re 1 µPa. For an airgun array firing every 10 seconds, this corresponded to a received single pulse sound exposure level at the whale of ~106 dB re 1 µPa (Blackwell et al. 2012). At the onset of airgun use, Bowhead whale call localization rates dropped significantly at sites near airguns, where median received levels from airgun pulses were 116-129 dB re 1 Pa (10-450 Hz). Call localization rates remained unchanged at sites distant from the airguns, where median received levels were 99-108 dB re 1 Pa

(Blackwell et al. 2013). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran et al. 2002b).

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

Twenty years of aerial bowhead whale observation data in the Beaufort Sea demonstrated that durations of surfacings decreased upon exposure to seismic operations, especially for traveling or socializing non-calf whales. The presence of seismic operations also affected dive durations, though effects depended on other variables such as season and whale activity, suggesting that changes in behavior of bowhead whales exposed to seismic operations are context dependent (Robertson et al. 2013).

Multibeam Sonar

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

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

to received levels such as those used in these experiments. Further, the responses of marine animals in the wild may be more subtle than those described by Ridgway et al. (1997) and Schlundt et al. (2000).

In 2008, a mass stranding of approximately 100 melon-headed whales in a lagoon system in Northwest Madagascar was attributed to a high-power 12 KhZ multi-beam echosounder system (MBES) operated intermittently by a survey vessel moving in a directed manner down the shelf break the day before the event. The highly unusual stranding event represented the first known marine mammal stranding event closely associated with relatively high frequency mapping systems. An independent scientific review panel concluded that for odontocete cetaceans that hear well in the 10-100 KhZ range, where ambient noise is typically quite low, high-power active sonars operating in this range may be more easily audible and have potential effects over larger areas than low frequency systems that have more typically been considered in terms of anthropogenic noise impacts (Southall et al. 2013).

Drilling

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

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

Pingers

Morton et al. (2002) exposed killer whales to sounds produced by acoustic harassment devices (devices that were designed to harass harbor seals, source levels were 194 dB at 10 kHz re 1μ Pa at 1 meter). They concluded that observations of killer whales declined dramatically in the experimental area (Broughton Archipelago) during the time interval the harassment devices had been used (but not before or after the use).

Vessel noise

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

Nowacek et al. (Nowacek et al. 2004) conducted controlled exposure experiments on North Atlantic right whales using ship noise, social sounds of con-specifics, and an alerting stimulus (frequency modulated tonal signals between 500 Hz and 4.5 kHz). Animals were tagged with acoustic sensors (DTAGs) that simultaneously measured movement in three dimensions. Whales reacted strongly to alert signals at received levels of 133-148 dB SPL, mildly to conspecific signals, and not at all to ship sounds or actual vessels. The alert stimulus caused whales to immediately cease foraging behavior and swim rapidly to the surface. Several studies have demonstrated that cetaceans will avoid human activities such as vessel traffic, introduced sounds in the marine environment, or both. Lusseau (Lusseau 2003) reported that bottlenose dolphins in Doubtful Sound, New Zealand, avoided approaching tour boats by increasing their mean diving interval. Male dolphins began to avoid tour boats before the boats were in visible range, while female dolphins only began to avoid the boats when the boats became intrusive (he attributed the differential responses to differences in energetics: the larger body size of male dolphins would allow them to compensate for the energy costs of the avoidance behavior more than female dolphins). Bejder et al. (2006a) studied the effects of vessel traffic on bottlenose dolphins in Shark Bay, Australia, over three consecutive 4.5-year periods. They reported that the dolphins avoided the bay when two tour operators began to operate in the bay.

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

years. Salden (1988) suggested that humpback whales avoid some nearshore waters in Hawai′i for the same reason.

Pinnipeds appear to engage in a wide variety of responses when exposed to anthropogenic noise. Captive hooded seals responded to an initial exposure to simulated MFA sonar (1-7 kHz) above 160 to 170 dB (re 1 μPa) with avoidance behavior including reduced diving activity, commencement of rapid exploratory swimming at surface, and eventual displacement to areas of least SPL. Upon the second exposure, initial rapid swimming activity was absent, while the reduction in diving activity became even more pronounced (Kvadsheim et al. 2010). Demarchi et al (Demarchi et al. 2012) documented the short-term behavioral responses of Steller sea lions on a haulout complex to military explosions. Acoustic measurements confirmed that in-air noise reached levels capable of causing pinniped disturbance (i.e., > 109 dB peak) but not PTS (i.e., < 149 dB peak). Sea lions showed a significant increase in activity following blasting and were commonly displaced from haulouts, but activity levels dropped sharply and displaced animals usually began returning to haulouts within minutes of the disturbance. Modelling showed no evidence or no conclusive evidence of an effect of blasting on sea lion abundance. The authors speculated that long-term effects on sea lions at the site are unlikely; noting that there has been an increase in peak numbers of sea lions at the site in recent decades while blasting has been ongoing.

Frost and Lowry (Frost et al. 1988) reported that ringed seal densities around islands on which drilling was occurring declined over the period of observation; they concluded that the acoustic exposure was at least a contributing factor in that reduced density. Richardson et al. (Richardson et al. 1991; Richardson et al. 1990), however, reported that ringed and bearded seals appeared to tolerate playbacks of underwater drilling sounds. Norberg (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 (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. (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. (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. (Moulton et al. 2005; Moulton et al. 2003) studied ringed seals before and during the construction and operation of an oil production facility and reported that the ringed seals did not avoid the area around the various industrial sources. Studies of the effects of low frequency sounds on elephant seals (Mirounga spp.), which are considered more sensitive to low frequency sounds than other pinnipeds (Croll et al. 1999b; Kastak and Schusterman 1996; LeBoeuf and Peterson 1969), suggest that elephant seals did not experience even short-term changes in behavior given their exposure to low frequency sounds.

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

behavior that does not bring them closer to the training activity. At the closest distances, we assume that endangered and threatened marine mammals would engage in vertical and horizontal avoidance behavior unless they have a compelling reason to remain in a location (for example, to feed). In some circumstances, this would involve abrupt vertical or horizontal movement accompanied by physiological stress responses.

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

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

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

their diving pattern becomes sufficiently erratic such that they experience higher predation risk or strand during the process of abandoning a site.

6.5.8 Likely Responses to Acoustic Sources by Species

Below we summarize the likely responses to acoustic sources for each ESA-listed species for which we expect an exposure and a response.

Blue Whale

While we recognize that animal hearing evolved separately from animal vocalizations and, as a result, it may be inappropriate to make inferences about an animal's hearing sensitivity from their vocalizations, we have no data on blue whale hearing so we assume that blue whale vocalizations are partially representative of their hearing sensitivities. Blue whales are not likely to respond to high-frequency sound sources associated with the proposed training exercises and testing activities because of their hearing sensitivities. Preliminary results from the behavioral response study on the Southern California Range Complex suggest that despite previous estimates based on vocalizations and anatomy that have assumed they are likely to predominantly hear low-frequency sounds below 400 Hz (Croll et al., 2001; Oleson et al., 2007; Stafford and Moore, 2005), blue whales not only hear mid-frequency active sonar transmissions, in some cases they respond to those transmissions (Southall et al. 2011a). Southall et al. (Southall et al. 2011a) reported that blue whales appeared to ignore sonar transmissions at received levels lower than about 150 dB and ignored received levels greater than these when they were engaged in some feeding behavior. In other instances, blue whales engaged in short, avoidance movements when they were engaged in other kinds of feeding behavior (Southall et al. 2011a).

Goldbogen et al (Goldbogen et al. 2013a) used DTAGs to test the response of blue whales in the Southern California Bight to playbacks of simulated MFA sonar. Simulated sonar and control sounds in the 3.5–4.0 kHz range were ramped up in 3 dB increments from 160 to 210 dB re 1 µPa. Responses varied depending on the whales' prior behavioral state: surface feeding whales showed no response, while deep feeding whales and whales that were not feeding were particularly affected. Responses among affected animals ranged from termination of deep foraging dives to prolonged mid-water dives. The reactions were context dependent leading the authors to conclude that a combination of received sound level and the behavioral state of the animal are likely to influence behavioral response. The authors note that whales responded even at low SPLs suggesting that received level alone is not a reliable predictor of resulting behavior. Avoidance responses to simulated sonar playbacks were not comparable to those previously observed in blue whales when attacked by killer whales.

Melcón et al. (2012) tested whether mid-frequency active sonar and other anthropogenic noises in the mid-frequency band affected the "D-calls" produced by blue whales in the Southern California Bight (the same area where Southall et al. conducted their study). Despite being

classified as "low-frequency hearing specialists," Melcón et al. (2012) reported that the proportion of blue whale D-calls in the presence of mid-frequency active sonar at received levels of 85, 95, 105, and 115 dB (re: 1 µPa) was 36.43 percent lower than D-calls recorded in the presence of non-anthropogenic noise at the same received levels. The authors concluded that blue whales heard and devoted attentional resources to the sonar, despite its high frequency (relative to their putative hearing sensitivity) and its low received level.

Results of studies on blue whales (Goldbogen et al. 2013c; Southall et al. 2011a) indicate that some individuals hear some sounds in the mid-frequency range and exhibit behavioral responses to sounds in this range depending on received level and context. Given the frequency range in which blue whales vocalize, it seems likely that sounds in this frequency range lie at the periphery of their hearing range. While they may devote attentional resources to stimuli in this range, it is unlikely that behavioral responses would have reproductive or fitness consequences. The exposures in which blue whales might occur between 0.56 and 10 kilometers of a sonar ping, might cause these whales to change their behavioral state if they are migrating, but they are not likely to change their behavioral state if they are actively foraging.

We do not expect any stress responses to continue long enough to have fitness consequences for individual blue whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and the additional demands of any stress responses. Therefore, we would not expect blue whales to experience reductions in their annual or lifetime reproductive success as a result of their response to being exposed to active sonar during the training and testing the U.S. Navy plans to conduct in the HSTT Study Area.

Fin Whale

Fin whales are not likely to respond to high-frequency sound sources associated with the proposed training exercises and testing activities because of their hearing sensitivities. While we recognize that animal hearing evolved separately from animal vocalizations and, as a result, it may be inappropriate to make inferences about an animal's hearing sensitivity from their vocalizations, we have no data on fin whale hearing so we assume that fin whale vocalizations are partially representative of their hearing sensitivities. Those vocalizations include a variety of sounds described as low frequency moans or long pulses in the 10-100 Hz band (Edds 1988; Thompson and Friedl 1982b; Watkins 1981a). The most typical signals are very long, patterned sequences of tonal infrasonic sounds in the 15-40 Hz range. Ketten (1997) reports the frequencies of maximum energy between 12 and 18 Hz. Short sequences of rapid calls in the 30-90 Hz band are associated with animals in social groups (Clark personal observation and McDonald personal communication cited in Ketten 1997). The context for the 30-90 Hz calls suggests that they are used to communicate but do not appear to be related to reproduction. Fin whale moans within the frequency range of 12.5-200 Hz, with pulse duration up to 36 seconds,

have been recorded off Chile (Cummings and Thompson 1994). The whale produced a short, 390 Hz pulse during the moan.

