National Marine Fisheries Service
Endangered Species Act Section 7(a)(2) Biological Opinion

Agencies: United States Navy, Pacific Fleet

National Marine Fisheries Service Office of Protected Resources – Permits and Conservation Division

Activities Considered: (1) The U. S. Navy's proposed training activities on the Gulf of Alaska Temporary Maritime Training Area from May 2013 to May 2016

(2) Issuance of a Letter of Authorization for the U.S. Navy to "take" marine mammals incidental to training on the Gulf of Alaska Temporary Maritime Training Area from May 2013 to May 2016

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

Approved by: ______________________ Date: MAY 14 2013

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This biological opinion was prepared by NOAA's National Marine Fisheries Service (NMFS) Endangered Species Act Interagency Cooperation Division in accordance with section 7(b) of the Endangered Species Act (ESA; 16 U.S.C. 1531 et seq.) and implementing regulations at 50 CFR §402. It is in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Data Quality Act) (44 U.S.C. 3504 (d)(1) and 3516), and underwent pre-dissemination review. This document represents NMFS final biological opinion on the effects of these proposals by the Navy and the NMFS Permits Division on endangered and threatened species and critical habitat that has been designated for those species.

Section 7(a)(2) of the ESA requires that each Federal agency shall ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a Federal agency "may affect" a listed species or critical habitat that has been designated for such species, that agency is required to consult with either NMFS or the U.S. Fish and Wildlife Service, depending upon the listed resources that may be affected. Federal agencies are exempt from this general requirement if they have concluded that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS or the U.S. Fish and Wildlife Service concurs with that conclusion (50 CRF 402.14(b)).

For the actions described in this document, the action agencies are the United States Navy (U. S. Navy), which proposes to (1) conduct training on the Gulf of Alaska Temporary Maritime Activities Area (TMAA) and (2) NMFS Office of Protected Resources – Permits and Conservation Division (Permits Division), which proposes to issue a Letter of Authorization that would allow the Navy to "take" marine mammals incidental to those military readiness activities under the Marine Mammal Protection Act (MMPA).

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1 INTRODUCTION

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1539(a)(2)) requires each Federal agency to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a Federal agency's action "may affect" a protected species, that agency is required to consult formally with the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR §402.14(a)). Federal agencies are exempt from this general requirement if they have concluded that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS or the U.S. Fish and Wildlife Service concurs with that conclusion (50 CFR §402.14(b)).

For the actions described in this document, the action agencies are the United States Navy (Navy), which proposes to (1) conduct training on the Gulf of Alaska Temporary Maritime Activities Area (TMAA) and (2) NMFS Office of Protected Resources – Permits and Conservation Division (Permits Division), which proposes to issue a Letter of Authorization (LOA) that would allow the Navy to "take" marine mammals incidental to those military readiness activities under the Marine Mammal Protection Act (MMPA) regulations at 50 CFR § 218 subpart N. This document represents NMFS final biological opinion (opinion) on the effects of these proposals by the Navy and the NMFS Permits Division on endangered and threatened species and critical habitat that has been designated for those species.

The opinion and incidental take statement (ITS) portions of this consultation were prepared by NMFS ESA IC 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.

1.1 Background

This consultation is based on information provided in the Navy's request for reinitation of consultation under the ESA For U.S. Navy training activities in the Gulf of Alaska TMAA (Navy 2012a), *Preliminary Final Environmental Impact Statement/Overseas Environmental Impact Statement* (EIS/OEIS) (Navy 2011) prepared pursuant to the National Environmental Policy Act (NEPA), the Navy's *Biological Evaluation for the Gulf of Alaska Temporary Maritime Activities Area* (Navy 2010c) prepared pursuant to the ESA, the Navy's application for an MMPA permit, NMFS Permits Division draft LOA pursuant to the MMPA regulations, the programmatic ESA consultation on the issuance of MMPA regulations (50 CFR § 218 subpart N) and the Navy's military readiness activities in the Gulf of Alaska proposed for April 2011 through April 2016 (NMFS 2011b), and published and unpublished scientific information on the biology and ecology of threatened and endangered marine mammals that occur within the Gulf of Alaska TMAA.