Results of studies on blue whales (Goldbogen et al. 2013c; Southall et al. 2011a), which have similar auditory physiology compared to fin whales, indicate that some individuals hear some sounds in the mid-frequency range and exhibit behavioral responses to sounds in this range depending on received level and context. However, given the frequency range in which fin whales vocalize, it seems likely that sounds in this frequency range lie at the periphery of their hearing range and they are less likely to devote attentional resources to stimuli in this frequency range. Based on this information, we would not expect fin whales that find themselves more than 54 kilometers from the source of a mid-frequency active sonar ping to devote attentional resources to that stimulus, even though received levels might be as high as 156 dB (at 54 kilometers). Although fin whales appear to be able to hear mid-frequency (1 kHz–10 kHz) sounds, sounds in this frequency range lie at the periphery of their hearing range and they are less likely to devote attentional resources to stimuli in this frequency rang geiven the frequency range in which fin whales vocalize. While they may devote attentional resources to stimuli in this range, it is unlikely that behavioral responses would have reproductive or fitness consequences. Fin whales that might occur between 0.56 and 10 kilometers of a sonar ping are likely to change their behavioral state, although such a change is less likely if they are actively foraging. We do not assume that these fin whales would respond only to the active sonar, rather all of the environmental cues produced by a vessel moving through the ocean while transmitting active sonar may result in short-term behavioral changes.

We would expect fin whale exposures that result in temporary threshold shift would result in short-term behavioral changes. We do not expect any stress responses to continue long enough to have fitness consequences for individual fin whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and the additional demands of any stress responses. Therefore, we would not expect fin whales to experience reductions in their annual or lifetime reproductive success as a result of their response to being exposed to active sonar during the training and testing the U.S. Navy plans to conduct in the HSTT Study Area.

Western North Pacific Gray Whale

While we recognize that animal hearing evolved separately from animal vocalizations and, as a result, it may be inappropriate to make inferences about an animal's hearing sensitivity from their vocalizations, we have no data on gray whale hearing so we assume that gray whale vocalizations are partially representative of their hearing sensitivities. Auditory structure suggests hearing is attuned to low frequencies (Ketten 1992a; Ketten 1992b). Responses of free-ranging and captive individuals to playbacks in the 160 Hz to 2 kHz range demonstrate the ability of individuals to hear within this range (Buck and Tyack 2000; Cummings and Thompson

1971a; Dahlheim and Ljungblad 1990; Moore and Clark 2002; Wisdom et al. 2001). Responses to low-frequency sounds stemming from oil and gas activities also support low-frequency hearing (Malme et al. 1986; Moore and Clark 2002).

Based on this information, we would not expect gray whales that find themselves more than 54 kilometers from the source of a mid-frequency active sonar ping to devote attentional resources to that stimulus, even though received levels might be as high as 156 dB (at 54 kilometers). Although gray whales appear to be able to hear mid-frequency (1 kHz–10 kHz) sounds, given the frequency range in which gray whales vocalize, it seems likely that sounds in this frequency range lie at the periphery of their hearing range. While they may devote attentional resources to stimuli in this range, it is unlikely that behavioral responses would have reproductive or fitness consequences. We would not expect gray whales that find themselves between 10 and 54 kilometers from a sonar transmission to change their behavioral state, despite being exposed to received levels over 156 dB; these whales might engage in low-level avoidance behavior or short-term vigilance behavior. Gray whales that might occur between 0.56 and 10 kilometers of a sonar ping are likely to change their behavioral state, although such a change is less likely if they are actively foraging. We do not assume that these gray whales would respond only to the active sonar, rather all of the environmental cues produced by a vessel moving through the ocean while transmitting active sonar may result in short-term behavioral changes.

We do not expect any stress responses to continue long enough to have fitness consequences for individual gray whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and the additional demands of any stress responses. Therefore, we would not expect gray whales to experience reductions in their annual or lifetime reproductive success as a result of their response to being exposed to active sonar during the training and testing the U.S. Navy plans to conduct in the HSTT Study Area.

Humpback Whale

Humpback whales are not likely to respond to high-frequency sound sources associated with the proposed training exercises and testing activities because of their hearing sensitivities. While we recognize that animal hearing evolved separately from animal vocalizations and, as a result, it may be inappropriate to make inferences about an animal's hearing sensitivity from their vocalizations, we have no data on humpback whale hearing so we assume that humpback whale vocalizations are partially representative of their hearing sensitivities. As discussed in the Status of the Species narrative for humpback whales, these whales produce a wide variety of sounds.

Humpback whales vocalize less frequently in their summer feeding areas than in their winter ranges at lower latitudes. Feeding groups produce distinctive sounds ranging from 20 Hz to 2 kHz, with median durations of 0.2-0.8 seconds and source levels of 175-192 dB (Thompson et al. 1986). These sounds are attractive and appear to rally animals to the feeding activity (D'Vincent

et al. 1985; Sharpe and Dill 1997). In summary, humpback whales produce at least three kinds of sounds:

1. Complex songs with components ranging from at least 20Hz – 4 kHz with estimated source levels from 144 – 174 dB; these are mostly sung by males on the breeding grounds (Payne and McVay 1971; Winn et al. 1970)

2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3kHz (Richardson et al. 1995b; Tyack and Whitehead 1983); and

3 Feeding area vocalizations that are less frequent, but tend to be 20Hz – 2 kHz with estimated source levels in excess of 175 dB re 1 µPa-m (Richardson et al. 1995b; Thompson et al. 1986). Sounds often associated with possible aggressive behavior by males (Silber 1986; Tyack 1983) are quite different from songs, extending from 50 Hz to 10 kHz (or higher), with most energy in components below 3 kHz. These sounds appear to have an effective range of up to 9 km (Tyack and Whitehead 1983).

Au et al. (2006) conducted field investigations of humpback whale songs that led these investigators to conclude that humpback whales have an upper frequency limit reaching as high as 24 kHz. Based on this information, it is reasonable to assume that the active mid-frequency sonar the U.S. Navy would employ during the active sonar training exercises and testing activitiesthe U.S. Navy proposes to conduct in the HSTT Study Area are within the hearing and vocalization ranges of humpback whales. There is limited information on how humpback whales are likely to respond upon being exposed to mid-frequency active sonar (most of the information available addresses their probable responses to low-frequency active sonar or impulsive sound sources). Maybaum (Maybaum 1993) conducted sound playback experiments to assess the effects of mid-frequency active sonar on humpback whales in Hawaiian waters. Specifically, she exposed focal pods to sounds of a 3.3-kHz sonar pulse, a sonar frequency sweep from 3.1 to 3.6 kHz, and a control (blank) tape while monitoring the behavior, movement, and underwater vocalizations. The two types of sonar signals differed in their effects on the humpback whales, although the whales exhibited avoidance behavior when exposed to both sounds. The whales responded to the pulse by increasing their distance from the sound source and responded to the frequency sweep by increasing their swimming speeds and track linearity. The frequency or duration of their dives or the rate of underwater vocalizations, however, did not change.

Humpback whales have been known to react to low frequency industrial noises at estimated received levels of 115-124 dB (Malme et al. 1985), and to calls of other humpback whales at received levels as low as 102 dB (Frankel et al. 1995). Malme et al. (1985) found no clear response to playbacks of drill ship and oil production platform noises at received levels up to 116 dB re 1 Pa. Studies of reactions to airgun noises were inconclusive (Malme et al. 1985). Humpback whales on the breeding grounds did not stop singing in response to underwater

explosions (Payne and McVay 1971). Humpback whales on feeding grounds did not alter short-term behavior or distribution in response to explosions with received levels of about 150 dB re 1 Pa/Hz at 350Hz (Lien et al. 1993; Todd et al. 1996). However, at least two individuals were probably killed by the high-intensity, impulse blasts and had extensive mechanical injuries in their ears (Ketten et al. 1993; Todd et al. 1996). The explosions may also have increased the number of humpback whales entangled in fishing nets (Todd et al. 1996). Frankel and Clark (1998) showed that breeding humpbacks showed only a slight statistical reaction to playbacks of 60-90 Hz sounds with a received level of up to 190 dB. Although these studies have demonstrated that humpback whales will exhibit short-term behavioral reactions to boat traffic and playbacks of industrial noise, the long-term effects of these disturbances on the individuals exposed to them are not known. Humpback whales in Stellwagen Bank National Marine Sanctuary reduced their calling rates coincident with an Ocean Acoustic Waveguide Remote Sensing experiment 200 kilometers away with FM pulses centered at 415, 734 and 949 Hz (Risch et al. 2012).

As discussed in the Proposed Mitigation section of this document, the Navy has agreed that training exercises utilizing mid-frequency active sonar in the designated Humpback Whale Cautionary Area would require a much higher level of clearance than is normal practice in planning and conducting mid-frequency active sonar training. Furthermore, no reported cases of harmful effects to humpback whales attributed to mid-frequency active sonar use have occurred during the Navy's 40-plus years of training in the waters off the Hawaiian Islands. Coincident with this use of mid-frequency active sonar, abundance estimates reflect an annual increase in the humpback whale stock (Mobley Jr 2001; Mobley Jr. 2003). A recent long-term study of humpback whales in Hawaiian waters shows long-term fidelity to the Hawaiian winter grounds, with many showing sighting spans ranging from 10 to 32 years (Herman et al. 2011). The overall abundance of humpback whales in the north Pacific has continued to increase and is now greater than some pre-whaling abundance estimates (Barlow et al. 2011a). The California, Oregon, Washington stock of humpback whales uses the waters within the Southern California portion of the HSTT Study Area as a summer feeding ground. No areas of specific importance for reproduction or feeding for other mysticetes have been identified in the HSTT Study Area.

Based on this information, we would not expect humpback whales that find themselves more than 54 kilometers from the source of a mid-frequency active sonar ping to devote attentional resources to that stimulus, even though received levels might be as high as 156 dB (at 54 kilometers). Although humpback whales appear to be able to hear mid-frequency (1 kHz–10 kHz) sounds, given the frequency range in which humpback whales vocalize, it seems likely that sounds in this frequency range lie at the periphery of their hearing range. While they may devote attentional resources to stimuli in this range, it is unlikely that behavioral responses would have reproductive or fitness consequences.We would not expect humpback whales that find themselves between 10 and 54 kilometers from a sonar transmission to change their behavioral

state, despite being exposed to received levels over 156 dB; these whales might engage in low-level avoidance behavior or short-term vigilance behavior. Humpback whales that might occur between 0.56 and 10 kilometers of a sonar ping are likely to change their behavioral state, although such a change is less likely if they are actively foraging. We do not assume that these gray whales would respond only to the active sonar, rather all of the environmental cues produced by a vessel moving through the ocean while transmitting active sonar may result in short-term behavioral changes.

We do not expect any stress responses to continue long enough to have fitness consequences for individual humpback whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and the additional demands of any stress responses. Therefore, we would not expect humpback whales to experience reductions in their annual or lifetime reproductive success as a result of their response to being exposed to active sonar during the training and testing the U.S. Navy plans to conduct in the HSTT Study Area.

Sei Whale

Like blue and fin whales, sei whales are not likely to respond to high-frequency sound sources associated with the proposed training exercises and testing activities because of their hearing sensitivities. As discussed in the Status of the Species section of this opinion, we have no specific information on the hearing sensitivity of sei whales. Based on their anatomical and physiological similarities to both blue and fin whales, we assume that the hearing thresholds of sei whales will be similar as well and will be centered on low-frequencies in the 10-200 Hz.

Results of studies on blue whales (Goldbogen et al. 2013c; Southall et al. 2011a), which have similar auditory physiology compared to sei whales, indicate that some individuals hear some sounds in the mid-frequency range and exhibit behavioral responses to sounds in this range depending on received level and context. However, given the frequency range in which sei whales vocalize, we make the same assumption with sei whales that we made with blue and fin whales: they are probably able to hear mid-frequency (1 kHz–10 kHz) sounds, but sounds in this frequency range lie at the periphery of their hearing range. While they may devote attentional resources to stimuli in this range, it is unlikely that behavioral responses would have reproductive or fitness consequences. We would not expect the instances in which sei whales might find themselves between 10 and 54 kilometers from a sonar transmission to cause these whales to change their behavioral state, despite being exposed to received levels as high as 156 dB; instead, these whales might engage in low-level avoidance behavior or short-term vigilance behavior. The exposures in which sei whales might occur between 0.56 and 10 kilometers of a sonar ping, might cause these whales to change their behavioral state if they are migrating, but they are not likely to change their behavioral state if they are actively foraging.

We do not expect any stress responses to continue long enough to have fitness consequences for individual sei whales because these whales are likely to have energy reserves sufficient to meet

the demands of their normal behavioral patterns and the additional demands of any stress responses. Therefore, we would not expect sei whales to experience reductions in their annual or lifetime reproductive success as a result of their response to being exposed to active sonar during the training and testing the U.S. Navy plans to conduct in the HSTT Study Area.

Sperm Whale

Although there is no published audiogram for sperm whales, sperm whales would be expected to have good, high frequency hearing because their inner ear resembles that of most dolphins, and appears tailored for ultrasonic (>20 kHz) reception (Ketten 1994). The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate, which suggest that neonatal sperm whales respond to sounds from 2.5 to 60 kHz. Sperm whales vocalize in high- and mid-frequency ranges; most of the energy of sperm whales clicks is concentrated at 2 to 4 kHz and 10 to 16 kHz. Other studies indicate sperm whales' wide-band clicks contain energy between 0.1 and 20 kHz (Goold and Jones 1995; Weilgart and Whitehead 1993). Ridgway and Carder (Ridgway and Carder 2001) measured low-frequency, high amplitude clicks with peak frequencies at 500 Hz to 3 kHz from a neonate sperm whale.

Based on their hearing sensitivities and vocalizations, the active sonar and sound pressure waves from the underwater detonations (as opposed to the shock waves from underwater detonations) the U.S. Navy proposes to conduct in the HSTT Study Area might mask sperm whale hearing and vocalizations. There is some evidence of disruptions of clicking and behavior from sonars (Goold 1999; Watkins 1985), pingers (Watkins and Schevill 1975), the Heard Island Feasibility Test (Bowles et al. 1994b), and the Acoustic Thermometry of Ocean Climate (Costa et al. 1998a). Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders (Watkins and Schevill 1975). Goold (1999) reported six sperm whales that were driven through a narrow channel using ship noise, echosounder, and fish finder emissions from a flotilla of 10 vessels. Watkins and Schevill (1975) showed that sperm whales interrupted click production in response to pinger (6 to 13 kHz) sounds. They also stopped vocalizing for brief periods when codas were being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995).

Because they spend large amounts of time at depth and use low frequency sound sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999b). Sperm whales have been observed dispersing from social aggregations, moving away from the sound source, becoming difficult to approach and ceasing echolocation in the presence of underwater pulses produced by echosounders and submarine sonar (Watkins 1985; Watkins and Schevill 1975). Sperm whales in the Norwegian Sea exposed to LFA sonar (1–2 kHz, maximum 197-214 dB re 1 µPa at 1m) shifted from deep diving behavior to shallower and shorter deep dives which lacked local activity, while sperm whales exposed to MFA sonar (6–7 kHz, maximum 197-214 dB re 1 µPa at 1m) in the same study showed no noticeable behavioral response (Sivle et al.

2012). In the Caribbean, sperm whales avoided exposure to mid-frequency submarine sonar pulses, in the range 1000 Hz to 10,000 Hz (IWC 2005).

Sperm whales 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). Results of experimental playbacks of killer whale sounds to five individual male sperm whales in the Norwegian Sea showed that, rather than diving away from the perceived predator, sperm whales responded by interrupting their foraging or resting dives and returning to the surface, changing their vocal production, and initiating a surprising degree of social behavior (Cure et al. 2013).

Other studies identify instances in which sperm whales did not respond to anthropogenic sounds. Sperm whales did not alter their vocal activity when exposed to levels of 173 dB re 1 Pa from impulsive sounds produced by 1 g TNT detonators (Madsen and Mohl 2000). Richardson et al. (1995b) citing a personal communication with J. Gordon suggested that sperm whales in the Mediterranean Sea continued calling when exposed to frequent and strong military sonar signals. When Andre et al. (1997b) exposed sperm whales to a variety of sounds to determine what sounds may be used to scare whales out of the path of vessels, sperm whales were observed to have startle reactions to 10 kHz pulses (180 dB re 1 Pa at the source), but not to the other sources played to them.

Published reports identify instances in which sperm whales have responded to an acoustic source and other instances in which they did not appear to respond behaviorally when exposed to seismic surveys. Mate et al. (1994) reported an opportunistic observation of the number of sperm whales to have decreased in an area after the start of airgun seismic testing. However, Davis et al. (2000) noted that sighting frequency did not differ significantly among the different acoustic levels examined in the northern Gulf of Mexico, contrary to what Mate et al. (1994) reported. Sperm whales may also have responded to seismic airgun sounds by ceasing to call during some (but not all) times when seismic pulses were received from an airgun array >300 km away (Bowles et al. 1994b).

A study offshore of northern Norway indicated that sperm whales continued to call when exposed to pulses from a distant seismic vessel. Received levels of the seismic pulses were up to 146 dB re 1 μPa peak-to-peak (Madsen et al. 2002). Similarly, a study conducted off Nova Scotia that analyzed recordings of sperm whale sounds at various distances from an active seismic program did not detect any obvious changes in the distribution or behavior of sperm whales (McCall-Howard 1999). Data from vessel-based monitoring programs in United Kingdom waters suggest that sperm whales in that area may have exhibited some changes in behavior in the presence of operating seismic vessels (Stone 1997; Stone 1998; Stone 2000; Stone 2001; Stone 2003). However, the compilation and analysis of the data led the author to

conclude that seismic surveys did not result in observable effects to sperm whales (Stone 2003). The results from these waters seem to show that some sperm whales tolerate seismic surveys.

Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses produced by echosounders and submarine sonar (Watkins 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999b). Furthermore, because of their apparent role as important predators of mesopelagic squid and fish, changes in their abundance could affect the distribution and abundance of other marine species.

These studies suggest that the behavioral responses of sperm whales to anthropogenic sounds are highly variable, but do not appear to result in the death or injury of individual whales or result in reductions in the fitness of individuals involved. Responses of sperm whales to anthropogenic sounds probably depend on the age and sex of animals being exposed, as well as other factors. There is evidence that many individuals respond to certain sound sources, provided the received level is high enough to evoke a response, while other individuals do not.

Based on this information, we would not expect the instances in which sperm whales would find themselves more than 56 kilometers from the source of a mid-frequency active sonar ping to cause the sperm whales devote attentional resources to that stimulus, even though received levels might be as high as 156 dB (at 54 kilometers). Similarly, we would not expect the instances in which sperm whales might find themselves between 10 and 51 kilometers from a sonar transmission to cause these whales to change their behavioral state, despite being exposed to received levels ranging from 140 and 150 dB; instead, these whales might engage in low-level avoidance behavior or short-term vigilance behavior. The exposures in which sperm whales might occur between 0.56 and 10 kilometers of a sonar ping might cause these whales to change their behavioral state if they are migrating, but they are not likely to change their behavioral state if they are actively foraging.

We do not expect any stress responses to continue long enough to have fitness consequences for individual sperm whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and the additional demands of any stress responses. Therefore, we would not expect sperm whales to experience reductions in their annual or lifetime reproductive success as a result of their response to being exposed to active sonar during the training and testing the U.S. Navy plans to conduct in the HSTT Study Area.

Main Hawaiian Island Insular False Killer Whale

Based on the evidence available, we would expect main Hawaiian Island Insular false killer whales that are exposed to mid-frequency active sonar in the Hawaii Range Complex to engage in horizontal movements that would allow them to avoid continued exposure. At the same time, we would expect main Hawaiian Islands Insular false killer whales to experience impaired communication because they vocalize at frequencies that overlap with those of the mid-frequency active sonar systems the Navy plans to employ during training on the Hawaii Range Complex. To preserve the saliency of their vocalizations and the coherence of their social interactions, main Hawaiian Islands Insular false killer whales might have to make one or more of the vocal adjustments discussed earlier in this narrative. Because any reductions in the active space of whale vocalizations that result from active sonar transmissions associated with the proposed missions would be temporary and episodic, any vocal adjustments MHI insular false killer whales would have to make would also be temporary. Studies on a captive false killer whales have demonstrated an ability to proactively change hearing sensitivity, apparently for protection, when a warning sound was provided prior to a more intense sound and that the animal learned to change its hearing sensitivity when warned that a loud sound was about to arrive. (Nachtigall and Supin 2013). Controlled exposure experiments in the Bahamas found that after each MFA reception of simulated MFA sonar sounds (3.1-3.4 kHz, source level 160-211 dB re 1 µPa) false killer whales increased their whistle rate and produced whistles that were more similar in their frequency characteristics to MFA sonar (DeRuiter et al. 2013a).

We do not expect any stress responses to continue long-enough to have fitness consequences for individual MHI insular false killer whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and the additional demands of any stress responses. Therefore, we would not expect MHI insular false killer whales to experience reductions in their annual or lifetime reproductive success as a result of their response to being exposed to active sonar during the training and testing the U.S. Navy plans to conduct in the HSTT Study Area.

Hawaiian Monk Seal

Hawaiian monk seals seem to have typical phocid hearing and can probably hear effectively up to 30 kHz and possibly as high as 60 kHz. Modelling results demonstrate that while many Hawaiian monk seals may be able to hear mid-frequency sonar only one seal is likely to receive enough acoustic energy to experience temporary threshold shift. The temporary threshold shift thresholds used in the Navy analysis on harbor seals and elephant seals, based on the minimum statistically significant shifts determined by Finneran et al. (2011) and others, are 6 dB of shift which generally lasts less than 5-10 minutes, often much less. While we cannot determine whether the one exposure was just above threshold or a higher exposure that might produce 20-30 dB temporary threshold shift lasting for many minutes or hours, we can say with confidence that the frequency bandwidth of the effect will cover about 1/3 octave centered about 1/3 octave

above the inducing sound – that is the effect from exposure to 3 kHz will be centered at 4.5 kHz across 3-6 kHz.

In 2010-2011, 13 monk seals were tagged in the Hawaii Range Complex for a total of 38,232 hours (1593 days) (Wilson and Littnan 2011). D'Amico and Wilson (2013) overlaid tag data with Navy sonar data to determine if seals were near active sonar and if so, what estimated received levels of sonar they were exposed to. By using geo-spatial databases, it was determined that 8 of these 13 seals were within 36 km of a hull mounted sonar ship for a total of 1473 hours 50 minutes (approximately 62 days) or 3.85 percent of the total tagged time. Considering concurrent active sonar activity during the 2 year period, 4 of the 8 seals were exposed to a total of 14.48 hours (less than 1 day) or 1.0 percent of concurrent sonar activity while the seal was within 36 km of a mid-frequency sonar ship. One seal was exposed to mid-frequency sonar transmissions for 30 minutes within the 5-15 km range bin, receiving a maximum receive level of 160dB. The majority of the time the 4 seals were exposed to mid-frequency sonar transmissions while in the 15-36 km range bin, receiving a maximum receive level of 150dB. None of these corresponded with seals identified as "outliers" by one of the authors (KW); therefore, available data suggest there were no significant impacts from mid-frequency active sonar on the Hawaiian monk seals tagged in the Hawaii Range Complex during the 2010-2011 time period.

We assume that, like the whales discussed previously, Hawaiian monk seals are likely to try to avoid being exposed to vessel traffic, active sonar, and sound-producing activities such as gunnery exercises or sinking exercises. We do not have the information necessary to determine which of the many sounds associated with an activity is likely to trigger avoidance behavior in Hawaiian monk seals (for example, engine noise, helicopter rotors, ordnance discharges, explosions, or some combination of these), but these animals are likely to avoid the general area in which an exercise would occur by remaining close to a shoreline or on a beach. This avoidance will not prevent Hawaiian monk seals from being exposed to received levels of active sonar or explosions, but it would prevent Hawaiian monk seals from being exposed at received levels that would injure Hawaiian monk seals, cause them physiological distress, or alter their reproductive success.