1.2 Consultation History

In March 2009, the Navy submitted an application for a letter of authorization to “take” marine mammals pursuant to the MMPA incidental to military readiness activities on the Gulf of Alaska TMAA to NMFS’ Permits Division (Navy 2009). That original request was intended to address readiness activities the Navy planned to conduct in the Gulf of Alaska TMAA from April 2011 through April 2016. In November 2009, the Navy submitted a revised application in response to questions posed by NMFS Permits Division.

On 11 December 2009, the Navy published its Draft EIS/OEIS for the Gulf of Alaska TMAA (Navy 2010a).

On 4 March 2010, the Navy submitted a Biological Evaluation on the potential impacts to ESA listed species from their proposed activities in the Gulf of Alaska TMAA (Navy 2010c).

On 20 October 2010, NMFS’ Permits Division published proposed regulations to govern the unintentional taking of marine mammals incidental to activities conducted in the Gulf of Alaska TMAA for the period of April 2011 through April 2016 (75 FR 64508).

On 6 April 2011, NMFS ESA IC Division issued a programmatic biological opinion on the suite of activities that would be authorized by the regulations the Permits Division proposed to issue pursuant to the MMPA as well as the Navy’s military readiness activities that would occur in the Gulf of Alaska TMAA (NMFS 2011b).

On 9 March 2011, NMFS Permits Division submitted a request for ESA consultation on their proposed issuance of a LOA that would allow the Navy to take marine mammals pursuant to the pending MMPA regulations. The proposed LOA would be effective for two years, May 2011 through May 2013.

On 4 May 2011, NMFS published the final regulations for the taking of marine mammals within the Gulf of Alaska TMAA pursuant to the MMPA (76 FR 25480).

On 17 May 2011, NMFS ESA Interagency Cooperation Division issued a biological opinion on the Navy’s proposed training activities that would occur from May 2011 through May 2013 and NMFS Permits Division’s issuance of an LOA that would allow the Navy “take” of marine mammals associated with those training activities.

On 28 November 2012, NMFS ESA Interagency Cooperation Division received a request from the Navy for formal ESA section 7 consultation for training activities on the Gulf of Alaska TMAA that are proposed to occur from May 2013 through May 2016.

On 28 March 2013, NMFS ESA Interagency Cooperation Division received a request from NMFS Permits Division for formal ESA section 7 consultation on the proposed issuance of a LOA to the Navy for training activities on the Gulf of Alaska TMAA that are proposed to occur from May 2013 through May 2016.

2 DESCRIPTION OF THE PROPOSED ACTION

The Navy has been conducting training activities in the ocean essentially since its inception in 1775. Training activities specific to the Gulf of Alaska TMAA have been occurring roughly annually since about 1973. The proposed training activities are described below (Section 2.1).

The second proposed action is NMFS' Permits Division action to issue an LOA pursuant to the MMPA regulations (Section 2.2).

The Navy (Section 2.3) and NMFS' Permits Division (Section 2.4) provided proposed mitigation measures to minimize take of marine mammals and ESA-listed species.

The Navy describes the proposed action as designed to meet Navy and the U.S. Department of Defense current and near-term operational training requirements (Navy 2010c). Under the Proposed Action, the Navy would continue the number of training activities at the level currently conducted including:

- The length of the training exercises would be 21 days (in the summer, April to October time frame);
- Conduct anti-submarine warfare (ASW) activities and use active sonar for ASW activities;
- Conduct training associated with the introduction of new weapon systems, vessels, and aircraft into the Fleet that may not been used in past activities; and
- Accommodate training enhancement instrumentation, to include the use of a portable undersea tracking range (PUTR).

Table 1. Activities the Navy proposes to conduct in the Gulf of Alaska Temporary Maritime Activities Area each year (adapted from Table 2-5 in (Navy 2012a)).