Guadalupe Fur Seal

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 (Richardson et al. 1995b; Schusterman 1978). The underwater hearing range of the northern fur seal ranges from 0.5Hz to 40 kHz (Babushina et al. 1991; Moore and Schusterman 1987) and the threshold is 50 to 60 dB re 1 μPa (Moore and Schusterman 1987). The best underwater hearing occurs between 4 and 17 to 28 kHz (Babushina

et al. 1991; Moore and Schusterman 1987). The maximum sensitivity in air is at 3 to 5 kHz for northern fur seals (Babushina et al. 1991) (Babushina et al. 1991).

Navy plans to conduct training exercises and testing activities on the Southern California Range Complex that 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 2003; 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 because the seals are actively foraging in waters on and around the range complex or migrating through the range complex.

Guadalupe fur seals have been exposed to Navy training exercises and testing activities on the Southern California Range Complex of the HSTT Study Area, 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 Navy training exercises and testing activities, this rate suggests that the number of Guadalupe fur seals would continue to increases despite being exposed to stressors associated with these training exercises and testing 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.

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 Navy plans to conduct in the HSTT Study Area annually, or over a five-year period, 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 species being exposed to active sonar, vessel traffic, or explosions associated with the activities the U.S. Navy plans to conduct in the HSTT Study Area.

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 (<2 kHz) (Bartol et al. 1999; Dow Piniak et al. 2012b; Lenhardt et al. 1983; Lenhardt et al. 1994; Martin et al. 2012; O'Hara and Wilcox 1990; Ridgway et al. 1969), with greatest sensitivity below 1 kHz.

Most of the sonars the U.S. Navy proposes to use during the training exercises and testing activities in the HSTT Study Area transmit at frequencies that are substantially higher than the hearing thresholds of sea turtles. As a result, sea turtles are not likely to respond upon exposure to mid-frequency active sonar and therefore are not likely to be adversely affected.

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 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 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. A study conducted in the Mediterranean Sea found that of 164 loggerhead turtles observed, 57 percent responded to the firing of an air gun array (source level 252 dB re 1 μPa [peak]) by diving at or before their closest point of approach to the airguns, with dive probability decreasing with increasing distance from the airgun array (DeRuiter and Larbi Doukara 2012).

Although it is possible that sea turtles in the vicinity of an in-water detonation might experience a temporary or permanent threshold shift, it is not known what energy levels and received levels are necessary to induce threshold shifts. The few studies completed on the auditory capabilities of sea turtles (adult green, loggerhead, and Kemp's ridley turtles) suggest that they could be capable of hearing low frequency sounds (Lenhardt 1994; Moein et al. 1993; Ridgway et al. 1969). Ridgway et al. (Ridgway et al. 1969) reported maximal sensitivity for green turtles occurred at 300 to 400 Hz, with a rapid decline in sensitivity for lower and higher tones. Similarly, Moein et al. (Moein et al. 1993) reported a hearing range of about 250 to 1,000 Hz for loggerhead turtles, and Lenhardt (Lenhardt 1994) stated that maximal sensitivity in sea turtles generally occurs in the range from 100 to 800 Hz. Calculated in-water hearing thresholds within the useful range appear to be high (e.g., about 160 to 200 dB re 1 μPa) (Lenhardt 1994). Piniak et al. reported maximum sensitivity between 100 and 400 Hz in water (84 dB re: 1 μPa at 300 Hz) and 50 and 400 Hz in air (62 dB re: 20 μPa at 300 Hz) for leatherback sea turtle hatchlings (Piniak et al. 2012a). In the absence of more specific information that could be used to determine the acoustic harassment range for sea turtles, the U.S. Navy assumed that frequencies >100 Hz (which are the acoustical harassment ranges predicted for odontocetes) would be conservative for sea turtles.

We conclude that training exercises and testing activities the U.S. Navy plans to conduct in the HSTT Study Area annually or over the next five years are not likely to interact with a 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, hawksbill, leatherback, loggerhead or olive ridley sea turtles surviving and recovering in the wild by reducing their reproduction, numbers, or distribution reducing their reproduction, numbers, or distribution.

6.6 Effects Resulting from Interaction 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. In each instance, we have explained how biological opinions consider "cumulative impacts" (in the NEPA sense of the term). There is a nuance to the idea of "cumulative impacts," however, that we have chosen to address separately and explicitly in this opinion: interactions between stressors associated with the activities the Navy plans to conduct in the HSTT Study Area 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 (Relyea 2009) who demonstrated that exposing several different amphibians to a combination of pesticides and chemical cues of natural predators, which induced stress, increased the mortality rates of the amphibians (Sih et al. 2004). For some species, exposing the amphibians to the

combination of stressors produced mortality rates that were twice as high as the mortality rates associated with each individual stressor. This section considers the evidence available to determine if interactions associated with mid-frequency active sonar are likely to produce responses we have not considered already or if interactions are likely to increase the severity and, therefore, the consequences of the responses we have already considered.

The activities the U.S. Navy proposes to conduct in the HSTT Study Area will continue to introduce a suite of stressors into the marine and coastal ecosystems of the main Hawaiian Islands, areas around southern California and the transit lanes in between: low, mid, and high-frequency active sonar from surface vessels, torpedoes, and dipping sonar; shock waves and sound fields associated with underwater detonations, acoustic and visual cues from surface vessels as they move through the ocean's surface, and sounds transferred into the water column from fixed-wing aircraft, helicopters, and through the hulls of hulks that are the targets of sinking exercises. Exposing endangered and threatened marine animals to each of these individual stressors could pose additional risks as the exposures accumulate over time. Also, exposing endangered and threatened marine animals to this suite of stressors could pose additional risks as the stressors interact with one another or with other stressors that already occur in those areas. More importantly, endangered and threatened marine animals that occur in the HSTT Study Area would be exposed to combinations of stressors produced by the Navy's activities at the same time they are exposed to stressors from other human activities and natural phenomena.

We recognize these interactions might have effects on endangered and threatened species that we have not considered thus far; however, the data available do not allow us to do more than acknowledge the possibility. Consider the stressor that has received the most attention thus far: mid-frequency active sonar. The proposed activities would add mid-frequency sound to ambient oceanic noise levels, which, in turn, could have cumulative impacts on the ocean environment, including listed species. During transmissions, mid-frequency sonar will add to regional noise levels produced by commercial shipping, recreational boating, and construction activities occurring along the coastlines, among others. However, there are no reliable methods for assessing potential interactions between these sound sources. The Navy conducted computer simulations to assess the potential cumulative impacts of mid-frequency active sonar. That assessment concluded that the "cumulative impacts" of mid-frequency sonar would be "extremely small" because the exercises would occur for relatively short periods of time, for relatively short periods of time in any given area; the sources of active sonar would not be stationary; and the effects of any mid-frequency exposure would stop when transmissions stop.

A greater cumulative impact is likely to result from an interaction between the number of times endangered or threatened species might be exposed to active sonar and explosions in association with the activities considered in this opinion and other activities the Navy and other agencies plan to conduct in the HSTT Study Area during the same time interval.

Richardson et al. (Richardson et al. 1995b) provided extensive information and arguments about the potential cumulative effects of man-made noise on marine mammals. Those effects included masking, physiological effects and stress, habituation, and sensitization. Those concerns were echoed by Clark and Fristrup (Clark and Fristrup 2001), National Research Council (NRC 2003b), and others. Although all of these responses have been measured in terrestrial animals reacting to airborne, man-made noises, those studies are counterbalanced by studies of other terrestrial mammals that did not exhibit these responses to similar acoustic stimuli.

The evidence available does not allow us to reach any conclusions about cumulative effects of the activities considered in this opinion and other activities that are occurring or are designed to occur in the HSTT Study Area. 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 Hawaii would not reduce the performance of the humpback whales that winter in waters off Hawaii. 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 Hawaii (for example, the Hawaiian nesting aggregation of green turtles has increased in abundance over the past 30 years as well).

Other inferences, however, that would undercut that inference are also consistent with the evidence. If humpback whales in waters off Hawaii were an isolated and resident population, it would be appropriate to infer that the existing stress regime has not reduced their performance as a population. Because that is not the case and the humpback whales that winter in Hawaii migrate there from foraging areas across the North Pacific Ocean (humpback whales have been reported to migrate to Hawaii from foraging areas in Russian, the Bering Sea, Aleutian Islands, western Gulf of Alaska, southeast Alaska, and British Columbia) (Calambokidis et al. 2008), one inference that is consistent with the data is that the increase in humpback whales reflects conditions in foraging areas that allow their numbers to increase despite conditions in Hawaii (the corollary being that as those conditions change, the population's performance would change). Another inference that is consistent with the evidence available is that humpback whales continue to migrate to Hawaii during the winter because these are their traditional wintering areas or because conditions in alternative wintering areas are worse.

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 in the HSTT Study Area, and other natural and anthropogenic stressors in the Action Area. The evidence available suggests that the population of at least humpback whales that winters 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.

6.7 Cumulative Effects

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this 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 is not aware of future private action in the action area that would not require Federal authorization or funding and is reasonably certain to occur during the reasonably foreseeable future.

7 INTEGRATION AND SYNTHESIS OF EFFECTS

Our effects analyses identified the probable risks the Navy's training exercises and testing activities pose to ESA-listed individuals that will be exposed to those activities. We measure risks to individuals of endangered or threatened species using changes in the individuals' "fitness" or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When we do not expect listed animals exposed to an action's effects to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise. As a result, if we conclude that listed animals are *not* likely to experience reductions in their fitness, we would conclude our assessment. If, however, we conclude that listed animals are likely to experience reductions in their fitness, we would assess the consequences of those fitness reductions for the population or populations the individuals in an action area represent.

As part of our risk analyses, we consider the consequences of exposing endangered, threatened, or proposed endangered or threatened species to the stressors associated with the proposed actions, individually and cumulatively, given that the individuals in the action areas for this consultation are also exposed to other stressors in the action area and elsewhere in their geographic range. These stressors or the response of individual animals to those stressors can produce consequences — or "cumulative impacts" (in the NEPA sense of the term) — that would not occur if animals were only exposed to a single stressor.

As we summarize in the narratives that follow, our analyses led us to conclude whether endangered or threatened individuals are likely to be exposed to the U.S. Navy's training exercises and testing activities in the HSTT Study Area and whether or not they are likely to experience reductions in the fitness of the individual animals that are likely to be exposed to those activities. The analysis considers exposures during both the five year period of the MMPA rule and LOAs and into the reasonably foreseeable future, based on an assumption that training and testing activities continue at similar levels.

7.1 Blue Whale

The estimates of blue whale exposures to training exercised and testing exercises that would result in a behavioral response annually are probably an over-estimate of the actual exposures even if it represents the best estimate available.Most blue whales would only be exposed periodically or episodically, if at all, to the activities the U.S. proposes to conduct in the HSTT Study Area. Many training exercises and testing activities will occur without any marine animals being exposed to U.S. Navy vessels, sound fields associated with active sonar pings, or shock waves associated with underwater detonations. While some blue whales detect and response to mid-frequency active sonar, mid-frequency active sonar is considered to be at periphery of blue whale hearing sensitivity.

Given the size of mitigation zone (extending to approximately 0.75 to 1.00 km [0.40 to 0.56 nm] from the transmitter) and the additional 1-km buffer zone, the detection probabilities associated with the HF/M3 sonar (above 95 percent probability of detecting small dolphins at about 750 m [0.4 nm], whale calves at 1,000 m [0.56 nm] and large whales at more than 1,500 m [0.81 nm]), and the depth of the transmitters, a marine mammal would have a high probability of being detected within the LFA mitigation zone and, as a result, a low probability of being exposed to sound levels greater than 180 dB.

Blue whales in the action area seem likely to respond to the ship traffic associated with each of the activities in ways that approximate their responses to whale watch vessels. Those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver, as well as the activity the whale is involved with at the time. Blue whales seem most likely to try to avoid being exposed to the activities and their avoidance response is likely to increase as an exercise progresses. We do not have the information necessary to determine which of the many sounds associated with an activity is likely to trigger avoidance behavior in blue whales (for example, engine noise, helicopter rotors, ordnance discharges, explosions, or some combination of these) or whether blue whales would avoid being exposed to specific received levels, the entire sound field associated with an exercise, or the general area in which an exercise would occur.

Individual blue whales might not respond to the vessels, while in other circumstances, whales are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social. Some of these whales might experience physiological stress (but not “distress”) responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, because of the relatively short duration of individual activity, the small number of large exercises, and the short duration of the unit- or intermediate-level training exercise and testing activities, we do not expect these responses of blue whales to reduce the fitness of those whales.

We do not anticipate any mortality of blue whales from acoustic stressors; however up to one death in a given year not to exceed three deaths over the five year period could occur as a result of vessel strike. In the event of a vessel strike to a blue whale resulting in severe injury or mortality, individuals would likely experience significant fitness consequences that may affect feeding and reproduction or would be totally removed from a population. Removal of one or more individuals of a particular species from a population will have different consequenses on the population depending on sex and maturity of the animal.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that training exercises and tesing activities the U.S. Navy plans to conduct in the HSTT Study Area on an annual basis, or cumulatively over the five year period from December 2013 through December 2018, or cumulatively for the reasonably foreseeable future (assuming

there are no significant changes to the status of the species or Environmental Baseline), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual blue whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities the U.S. Navy plans to conduct in the HSTT Study Area would not appreciably reduce the blue whales' likelihood of surviving and recovering in the wild.

7.2 Fin Whale

The estimates of fin whale exposures to training exercises and testing activities that would result in a behavioural response annually are probably an over-estimate of the actual exposures even if it represents the best estimate available. Most fin whales would only be exposed periodically or episodically, if at all, to the activities the U.S. proposes to conduct in the HSTT Study Area. Many training exercises and testing activities will occur without any marine animals being exposed to U.S. Navy vessels, sound fields associated with active sonar pings, or shock waves associated with underwater detonations. Frequencies associated with mid-frequency sonar have generally been considered above the hearing range of fin whales. However, recent observations of blue whale responses to the mid-frequency sonar sounds support the possibility that this ecologically, physiologically, and taxonomically similar species may be capable of detecting and responding to them. Additional data are necessary to determine the impact that mid-frequency sonar may or may not have on fin whales. Considering information presented in this opinion, we consider fin whales to be able to hear and respond to mid frequency sonar as blue whales appear to.

Fin whales in the action area seem likely to respond to the ship traffic associated with each of the activities in ways that approximate their responses to whale watch vessels. Those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver, as well as the activity the whale is involved with at the time. Fin whales seem most likely to try to avoid being exposed to the activities and their avoidance response is likely to increase as an exercise progresses. We do not have the information necessary to determine which of the many sounds associated with an activity is likely to trigger avoidance behavior in fin whales (for example, engine noise, helicopter rotors, ordnance discharges, explosions, or some combination of these) or whether fin whales would avoid being exposed to specific received levels, the entire sound field associated with an exercise, or the general area in which an exercise would occur.

Particular fin whales might not respond to the vessels, while in other circumstances, fin whales are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. Some of these whales

might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, because of the relatively short duration of individual activities, the small number of large exercises, and the short duration of the unit- or intermediate-level training exercises and testing activities, we do not expect these responses of fin whales to reduce the fitness of those whales.

In the event of a vessel strike to a fin whale resulting in severe injury or mortality, individuals would likely experience significant fitness consequences that may affect feeding and reproduction or would be totally removed from a population. Removal of one or more individual fin whales will have different consequenses on the population depending on sex and maturity of the animal.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that training exercises and tesing activities the U.S. Navy plans to conduct in the HSTT Study Area on an annual basis, or cumulatively over the five year period from December 2013 through December 2018, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual fin whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities the U.S. Navy plans to conduct in the HSTT Study Area would not appreciably reduce the fin whales' likelihood of surviving and recovering in the wild.

7.3 Western North Pacific Gray Whale

The estimates of western North Pacific gray whale exposures to training exercises and testing activities in the HSTT Study Area are probably an over-estimate of the actual exposures even if it represents the best estimate available. The few western North Pacific gray whales that may be exposed would only be exposed periodically or episodically, if at all, to the activities the U.S. proposes to conduct in the HSTT Study Area. Many training exercises and testing activities will occur without any marine animals being exposed to U.S. Navy vessels, sound fields associated with active sonar pings, or shock waves associated with underwater detonations. Frequencies associated with mid-frequency sonar have generally been considered above the hearing range of western North Pacific gray whale.

Western North Pacific gray whales in the action area seem likely to respond to the ship traffic associated with each of the activities in ways that approximate their responses to whale watch vessels. Those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver, as well as the activity the whale is involved with at the time. Western North Pacific

gray whales seem most likely to try to avoid being exposed to the activities and their avoidance response is likely to increase as an exercise progresses. We do not have the information necessary to determine which of the many sounds associated with an activity is likely to trigger avoidance behavior in western North Pacific gray whales (for example, engine noise, helicopter rotors, ordnance discharges, explosions, or some combination of these) or whether western North Pacific gray whales would avoid being exposed to specific received levels, the entire sound field associated with an exercise, or the general area in which an exercise would occur.

Particular western North Pacific gray whales might not respond to the vessels, while in other circumstances, western North Pacific gray whales are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. Some of these whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship during that attempt.

Because of the low number of western North Pacific gray whales in the HSTT Study Area, we do not expect any western North Pacific gray whales to be involved in a ship strike event.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that training exercises and testing activities the U.S. Navy plans to conduct in the HSTT Study Area on an annual basis, or cumulatively over the five year period from December 2013 through December 2018, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual Western North Pacific gray whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities the U.S. Navy plans to conduct in the HSTT Study Area would not appreciably reduce the Western North Pacific gray whales' likelihood of surviving and recovering in the wild.

7.4 Humpback Whale

As with the other species, the estimates exposures to training exercises and testing activities that would occur are probably an over-estimate of the actual exposures even if it represents the best estimate available. Most humpback whales would only be exposed periodically or episodically, if at all, to the activities the U.S. proposes to conduct in the HSTT Study Area. Many training exercises or testing activities will occur without any marine animals being exposed to U.S. Navy vessels, sound fields associated with active sonar pings, or shock waves associated with underwater detonations.

We assume that the humpback whales that might be exposed to active sonar between their arrival in waters off Hawaii might be any gender, age, or reproductive condition. However, historic patterns suggest that immature humpback whales and females without calves would arrive in the Maui Basin and Penguin Banks before females with calves, pregnant females, and males; as discussed previously, the pattern off the Island of Hawaii is different (females without calves arrive before immature whales) and may be different in other areas of Hawaii. Because humpback whales do not tend to reside in waters off Hawaii for more than 6 to 8 weeks, we would not expect individual whales to be exposed to major training exercises (for example, Undersea Warfare Exercises) multiple times, although individual whales might be exposed to multiple unit-level or intermediate-level training exercises.

Although studies have demonstrated that humpback whales will exhibit short-term behavioral reactions to boat traffic and playbacks of low frequency industrial noise, the long-term effects of these disturbances on the individuals exposed to them are not known.

The evidence available suggests that humpback whales are likely to detect mid-frequency sonar transmissions. In most circumstances, humpback whales are likely to try to avoid that exposure or are likely to avoid specific areas. Those humpback whales that do not avoid the sound field created by the mid-frequency sonar might experience interruptions in their vocalizations. In either case, humpback whales that avoid these sound fields or stop vocalizing are not likely to experience significant disruptions of their normal behavior patterns because most of the activities the Navy plans to conduct in the Hawaii Range Complex would occur before humpback whales arrive into waters off the Hawaiian Islands. As a result, we do not expect these disruptions to reduce the fitness (reproductive success or longevity) of any individual animal or to result in physiological stress responses that rise to the level of distress.

The increase in the number of humpback whales suggests that the stress regime these whales are exposed to in the HSTT Study Area has not prevented these whales from increasing their numbers in the action area. Humpback whales have been exposed to U.S. Navy training exercises in the HSTT Study Area, including vessel traffic, aircraft traffic, active sonar, and underwater detonations, for more than a generation. Although we do not know if more humpback whales might have used the action area or the reproductive success of humpback whales would be higher absent their exposure to these activities, the rate at which humpback whales occur in the HSTT Study Area suggests that humpback whale numbers have increased substantially in these important calving areas despite exposure to earlier training regimes. Although the U.S. Navy proposes to increase the frequency of some of these activities, we do not believe those increases are likely to affect the rate at which humpback whale counts are increasing.

We do not anticipate any mortality of humpback from acoustic stressors; however up to one death a year not to exceed three deaths over the five year period could occur as a result of vessel strike. In the event of a vessel strike to a humpback whale resulting in severe injury or mortality,

individuals would likely experience significant fitness consequences that may affect feeding and reproduction or would be totally removed from a population. Removal of one or more humpback whales from the population will have different consequenses on the population depending on sex and maturity of the animal.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that training exercises and tesing activities the U.S. Navy plans to conduct in the HSTT Study Area on an annual basis or cumulatively over the five year period from December 2013 through December 2018, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual humpback whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities the U.S. Navy plans to conduct in the HSTT Study Area would not appreciably reduce the humpback whales' likelihood of surviving and recovering in the wild.

7.5 Sei Whale

As with the other whale species, we have probably over-estimated the actual number of sei whales that might be exposed to one or more of the training exercises or testing activities. Most marine mammals would only be exposed periodically or episodically, if at all, to the activities the U.S. proposes to conduct in the HSTT Study Area. Many training exercises and testing activities will occur without any marine animals being exposed to U.S. Navy vessels, sound fields associated with active sonar pings, or shock waves associated with underwater detonations. Nevertheless, sei whales are not likely to respond to mid-frequency active sonar because they are not likely to hear those sonar transmissions.

We have no specific information on the sounds produced by sei whales or their sensitivity to sounds in their environment. Based on their anatomical and physiological similarities to both blue and fin whales, we assume that the hearing thresholds of sei whales will be similar as well and will be centered on low-frequencies in the 10-200 Hz. This information would lead us to conclude that, like blue and fin whales, sei whales exposed to these received levels of active mid-frequency sonar are not likely to respond if they are exposed to mid-frequency sounds.

Sei whales seem likely to respond to the ship traffic associated with each of the activities in ways that approximate their responses to whale watch vessels. Those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver, as well as the activity the whale is involved with at the time. Sei whales seem most likely to try to avoid being exposed to the activities and their avoidance response is likely to increase as an exercise progresses. We do not have the

information necessary to determine which of the many sounds associated with an activity is likely to trigger avoidance behavior in sei whales (for example, engine noise, helicopter rotors, ordnance discharges, explosions, or some combination of these) or whether sei whales would avoid being exposed to specific received levels, the entire sound field associated with an exercise, or the general area in which an exercise would occur.

Particular sei whales' might not respond to the vessels, while in other circumstances, sei whales are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. Some of these whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, because of the relatively short duration of individual activities, the small number of large exercises, and the short duration of the unit- or intermediate-level training exercises and testing activities, we do not expect these responses of sei whales to reduce the fitness of those whales.