Range Operation	**Platform(s)**	**System or Ordnance**	**Proposed Action**	**Location**
Anti-Air Warfare (AAW) Training				
Aircraft Combat Maneuvers	EA-6B, EA-18G, FA-18, F-16, F-15, F-22	None	600 sorties[1]	TMAA, Air Force SUA
Air Defense Exercise	FA-18, F-16, F-15, F-22, EA-6B, EA-18G, P-3C, P-8 MMA, CVN, CG, DDG, FFG	None	8 events	TMAA
Surface-to-Air (S-A) Missile Exercise	CVN, CG, DDG, FFG	Sea Sparrow Missile, Standard Missile 1, or RAM Target: BQM-74E	6 events	TMAA
S-A Gunnery Exercise	CG, DDG, FFG, AOE	5”/54 BLP, 20mm CIWS, 7.62mm Target: Towed TDU-34	6 events	TMAA
Air-to-Air (A-A)Missile Exercise	FA-18, F-16, F-15, F-22 E-2C, EA-6B, EA-18G	AIM-7, AIM-9, AIM-120 AMRAAM Targets: TALD or LUU-2B/B	6 events	TMAA, Air Force SUA
Anti-Surface Warfare (ASUW) Training				
Visit Board Search and Seizure	MH-60S, RHIB, NSW Personnel	None	24 events	TMAA
Air-to-Surface (A-S) Missile Exercise	MH-60R/S, FA-18, F-16, F-15, F-22, EA-6B, EA-18G	CATM-114 Hellfire, CATM-84 (SLAM-ER), an CATM-84 Harpoon, or an CATM-65 Maverick (all captive carry/not released)	4 events	TMAA
A-S Bombing Exercise	FA-18, F-16, F-15, F-22	MK-82 (live),MK-83 (live), MK-84 (live) BDU-45 (inert), MK-58 marine marker	36 events	TMAA
A-S Gunnery Exercise	MH-60R/S	GAU-16 (0.50-cal) or M-60 (7.62mm) machine gun Targets: HSMST, Trimaran, SPAR, Surface Target Balloon	14 events	TMAA
Surface-to-Surface (SS) Gunnery Exercise	CVN, CG, DDG, FFG, AOE	5”/54 BLP, 20mm CIWS, 25 mm, 7.62mm, 57mm, .50 cal Targets: SMST, Trimaran, SPAR, Surface Target Balloon	12 events	TMAA

Range Operation	**Platform(s)**	**System or Ordnance**	**Proposed Action**	**Location**
Maritime Interdiction	All	None	28 events	TMAA
Sea Surface Control	FA-18, EA-6B, EA-18G, P-3C, P-8 MMA, CG, DDG, FFG	None	12 events	TMAA
Sink Exercise	FA-18, F-16, F-15, F-22, EA-6B, EA-18G, P-3C, P-8 MMA,MH-60R/S, CVN, CG, DDG, FFG	MK-82 (Inert), MK-82 (live), MK- 83, AGM-88 HARM, AGM-84 Harpoon, AGM-65 Maverick, AGM-114 Hellfire, AGM-119 Penguin, Standard Missile 1, Standard Missile 2, 5"/54 BLP	2 events	TMAA
Anti-Submarine Warfare (ASW) Training				
ASW Tracking Exercise - Helicopter	MH-60R	Targets: SSN, MK-39 EMATT Sonobuoys: AN/AQS-22, SSQ-36 BT, SSQ-53 DIFAR (passive), SSQ-62 DICASS (active), SSQ-77 VLAD Other: MK-58 marine marker	44 events	TMAA
ASW Tracking Exercise - MPA	P-3C, P-8 MMA	Targets: SSN, MK-39 EMATT Sonobuoys: SSQ-36 BT, SSQ-53 DIFAR (passive), SSQ-62 DICASS (active), SSQ-77 VLAD Other: MK-58 marine marker	26 events	TMAA
ASW Tracking Exercise - Extended Echo Ranging (EER) (includes IEER and MAC)	P-3C, P-8 MMA	SSQ-110A EER/IEER, SSQ-125 MAC, SSQ-77 VLAD	4 events	TMAA
ASW Tracking Exercise - Surface Ship	DDG, FFG	SQS-53C, SQS-56 MFA sonar Targets: SSN, MK-39 EMATT	3 events	TMAA
ASW Tracking Exercise - Submarine	SSBN, SSGN	Targets: MK-39 EMATT	3 events	TMAA
Electronic Combat (EC) Training				
EC Exercises	EA-6B, EA-18G, P-3, EP-3, CVN, CG, DDG, FFG	None	10 events	TMAA, Air Force SUA
Chaff Exercises	EA-6B, EA-18G, P-3, EP-3,	Chaff	4 events	TMAA,

Range Operation	**Platform(s)**	**System or Ordnance**	**Proposed Action**	**Location**
	FA-18, CVN, CG, DDG, FFG, AOE			Air Force SUA
Counter Targeting Exercises	EA-6B, EA-18G, P-3, EP-3, FA-18, CVN, CG, DDG, FFG, AOE	None	8 events	TMAA
Naval Special Warfare (NSW) Training				
Special Warfare Operations	C-130, MH-60S, SDV, RHIB, NSW Personnel.	None	20 events	TMAA, Air Force SUA, Army Training Lands
Strike Warfare (STW) Training				
Air-to-Ground Bombing Exercise	FA-18, F-16, F-15, F-22, EA-6B, EA-18G	MK-82/83/84 (live/Inert), BDU-45 (inert), CATM-88C (not released)	300 sorties	Air Force SUA, Army Training Lands
Personnel Recovery	CVN, CG, DDG, FFG, AOE, MH-60S, RHIB, NSW Personnel	None	8 events	Air Force SUA, Army Training Lands
Support Operations Training				
Deck Landing Qualifications	Helicopters (Air Force, Army, Coast Guard – various)	None	12 events	TMAA

[1] *A single activity by a single aircraft is termed a "sortie"- one complete flight from takeoff to landing*.

Table 2. Ordnance and expendables proposed to be used in the Gulf of Alaska temporary training activities area annually (Navy 2011).

Ordnance/Expendable	Number per Year	Ordnance/Expendable	Number per Year
Bombs		Missiles	
Bomb dummy unit (BDU)-45 (inert)	216	AIM-7 Sparrow	18
Mark (MK)-82 (HE)	128	M-9 Sidewinder	24
MK-83 (HE)	12	AIM-120 AMRAAM	18
MK-84 (HE)	4	Standard Missile	6
Naval Gunshells		Small Arms Rounds	
20mm (inert)	20,000	7.62mm Projectile	9,000
25mm (inert)	6,000	.50 cal machine gun	2,400
57mm (inert)	200	Pyrotechnics	
76mm (inert)	28	LUU-2B/B Flare	36
76mm (HE)	16	MK-58 Marine Marker (Day/Night smoke/flare)	120
5 inch (HE)	84		
5 inch (inert)	48	Sonobuoys	
Targets		SSQ-36 BT	120
MK-39 Expendable Mobile ASW Training Target (EMATT)	12	SSQ-53 DIFAR Passive	1,000
		SSQ-62 DICASS Active	267
Tactical Air Launched Decoy (TALD)	24	SSQ-77 VLAD	120
		SSQ-110A EER/IEER, SSQ-125 MAC	80
TDU-34 Towed Target (Retained, not expended)	6	Signaling Device	
		SUS MK-84	24
BQM-74E	4	Chaff	
SPAR (Recovered)	24	ALE-43 Dispenser (Aluminized glass roll)	1,080 lbs
Killer Tomato (Recovered)	24		