One sei whale death in a given year, not to exceed three deaths over the five year period, could occur as a result of vessel strike. In the event of a vessel strike to a sei whale resulting in severe injury or mortality, individuals would likely experience significant fitness consequences that may affect feeding and reproduction or would be totally removed from a population. Removal of one or more individuals of a particular species from a population will have different consequenses on the population depending on sex and maturity of the animal.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that training exercises and tesing activities the U.S. Navy plans to conduct in the HSTT Study Area on an annual basis or cumulatively over the five year period from December 2013 through December 2018, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual sei whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities the U.S. Navy plans to conduct in the HSTT Study Area would not appreciably reduce the sei whales' likelihood of surviving and recovering in the wild.

7.6 Sperm Whale

If exposed to mid-frequency sonar transmissions, sperm whales are likely to hear and respond to those transmissions. 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 also produce loud broad-band clicks from about 0.1 to 20 kHz (Goold and Jones 1995; Weilgart and Whitehead 1993). 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 (Clarke 1979; Cranford 1992; Norris and Harvey 1972). 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 (Goold and Jones 1995; Weilgart and Whitehead 1993). 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 interactions within social groups (Weilgart and Whitehead 1993).

Based on the frequencies of their vocalizations, which overlap the frequency range of mid-frequency active sonar, sonar transmissions might temporarily reduce the active space of sperm whale vocalizations.

There is some evidence of disruptions of clicking and behavior from sonars, pingers (Watkins and Schevill 1975), the Heard Island Feasability Test (Bowles et al. 1994b), and the Acoustic Thermometry of Ocean Climate (Costa et al. 1998b). Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders. They may also stopped vocalizing for brief periods when codas were being produced by other individuals, perhaps because they can hear better when not vocalizing themselves.

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. Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure or to avoid the location of the exposure.

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 1g TNT detonators (Madsen and Mohl 2000). Richardson et al. (Richardson et al. 1995b) citing a personal communication with J. Gordon suggested that sperm whales in the Mediterranean Sea continued calling when exposed to frequent and strong military sonar signals. When Andre et al. (Andre and Jurado 1997b) 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.

Some sperm whales are likely to avoid continued exposure to mid-frequency active sonar, although we assume these whales would respond to both the active sonar, any salient acoustic cues produced by surface vessels involved in an exercise, and their perception of whether ships are approaching them or moving away when they decide whether or not to avoid the active

sonar. Based on the evidence available, sperm whales seem more likely to avoid continued exposure at lower, initial received levels and the avoidance would consist of horizontal movement away from an exercise at slow to moderate swimming speeds. Other sperm whales would engage in evasive travel which would involve faster swimming speeds, deeper dives, and short times at surface. Sperm whales may also exhibit behavioral disturbance or a shift from one behavioral state to another; they are most likely to shift from a resting behavioral state to an active behavioral state.

Sperm whales exposed to pressure waves or sound fields associated with underwater detonations may exihibit behaviors that would be considered behavioral harassment (as that term is defined by the MMPA). A few sperm whales might be exposed to sound fields from underwater detonations at received levels that might temporarily cause noise-induced hearing losses.

These studies suggest that the behavioral responses of sperm whales to anthropogenic sounds are highly variable, but do not appear to result in the death or injury of individual whales or result in reductions in the fitness of individuals involved. Responses of sperm whales to anthropogenic sounds probably depend on the age and sex of animals being exposed, as well as other factors. There is evidence that many individuals respond to certain sound sources, provided the received level is high enough to evoke a response, while other individuals do not.

The sperm whales that might be exposed to the activities the U.S. Navy plans to conduct in the HSTT Study Area annually, or over the five years, particularly active sonar transmissions, ship traffic, and explosions. The evidence available suggests that sperm whales are likely to detect mid-frequency sonar transmissions. In most circumstances, sperm whales are likely to try to avoid that exposure or are likely to avoid areas specific areas. Those sperm whales that do not avoid the sound field created by the mid-frequency sonar might interrupt communications, echolocation, or foraging behavior. In either case, sperm whales that avoid these sound fields, stop communcating, echolocating or foraging might experience significant disruptions of normal behavior patterns that are essential to their individual fitness. Because of the relatively short duration of the acoustic transmissions associated with the major training exercises and other training exercises and testing activities, we do not, however, expect these disruptions to result in the death or injury of any individual animal or to result in physiological stress responses that rise to the level of distress.

Individual sperm whales are likely to respond to the ship traffic in ways that might approximate their responses to whale watch vessels. Those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver. The closer sperm whales are to these maneuvers and the greater the number of times they are exposed, the greater their likelihood of being exposed and responding to that exposure. Particular whales might not respond to the vessels, while in other circumstances, sperm whales are likely to change their vocalizations, surface time, swimming

speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. Some of these whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, because of the relatively short duration of the exercise, we do not expect these responses to continue long-enough to have fitness consequences for individual sperm whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and those of a stress physiology.

We do not anticipate any mortality of sperm whales from acoustic stressors; however up to one sperm whale death in a given year not to exceed three deaths over the five year period could occur as a result of vessel strike. In the event of a vessel strike to a sperm whale resulting in severe injury or mortality, individuals would likely experience significant fitness consequences that may affect feeding and reproduction or would be totally removed from a population. Removal of one or more individuals of a particular species from a population will have different consequenses on the population depending on sex and maturity of the animal.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that training exercises and testing activities the U.S. Navy plans to conduct in the HSTT Study Area annually or cumulatively over the next five years or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline), are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual sperm whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual sperm whales would not be likely to reduce the viability of the populations those individual whales represent by reducing the population dynamics, behavioral ecology, and social dynamics of those populations (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities the U.S. Navy plans to conduct in the HSTT Study Area annually and over the five years would not be expected to appreciably reduce the sperm whales' likelihood of surviving and recovering in the wild.

7.7 Main Hawaiian Islands Insular False Killer Whale

The evidence available suggests that main Hawaiian Islands (MHI) Insular false killer whales are likely to detect mid-frequency sonar transmissions. In most circumstances, MHI insular false killer whales are likely to try to avoid that exposure or are likely to avoid areas where Navy vessels are operating.

Like the other cetacean species, MHI insular false killer whales are also likely to respond to the ship traffic in ways that might approximate their responses to whale watch vessels. Those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver. The closer animals are to these maneuvers and the greater the number of times they are exposed, the greater

their likelihood of being exposed and responding to that exposure. Particular MHI insular false killer whales might not respond to the vessels, while in other circumstances, MHI insular false killer whales are likely to change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. Some of these whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, because of the relatively short duration of the exercise, we do not expect these responses to continue long enough to have fitness consequences for individual MHI insular false killer whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and those of a stress physiology.

We do not expect any MHI insular false killer whales to be involved in a ship strike associated with the Navy's training exercises or testing activities in the HSTT Study Area.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that stressors from training exercises and testing activities the U.S. Navy plans to conduct annually, over the five year period of the MMPA rule and into the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline) in the HSTT Study Area are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual MHI insular false killer whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual MHI insular false killer whales is not likely to reduce the viability of the populations those individual whales represent (that is, we do not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities the U.S. Navy plans to conduct in the HSTT Study Area annually, over the five year period of the MMPA rule and into the reasonably foreseeable future are not expected to appreciably reduce the MHI insular false killer whales' likelihood of surviving and recovering in the wild.

7.8 Hawaiian Monk Seal

As with other marine mammals, Hawaiian monk seals that might be exposed to one or more of the training exercises or testing activities would be exposed periodically or episodically, if at all, to the activities the U.S. proposes to conduct in the HSTT Study Area. Many training or testing exercises will occur without any marine animals being exposed to U.S. Navy vessels, sound fields associated with active sonar pings, air-to-ground bombing exercises on Kaula or shock waves associated with underwater detonations. The estimates of the number of Hawaiian monk seals that would result in a behavioral reaction annually are probably over-estimates of the actual exposures even if it represents the best estimate available.

The information available does not allow us to assess the probable responses of Hawaiian monk seals after they are exposed to mid-frequency active sonar transmissions. In the past, we have

assumed the Hawaiian monk seals do not seem likely to respond to those transmissions because the sonar that would be used during the anti-submarine warfare exercises transmits at frequencies above the hearing thresholds for Hawaiian monk seals.

At a minimum, we would assume that a Hawaiian monk seal that experienced a loss in hearing sensitivity would be aware of the impairment and would experience a stress response as a result. We assume that, like the whales discussed previously, monk seals are likely to try to avoid being exposed to vessel traffic, active sonar, and sound-producing activities such as gunnery exercises or sinking exercises. We do not have the information necessary to determine which of the many sounds associated with an activity is likely to trigger avoidance behavior in Hawaiian monk seals (for example, engine noise, helicopter rotors, ordnance discharges, explosions, or some combination of these), but these animals are likely to avoid the general area in which an exercise would occur by remaining close to a shoreline or on a beach. This avoidance will not prevent monk seals from being exposed to active sonar or explosions, but it would prevent monk seals from being exposed at received levels that would injure a monk seal, cause them physiological distress, or alter their reproductive success.

Hawaiian monk seals have been exposed to Navy training exercises and testing activities in the HSTT Study Area, specifically in the Hawaii Range Complex, including vessel traffic, aircraft traffic, active sonar, air-to-ground bombing exercises at Kaula and underwater detonations, for more than a generation. Although we do not know if more monk seals might have used the action area or the reproductive success of monk seals in the Hawaii Range Complex would be higher absent their exposure to these activities, the rate at which Hawaiian monk seals occur in the main Hawaiian Islands suggests that monk seals numbers in the action area continue to increases despite exposure to earlier training exercises and testing activities. Although the Navy proposes to increase the frequency of some of these activities, we do not believe those increases are likely to affect the rate at which monk seal counts in the main Hawaiian Islands are increasing.

We do not expect any Hawaiian monk seals to be involved in a ship strike associated with the Navy's training exercises or testing activities in the HSTT Study Area.

Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that training exercises and testing activities the Navy plans to conduct in the Hawaii Range Complex annually, over the next five years, and into the reasonably foreseeable future are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual Hawaiian monk seals in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual monk seals would not be likely to reduce the viability of those populations of Hawaiian monk seals 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, we conclude that the activities the Navy plans to conduct in the HSTT Study Area annually, over

the five years of the MMPA rule or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline) would not be expected to appreciably reduce the Hawaiian monk seals' likelihood of surviving and recovering in the wild.

7.9 Guadalupe Fur Seal

The training exercises and testing activities the Navy plans to conduct in the HSTT Study Area, specifically the Southern California Range Complex, on an annual basis from December 2013 through December 2018 are likely to cause some individual Guadalupe fur seals to experience changes in their behavioral states. 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.

Guadalupe fur seals have been exposed to Navy training exercises 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 Navy activities, this rate suggests that the number of Guadalupe fur seals would continue to increases despite being exposed to stressors associated with these training exercises and testing 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.

We do not expect any Guadalupe fur seals to be involved in a ship strike associated with the Navy's training exercises or testing activities in the HSTT Study Area.

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. As a result, the activities the Navy plans to conduct annually in the HSTT Study Area, or over the period of the MMPA rule from December 2013 through December 2018, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline) are not likely to appreciably reduce the Guadalupe fur seals' likelihood of surviving and recovering in the wild.

7.10 Sea Turtles

Most of the sonars that would be used during the proposed exercises transmit at frequencies above hearing thresholds for green, hawksbill, olive ridley, leatherback, and loggerhead sea turtles. Turtles that are exposed to those transmissions are not likely to respond to the exposures. As a result, mid-frequency active sonar associated with the proposed exercises is not likely to adversely affect sea turtles. Other stimuli including collision with vessels and projectiles and exposure to underwater detonations are also unlikely due to low densities of sea turtles at sea in the Action Area and the Navy mitigation measures including buffer zones. Therefore, these species are not likely to experience reductions in the fitness of the individual animals that are likely to be exposed to those activities.