[1] *HE = high explosive*

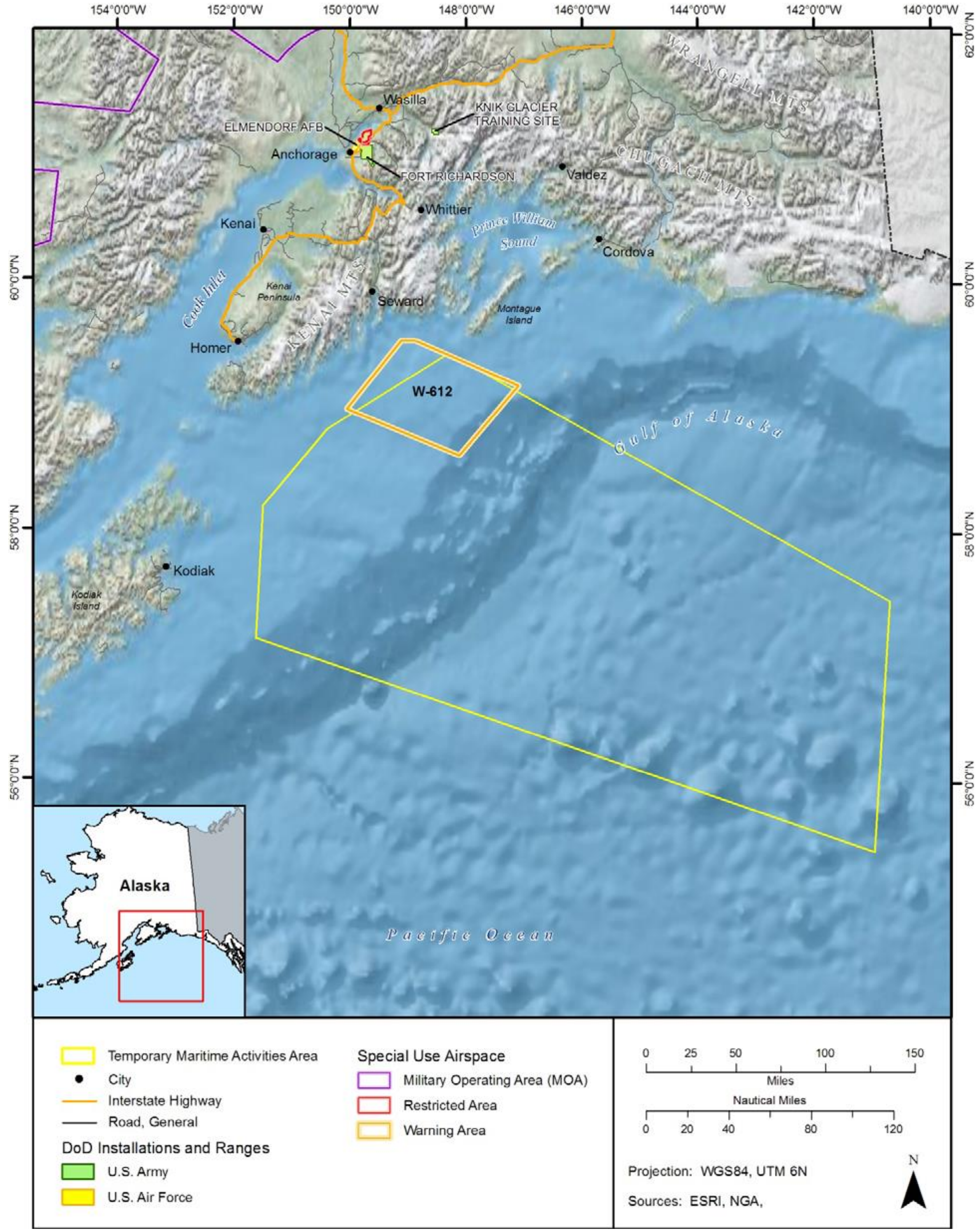


Figure 1. Map of the Gulf of Alaska indicating temporary maritime training area.

2.1 Proposed Navy Training Exercises

The proposed Navy training activities for the Gulf of Alaska TMAA can be divided into eight primary mission areas: anti-air warfare (AAW), anti-surface warfare (ASUW), anti-submarine warfare (ASW), electronic combat (EC), naval special warfare (NSW), strike warfare (SW), other training, and new instrumentation technology.

2.1.1 Anti-Air Warfare Training

Anti-air warfare includes combat activities by air and surface forces against hostile aircraft. Navy ships contain an array of modern anti-aircraft weapon systems, including naval guns linked to radar-directed fire-control systems, surface-to-air missile systems, and radar-controlled cannon for close-in point defense. Strike/fighter aircraft carry anti-aircraft weapons, including air-to-air missiles and aircraft cannons. Training encompasses events and exercises to train ship and aircraft crews in employment of these weapon systems against mock threat aircraft or targets. Anti-air warfare includes air combat maneuvers (ACM), air defense exercise (ADEX), surface-to-air and air-to-air missile exercises (SAMEX and AAMEX), and surface-to-air gunnery exercises (GUNEX S-A).