Sea turtles have a small probability of being exposed to low frequency sonar transmissions. Sea turtles are able to detect low-frequency sounds and will be able to detect low frequency transmissions. Information on their behavioral response to these decibel levels is limited. However, green sea turtles were observed to avoid passing through a sound barrier created by an array of air guns with a broadband spectrum of 20 to 1,000 Hz; received levels were 141 to 150 dB (O'Hara and Wilcox 1990). The probability that a sea turtle would be within an ensonified area that would elicit a similar or other behavioral response is low because most of the turtles make shallow dives of about 300 m (984 ft; dive observed for the olive ridley sea turtle). As for the leatherback sea turtles, which can dive to depths of 1,000 m (3,280 ft), the opportunity for a behavioral response is also considered to be low because 95 percent of their dives are less than 200 m (656 ft) deep, which would minimize their exposure to the sonar 180-dB sound field. Based on the hearing data, it is possible that if a sea turtle happened to be in proximity of a low frequency sonar operations area, it will hear the transmissions. Given that the majority of sea turtles encountered would probably be transiting in the open ocean from one site to another, the possibility of significant displacement would be unlikely. Based on these parameters, we would not expect received levels of low frequency sonar transmissions to reduce the reproduction, numbers, or distribution of sea turtles; as a result, these transmissions would not be expected to appreciably reduce these turtles likelihood of surviving and recovering in the wild.

We are not able to estimate the likelihood of individual sea turtles to be involved in a ship strike associated with the Navy's training exercises or testing activities in the HSTT Study Area. If a sea turtle is struck by a Navy vessel, it may sustain an injury or be killed.

We conclude that training exercises and testing activities the Navy plans to conduct in the HSTT Study Area annually, or over the next five years of the MMPA rule (December 2013 through December 2018), or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the status of the species or Environmental Baseline) are not likely to interact with a 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, hawksbill, leatherback, loggerhead, or olive ridley turtles surviving and recovering in the wild by reducing their reproduction, numbers, or distribution reducing their reproduction, numbers, or distribution.

8 CONCLUSION

During the consultation, we reviewed the current status of endangered blue, fin, western north Pacific gray, humpback, sei, sperm, and main Hawaiian Island insular false killer whales, endangered Hawaiian monk seals, threatened Gualalupe fur seals, endangered green, hawksbill, loggerhead, olive ridley, and leatherback turtles, endangered southern California steelhead trout, black abalone, and white abalone. We also reviewed the current status of multiple coral species that are proposed for listing under the ESA.

Our consultation evaluated the effects on the ESA-listed species listed above in the context of the current environmental baseline and cumulative effects of U.S. Navy proposed military readiness activities (training exercises and testing activities) in the Hawaii-Southern California Training and Testing Study Area from December 2013 through December 2018, the National Marine Fisheries Service's Permit and Conservation Division's promulgation of the proposed rule under the Marine Mammal Protection Act (MMPA) on the taking of marine mammals incidental to the Navy's proposed military readiness activities, and the subsequent issuance of two letters of authorization pursuant to the MMPA rule.

It is NMFS' opinion that the U.S. Navy's military readiness activities in the Hawaii-Southern California Training and Testing Study Area, the Permits Division's promulgation of the MMPA rule and subsequent issuance of LOAs pursuant to that rule, are likely to adversely affect, but are not likely to jeopardize the continued existence of; endangered blue, fin, western North Pacific gray, humpback, sei, sperm, or main Hawaiian Island insular false killer whales, Hawaiian monk seals, threatened Guadalupe fur seals, endangered green, hawksbill, loggerhead, olive ridley, and leatherback turtles.

We find that these same proposed actions are not likely adversely affect endangered Southern California steelhead trout, endangered black abalone, or endangered white abalone. We find that the proposed actions are not likely to jeopardize the continued existence of any of the species of coral proposed for listing under the ESA.

After reviewing the current status of *Acropora paniculata, Alveopora verrilliana, Pocillopora elegans* - Indo Pacific, *Euphyllia paraancora, Montipora dilatata, Montipora flabellata, Montipora turgescens,* and *Montipora patula* (*verrilli*), the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is NMFS's conference opinion that the military readiness activities, promulgation of the MMPA rule and subsequent issuance of two LOAs pursuant to that rule, as proposed, are not likely to jeopardize the continued existence of the proposed coral species. Critical habitat for the coral species has not been proposed at this time.

We also find that the proposed actions are not likely to result in the destruction or adverse modification of critical habitat that has been designated for endangered or threatened species in the HSTT Study Area.

We believe these conclusions are valid for the five-year period of the MMPA rule and into the reasonably forseable future beyond the five-year period, assuming that the type, amount and extent of training exercises and testing activities do not exceed levels assessed in this biological and conference opinion and the status of the species affected by these actions does not change substantially from what was assessed in this opinion.

This opinion also concludes that the NMFS' issuance of the rule and two letters of authorization (LOAs) pursuant to the proposed MMPA rule as assessed in this opinion for respective training and testing activities to take marine mammals for a period beginning in December 2013 and ending in December 2018, incidental to the U.S. Navy's testing and training exercises are likely to adversely affect but are not likely to jeopardize the continued existence of these threatened and endangered species under NMFS' jurisdiction and are not likely to result in the destruction or adverse modification of critical habitat that has been designated for endangered or threatened species in the HSTT Study Area.

This concludes the conference for the proposed listing of Pacific coral species; *Acropora paniculata, Alveopora verrilliana, Pocillopora elegans* - Indo Pacific, *Euphyllia paraancora, Montipora dilatata, Montipora flabellata, Montipora turgescens,* and *Montipora patula* (*verrilli*). The U.S. Navy and NMFS Permits Division may ask NMFS to confirm the conference opinion as a biological opinion issued through formal consultation if any of the coral species is listed or critical habitat is designated. The request must be in writing. If we review the proposed action and find that there have been no significant changes in the action as planned or in the information used during the conference, we will confirm the conference opinion as the biological opinion on the project and no further section 7 consultation will be necessary.

9 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit 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 Marine Mammal Protection Act, there is a definition of what is referred to as Level B harassment: "any act of pursuit, torment, or annoyance which . . . 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 but which does not have the potential to injure a marine mammal or marine mammal stock in the wild" 16 U.S.C. §1362(18)(A)(ii). For this consultation, we interpret "harassment" using the MMPA training exercises and testing definition of harassment to marine mammals. For other species, specifically sea turtles, we apply "harass" to mean an intentional or negligent action that has the potential to injure an animal or disrupt its normal behavior to a point where such behaviors are abandoned or significantly altered. Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

9.1 Amount or Extent of Take Anticipated

The section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 CFR § 402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by proposed actions while the extent of take or "the extent of land or marine area that may be affected by an action" may be used if we cannot assign numerical limits for animals that would be incidentally taken during the course of an action (51 FR 19953). The amount of take resulting from the Navy's activities was estimated based on the best information available.

We do not expect take of southern California steelhead trout, black abalone, white abalone, or of any coral species proposed for listing from any training exercises or testing activities.

Here we summarize the anticipated take from annual and non-annual training exercises by species as proposed by the Navy in the HSTT Study Area, the interrelated and interdependent actions of issuance of a five-year regulation, and LOAs by NMFS' Permits Division to authorize take of marine mammals pursuant to the MMPA regulations. Below we provide numeric

estimates for each species for which we could develop such estimates. These estimates involve many assumptions and a level of uncertainty remains.

Section 7(b)(4)(C) of the ESA provides that if an endangered or threatened marine mammal is involved, the taking must first be authorized by section 101(a)(5) of the MMPA. Accordingly, the terms of this incidental take statement and the exemption from section 9 of the ESA become effective only upon the issuance of MMPA authorization to take the marine mammals identified here. Absent such authorization, this statement is inoperative for marine mammals. The amount or extent of incidental take for marine mammals will be exempted upon issuance of the LOAs.

The anticipated take incidental to annual and non-annual training exercises in a given year where all possible activities are carried out in that year is provided below. For marine mammals, we provide the annual take and take from non-annual training (not occurring every year) and a total for the five-year period in Table 55. As such, take from non-annual activities would be less than the sum of the total of each year given a scenario where all annual and all non-annual activities take place in that year. Where the five-year total would be the same as the totalling of the annual take, the amount of take is provided per year.

The estimation of take below is directly linked to the levels of training exercises described in the description of the action and in our risk analysis. Therefore, these training levels (location, frequency, duration, timing, etc.) also serve as an indicator of take. For example, if hours of specific activities or categories of activities assessed are exceeded, the quantitative or qualitative take estimates may also be exceeded.

The anticipated take incidental to annual and non-annual training exercises of sea turtles in a given year where all possible activities are carried out in that year is provided in Table 56. As such, take from non-annual activities would be less than the sum of the total of each year given a scenario where all annual and all non-annual activities take place in that year. Behavioral responses of sea turtles to impulsive and non-impulsive sound stressors are not well studied and cannot be quantified in this opinion. The take estimates for sea turtles includes only modeled TTS and other effects from exposure to acoustic sources but does not exclude associated behavioral responses that could occur. Take from behavioral disturbance will be exceeded if activity levels as proposed are exceeded.

Table 55. Take of ESA-listed marine mammals incidental to annual and non-annual training exercises, issuance of the Marine Mammal Protection Act Regulation, and issuance of the Letter of Authorization pursuant to those MMPA regulations.

ESA-Listed Species	Annual and Non-Annual Training Exercises				
	Acoustic Stressors				Vessel Strike
	Harass (Behavioral & Temporary Threshold Shift)	Harm (Permanent Threshold Shift)	Harm (GI Tract, Slight Lung Injury, Other)	Mortality	Injury or Mortality
Blue Whale	Up to 4,325 per year; Not to exceed 21,559 total in 5 years	0	0	0	1 of any whale species per year; not to exceed 3 of any combination of species in 5 years
Fin Whale	Up to 1,719 per year; Not to exceed 8,531 total in 5 years	0	0	0	
Humpback Whale	Up to 9,273 per year; Not to exceed 46,365 total in 5 years	0	0	0	
Sei Whale	Up to 630 per year; Not to exceed 2,996 total in 5 years	0	0	0	
Western North Pacific Gray Whale	Up to 10 per year; Not to exceed 50 total in 5 years	0	0	0	0
Main Hawaiian Island Insular False Killer Whale	Up to 49 per year; Not to exceed 220 total in 5 years	0	0	0	0
Sperm Whale	Up to 3,332 per year; Not to exceed 15,920 total in 5 years	0	0	0	0
Hawaiian Monk Seal	Up to 1,292 per year; Not to exceed 6,334 total in 5 years	0	0	0	0
Guadalupe Fur Seal	Up to 2,603 per year; Not to exceed 13,015 total in 5 years	0	0	0	0

NOTE: Non-annual events, those events that may only take place a few times over the five-year period and do not reoccur every year; take from non-annual activities is included with annual take to represent a maximium take in any given year.

Table 56. Annual take of ESA-listed sea turtles incidental to annual and non-annual training exercises, issuance of the Marine Mammal Protection Act Regulation, and issuance of the Letter of Authorization pursuant to those MMPA regulations.