Air Combat Maneuvers (ACM). Includes basic flight maneuvers where aircraft engage in offensive and defensive maneuvering against each other. During an ACM engagement, no ordnance is fired. These maneuvers typically involve two aircraft; however, based upon the training requirement, ACM exercises may involve over a dozen aircraft. For the purposes of this document, aircraft activities will be described by the term “sortie.” A sortie is defined as a single activity by one aircraft (i.e., one takeoff and one final landing). Air combat maneuver activities within the Alaska training areas are conducted above the TMAA. Subsequently, these activities would involve flights within the TMAA at flight levels 5,000 ft above sea level for Naval aircraft and 10,000 ft above sea level for Air Force aircraft. These activities are primarily conducted by F/A-18 aircraft. Additionally, Air Force F-15s, F-16s, and F/A-22s also conduct ACM in the TMAA. No ordnance is released during these exercises. The Navy proposes to conduct 600 sorties of ACM annually (Table 1).

Air Defense Exercise (ADEX). Air defense exercise is to train surface and air assets in coordination and tactics for defense of the strike group or other Naval Force from airborne threats. The activities occur within the TMAA and would involve aircraft flying at 5,000 ft above sea level. No ordnance is fired during this activity.

Surface to Air Missile Exercise (SAMEX). During a SAMEX, surface ships engage threat missiles and aircraft equipped with missiles within the TMAA with the goal of disabling or destroying the missile threat. One live or inert-missile is expended against a target drone (such as the BQM-74) towed by a commercial air services Lear jet after two or three tracking runs. The BQM-74 target drone, a high-value reusable vehicle, sometimes augmented with a target drone unit (a less expensive, expendable unit), is used as an alternate target for this exercise. The BQM-74 target is a subscale, subsonic, remote controlled ground or air launched target. A parachute deploys at the end of target flight to enable recovery at sea. The Navy proposes to conduct 6 SAMEX events annually with each exercise lasting about 2 hours (Table 1).

Surface-to-Air Gunnery Exercise (GUNEX S-A). During a GUNEX S-A, a ship's gun crews engage threat aircraft or missile targets with their guns with the goal of disabling or destroying the threat. These activities occur within the TMAA. A typical scenario involving a guided missile destroyer with 5-inch guns or a guided missile frigate with 76 millimeter (mm) main battery guns would have a threat aircraft or anti-ship missile being simulated by an aircraft towing a target (a cloth banner measuring approximately 5 ft by 30 ft [1.5 m by 9 m]) toward the ship below 10,000 ft (3,048 m), at a speed between 250 and 500 knots (575 kilometers per hour [km/h]). This is a defensive exercise where about six rounds of 5-inch variable timed, non-fragmentation ammunition and 12 rounds of 76-mm per gun mount are fired at a target towed by a commercial air services Lear jet. The ship will maneuver but will typically operate at 10 to 12 knots or less during the exercise. The exercise normally includes several non-firing tracking runs followed by one or more firing runs. The target must maintain an altitude 500 ft (152 m) above sea level for safety reasons, and is occasionally not destroyed during the exercise. Aircraft flights to and from the TMAA would be done at an altitude greater than 15,000 ft (4,572 m) above sea level. The Navy proposes to conduct 6 GUNEX S-A annually, each lasting about 2 hours (Table 1).

Air-to-Air Missile Exercise (AAMEX). During an AAMEX, aircraft attack a simulated threat target aircraft with air-to-air missiles with the goal of destroying the target. Air-to-air missiles (approximately half of the missiles have live warheads and about half have an inert telemetry package) are fired from aircraft against aerial targets to provide aircrews with experience using aircraft missile firing systems and training on air-to-air combat tactics. These activities occur within the TMAA and would involve flights at an altitude at least 5,000 ft above sea level.

A typical scenario would involve a flight of two aircraft operating between 15,000 and 25,000 ft (4,572 and 7,620 m) and at a speed of about 450 knots (834 kilometers per hour [km/h]) that approach a target from several miles away and, when within missile range, launch their missiles against the target. The missiles fired, to include the active infrared missile (AIM) -7 Sparrow, AIM-9 Sidewinder and AIM-120 AMRAAM (advanced medium-range air-to-air missile), are not recovered. The target is either a tactical air launched decoy or a LUU-2B/B illumination paraflare (an illumination flare that hangs from a parachute). Both the tactical air launched decoys and the paraflares are expended. These exercises would be conducted in the TMAA outside of 12 nautical miles (nm; 22 km) and well above 3,000 ft (914 m) sea level. The Navy proposes to conduct 6 AAMEX annually lasting about 1 hour each (Table 1).

2.1.2 Anti-Surface Warfare Training

Anti-surface warfare includes combat (or interdiction) activities in which aircraft, surface ships, and submarines employ weapons and sensors directed against enemy surface ships or boats. Air-to-surface ASUW is conducted by aircraft assets employing long-range attack maneuvers using precision guided munitions or aircraft cannons. Warships conduct ASUW using naval guns and surface-to-surface missiles. Submarines attack surface ships using submarine-launched, anti-ship cruise missiles. Training in ASUW includes surface-to-surface gunnery and missile exercises, air-to surface gunnery and missile exercises, and submarine missile launch events. Training generally involves expenditure of ordnance against a towed target. The ASUW exercises also encompasses maritime interdiction, that is, the interception of a suspect surface ship by a Navy ship for the purpose of boarding-party inspection or the seizure of the suspect ship.

Visit, Board, Search, and Seizure/Vessels of Interest (VBSS/VOI). These missions are the principal type of maritime interdiction operations used by naval forces. Highly trained teams of armed personnel, wearing body armor, flotation devices, and communications gear are deployed from ships at sea into small Zodiac boats or helicopters to board and inspect ships and vessels suspected of carrying contraband. Once aboard, the team takes control of the bridge, crew, and engineering plant, and inspects the ship's papers and its cargo. These activities occur within the TMAA. The Navy proposes to conduct 24 of these events annually (Table 1).

Air-to-Surface Missile Exercise (A-S MISSILEX). Air-to-surface MISSILEX involves fixed winged aircraft and helicopter crews launching missiles at surface maritime targets, day and night. The goal is to teach personnel how to disable or destroy enemy ships or boats using missiles. These activities occur within the TMAA; however, all missile launches are simulated. The Navy proposes to conduct 4 events annually (Table 1).

Air-to-Surface Bombing Exercise (A-S BOMBEX). During an A-S BOMBEX, maritime patrol aircraft or F/A-18 deliver free-fall bombs against surface maritime targets. The goal is to teach personnel how to disable or destroy enemy ships or boats using free-fall bombs. Typical bomb release altitude is below 3,000 ft (914 m) and within a range of 1,000 yards (yd) (914 m) for unguided munitions, and above 15,000 ft (4,572 m) and in excess of 10 nm (18 km) for precision guided munitions. Bombs or other munitions are not released from aircraft at night because of safety concerns. Therefore, exercises at night are normally performed with captive carry (no drop) weapons. Laser designators from the aircraft releasing the laser guided weapon or a support aircraft are used to illuminate certified targets for use with lasers when using laser guided weapons. Bombs used could include Bomb Dummy Unit (BDU)-45 (inert) or Mark-82/83/84 (live and inert). These activities occur within the TMAA. The Navy proposes to conduct 36 A-S BOMBEX annually (Table 1).

Air-to-Surface Gunnery Exercise (A-S GUNEX). Air-to-surface GUNEX involves strike fighter aircraft and helicopter crews, including embarked Naval special warfare personnel, using guns to attack surface maritime targets, day or night, with the goal of destroying or disabling enemy ships, boats, or floating or near-surface mines. The target is normally a floating object such as an expendable marine marker, steel drum, or cardboard box, but may be a remote controlled speed boat or jet ski type target. For fixed-wing A-S GUNEX, a flight of two F/A-18 aircraft begin a descent to the target from an altitude of about 3,000 ft (914 m) while still several miles away. Within a distance of 4,000 ft (1,219 m) from the target, each aircraft fires a burst of about 30 rounds from its 20 mm cannon before reaching an altitude of 1,000 ft (305 m). These activities occur within the TMAA. For rotary-wing A-S GUNEX, a single helicopter carries several air crewmen needing gunnery training and flies at an altitude between 50 and 100 ft (15 to 30 m) in a 300-ft (91-m) racetrack pattern around an at-sea target. The exercise lasts about 1 hour and occurs within the TMAA. The Navy proposes to conduct 14 A-S GUNEX annually (Table 1).