ESA-Listed Species	Annual and Non-Annual Training Exercises			
	Acoustic Stressors			
	Harass (Temporary Threshold Shift)	Harm (Permanent Threshold Shift)	Harm (GI Tract, Slight Lung Injury, Other)	Mortality
Green Turtle [1]	0	0	0	0
Pacific Sea Turtle [2]	594	21	13	4

[1] Green turtle take in the Southern California Range as of the HSTT Study Area

[2] The Pacific sea turtle category including green, hawksbill, loggerhead, olive ridley, and leatherback turtles in the Hawaii Range Complex and Transit Cooridor areas of the HSTT Study Area

NOTE: Non-annual events, those events that may only take place a few times over the five-year period and do not reoccur every year; take from non-annual activities is included with annual take to represent a maximium take in any given year.

The anticipated take incidental to annual testing activities and for the five-year period is provided in Table 57 and Table 58. The estimation of take below is directly linked to the levels of testing activities described in the description of the action and in our risk analysis. Therefore, these testing levels (location, frequency, duration, timing, etc.) also serve as an indicator of take. For example, if hours of a specific activities or categories of testing activities assessed are exceeded, the quantitative or qualitative take estimates may also be exceeded.

Table 57. Take Authorized Incidental to Annual Testing Activities, Issuance of the Marine Mammal Protection Act Regulation, and Issuance of the Letter of Authorization pursuant to those MMPA regulations.

ESA-Listed Species	Annual Testing Activities				
	Acoustic Stressors				Vessel Strike
	Harass (Behavioral & Temporary Threshold Shift)	Harm (Permanent Threshold Shift)	Harm (GI Tract, Slight Lung Injury, Other)	Mortality	Injury or Mortality
Blue Whale	Up to 428 per year; Not to exceed 2,140 total in 5 years	0	0	0	2 of any whale species per year; not to exceed 4 of any combination of species in 5 years
Fin Whale	Up to 225 per year; Not to exceed 1,125 total in 5 years	0	0	0	
Humpback Whale	Up to 927 per year; Not to exceed 4,635 total in 5 years	0	0	0	
Sei Whale	Up to 51 per year; Not to exceed 255 total in 5 years	0	0	0	
Western North Pacific Gray Whale	Up to 2 per year; Not to exceed 10 total in 5 years	0	0	0	0
Main Hawaiian Island Insular	Up to 4 per year; Not to exceed 20 total in 5 years	0	0	0	0
Sperm Whale	Up to 263 per year; Not to exceed 1,315 total in 5 years	0	0	0	0
Hawaiian Monk Seal	Up to 358 per year; Not to exceed 1,790 total in 5 years	0	0	0	0
Guadalupe Fur Seal	Up to 269 per year; Not to exceed 1,345 total in 5 years	0	0	0	0

NOTE: Non-annual events, those events that may only take place a few times over the five-year period and do not reoccur every year; take from non-annual activities is included with annual take to represent a maximium take in any given year.

Behavioral responses of sea turtles and fish to impulsive and non-impulsive sound stressors are not well studied and cannot be quantified in this opinion. This number for turtles includes only modeled TTS and other effects from exposure to acoustic sources but does not exclude associated behavioral responses that could occur. Take from behavioral disturbance will be exceeded if activity levels as proposed are exceeded.

Table 58. Annual take of ESA-listed sea turtles authorized incidental to annual testing activities, issuance of the Marine Mammal Protection Act Regulation, and issuance of the Letter of Authorization pursuant to those MMPA regulations.

ESA-Listed Species	Annual Testing Activities			
	Acoustic Stressors			
	Harass (Temporary Threshold Shift)	Harm (Permanent Threshold Shift)	Harm (GI Tract, Slight Lung Injury, Other)	Mortality
Green Turtle[1]	616	97	0	0
Pacific Sea Turtle [2]	401	5	0	0

[1] Green turtle take in the Southern California Range Complex areas of the HSTT Study Area
[2] The Pacific sea turtle category including green, hawksbill, loggerhead, olive ridley, and leatherback turtles in the Hawaii Range Complex and Transit Corridor areas of the HSTT Study Area
NOTE: Non-annual events, those events that may only take place a few times over the five-year period and do not reoccur every year; take from non-annual activities is included with annual take to represent a maximium take in any given year.

9.2 Effects of the Take

In the accompanying biological opinion, we determined that the number of individuals that might be exposed to stressors created by training exercises and testing activities the U.S. Navy plans to conduct in the Hawaii-Southern California Training and Testing Study Area 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 ESA is not likely to jeopardize the continued existence of blue, fin, western north Pacific gray, humpback, sei, or sperm whales, main Hawaiian Island Insular false killer whales, Hawaiian monk seals, Guadalupe fur seals, or green, hawksbill, loggerhead, olive ridley and leatherback turtles.

The instances of harassment of marine mammals identified in Table 55 and Table 57 and for sea turtles in Table 56 and Table 58 would generally represent changes from resting, milling, or other behavioral states that require lower energy expenditures to traveling, avoidance, or other 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 training exercises and testing activities because we assume animals would respond to a suite of environmental cues that include sound fields produced by active sonar, sounds produced by explosives, sounds produced by the engines of surface vessels, sounds produced by displacement hulls, and other sounds associated with training exercises and testing activities. That is, we assume endangered marine mammals will perceive and respond to all of the environmental cues associated with training and testing 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, fin, sei and Hawaiian Islands Insular false killer 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 55 and Table 57 reflect that expectation. However, we assume that humpback and sperm whales would change their behavior in response to the sound field produced by active sonar and cues from the vessels involved in training exercises and testing activities.

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.

We expect that any instances in which a whale is struck by a Navy vessel would result in serious injury or death of that individual. Dead animals are no longer capable of contributing to the survival and recovery of the population or the species. The death of a female of any of the large whale species would result in a reduced reproductive capacity of the population or species.

Harm of sea turtles would be in the form of permanent threashold shift or slight lung injury. Sea turtles that experience a permanent loss of hearing would not be expected to have a reduction in survival or reproductive potential. However, sea turtles that experience even a slight lung injury may not recover from such injury and would be expected to die as a result of that injury. In addition to the mortality from slight lung injury, four sea turtles would be killed each year as a result of underwater explosions.

While the loss of any turtle from injury or direct mortality from underwater explosions or vessel strike, has likely adversely affected the ability of the sea turtle populations considered in this opinion to maintain or increase their numbers by limiting the number of individuals in these populations, the loss of reproductive adults results in reductions in future reproductive output.

Species with delayed maturity such as sea turtles are demographically vulnerable to increases in mortality, particularly of juveniles and subadults, those stages with higher reproductive value. The potential for a hatchling to develop into a juvenile, and finally into a sexually mature adult sea turtle varies among species, populations, and the degree of threats faced during each life stage. Each juvenile that does not survive to reproduce will be unable to contribute to the maintenance or improvement of the species' status. Reproducing females that are prematurely killed due the threats mentioned in the above sections, while possibly having contributed something before being removed from the population, will not be allowed to realize their reproductive potential. Similarly, reproductive males prematurely removed from the population will be unable to make their reproductive contribution to the species' population. Additionally, our estimate of future take is based on our belief that the same level of take occurred in the past. We believe that this level of take will not result in an appreciable reduction in the likelihood of recovery of any of the Pacific sea turtle species in the wild.

9.3 Reasonable and Prudent Measures

The measures described below are non-discretionary, must be undertaken by NMFS Permits and Conservation Division and the U.S. Navy so they become binding conditions of any permit or Letter of Authorization issued to the U.S. Navy, in order for the exemption in section 7(o)(2) to apply. The NMFS Permits and Conservation Division and the U.S. Navy have a continuing duty to regulate the activity covered by this Incidental Take Statement. If NMFS Permits and Conservation 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. In order to monitor the impact of incidental take, NMFS Permits and Conservation Division and the U.S. Navy must report the progress of the action and its impact on the species to NMFS ESA Interagency Cooperation division as specified in the incidental take statement (50 CFR §402.14(i)(3)). NMFS believes the following reasonable and prudent measure is necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

1. The U.S. Navy and NMFS Permits Division shall submit reports that identify the general location, timing, number of sonar hours and other aspects of the training exercises and testing activities they conduct in the Hawaii and Southern California study area over the five year period of the MMPA regulations and letters of authorization to help assess the actual amount or extent of take incidental to training and testing activities.

9.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, as amended, NMFS' Permits and Conservation Division and the U.S. Navy must comply with the following terms and conditions, which implement the reasonable and prudent measure described above and outline the reporting

requirements required by the section 7 regulations (50 CFR 402.14(i)). The terms and conditions described below are non-discretionary, and NMFS Permits and Conservation Division and the U.S. Navy or any applicant must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). NMFS Permits and Conservation Division and the U.S. Navy or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the following terms and conditions are not complied with, the protective coverage of section 7(o)(2) will likely lapse.

1. The U.S. Navy shall implement all mitigation and monitoring measures as proposed in their proposed action described in the final EIS/OEIS and consultation initiation package and as described in Section 2.3.1of this biological opinion.
2. NMFS' Permits Division shall ensure that all mitigation and monitoring measures as proposed in the final rule in Section 2.3 of this biological opinion are implemented by the U.S. Navy through the issuance of a final rule and subsequent letters of authorization pursuant to the Marine Mammal Protection Act.
3. The U.S. Navy and NMFS' Permits Division shall compile and summarize annual monitoring and exercise reports and describe interactions with ESA-listed species and designated critical habitat.

10 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

1. Collect sighting and stranding data for ESA-listed marine mammals and sea turtles in the HSTT Study Area.
2. As practicable, develop procedures to aid any individuals of an ESA-listed species that has been impacted by U.S. Navy training exercises and testing activities that is in a condition where assistance would increase likelihood of survival.
3. Continue to model impacts to ESA-listed species using NAEMO and other relevant models; validate assumptions used in risk analyses; and seek new information and higher quality data for use in such efforts.
4. Continue technical assistance/adaptive management efforts with NMFS to help inform future consultations on U.S. Navy military readiness activities in the HSTT Study Area.
5. The U.S. Navy should continue to work with NMFS Endangered Species Interagency Cooperation Division and other relevant stakeholders (the Marine Mammal Commission, International Whaling Commission, and the marine mammal research community) to develop methods 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, behavioural, and social ecology of these species.

In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

11 REINITIATION NOTICE

This concludes formal consultation on the U.S. Navy's proposal to undertake military training and testing activities in the Hawaii-Southern California Training and Testing Study Area from December 2013 through December 2018 and NMFS Permits and Conservation Division's proposal to issue regulations pursuant to the Marine Mammal Protection Act that would allow for the issuance of one or more letters of authorization that would authorize the "take" of marine mammals in association with those activities, and NMFS Permits and Conservation Division proposal to issue two letters of authorization to the U.S. Navy pursuant to the MMPA regulations. 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.

12 DATA QUALITY ACT

Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (Public Law 106-554, AKA the Data Quality Act or Information Quality Act) directed the Office of Management and Budget (OMB) to issue government-wide guidelines that "provide policy and procedural guidance to Federal agencies for ensuring and maximizing the quality, objectivity, utility, and integrity of information (including statistical information) disseminated by Federal agencies." OMB complied by issuing guidelines which direct each Federal agency to 1) issue its own guidelines; 2) establish administrative mechanisms allowing affected persons to seek and obtain correction of information that does not comply with the OMB 515 Guidelines or the agency guidelines; and 3) report periodically to OMB on the number and nature of complaints received by the agency and how the complaints were handled. The OMB Guidelines can be found at:

http://www.whitehouse.gov/omb/fedreg/reproducible2.pdf

The Department of Commerce Guidelines can be found at:
http://ocio.os.doc.gov/ITPolicyandPrograms/Information_Quality/index.htm

The NOAA Section 515 Information Quality Guidelines, created with input and reviews from each of the components of NOAA Fisheries, went into effect on October 1, 2002. The NOAA Information Quality Guidelines are posted on the NOAA Office of the Chief Information Officer Webpage. http://www.cio.noaa.gov/Policy_Programs/info_quality.html

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