Surface-to-Surface Gunnery Exercise (S-S GUNEX). These exercises train surface ship crews in high-speed surface engagement procedures against mobile (towed or self-propelled) seaborne targets. Both live and inert training rounds are used against the targets. The training consists of the pre-attack phase, including locating, identifying, and tracking the threat vessel, and the attack phase in which guns are fired at the target. In a live-fire event, aircraft conduct a surveillance flight to ensure that the range is clear of nonparticipating ships. These activities occur within the TMAA. The Navy proposes to conduct 12 S-S GUNEX annually (Table 1).

Maritime Interdiction (MI). Maritime interdiction training involves a coordinated defensive attack against multiple sea-borne and air targets using airborne and surface assets with the objective of delivering a decisive blow to enemy forces. These exercises typically involve all the assets of the carrier strike group and joint forces in an attempt to neutralize the threat. The firing of weapons is simulated, and the exercise occurs exclusively within the TMAA each day. This activity would involve over-flights, but over-flights would be conducted at 15,000 ft (4,572 m) above sea level. The Navy proposes to conduct 28 MI events annually (Table 1).

Sea Surface Control (SSC). Sea surface control exercises involve aircraft, typically FA-18 hornets, performing reconnaissance of the surrounding battle space. Under the direction of the sea combat commander, the airborne assets investigate surface contacts of interest and attempt to identify, via onboard sensors or cameras, the type, course, speed, name, and other pertinent data about the ship of interest. Due to the curvature of the earth, surface assets are limited in their ability to see over the horizon. The airborne assets, due to their speed and altitude, can cover great distances in relatively short periods, and see far beyond the capabilities of the surface ship. This enables them to report contacts that cannot be seen by ships. By using airborne assets, the sea combat commander, in effect, is able to see beyond the horizon and develop a clearer tactical picture well in advance. These activities occur within the TMAA. The Navy proposes to conduct 12 SSC events annually (Table 1).

2.1.3 Anti-Submarine Warfare Training

The Navy proposes to conduct ASW TRACKEX training exercises involving aircraft, ship, and submarine crews in tactics, techniques, and procedures for search, detection, localization, and tracking of submarines with the goal of determining a firing solution that could be used to launch a torpedo and destroy the submarine. Participating units use active and passive sensors, including hull-mounted sonar, towed arrays, dipping sonar, variable depth sonar and sonobuoys for tracking. These activities will include the use of active sonar.

Helicopter ASW TRACKEX. A helicopter ASW TRACKEX typically involves one or two MH-60R helicopters using both passive and active sonar for tracking submarine targets. For passive tracking, the MH-60R will deploy patterns of passive sonobuoys that will receive underwater acoustic signals, providing the helicopter crew with locating information on the target. Active sonobuoys may also be used. An active sonobuoy, as in any active sonar system, emits an acoustic pulse that travels through the water, returning echoes if any objects, such as a submarine, are within the range of the acoustic detection.

For active sonar tracking, the MH-60R crew will rely primarily on its AQS-22 Dipping Sonar. The sonar is lowered into the ocean while the helicopter hovers within 50 ft (15 m) of the surface. Similar to the active sonobuoy, the dipping sonar emits acoustic energy and receives any returning echoes, indicating the presence of an underwater object. A Helicopter TRACKEX usually takes 2 to 4 hours. No torpedoes are fired during this exercise. The Navy proposes to conduct 44 helicopter ASW TRACKEX events annually.

Maritime Patrol Aircraft ASW TRACKEX. During these exercises, a typical scenario involves a single maritime patrol aircraft dropping sonobuoys, from an altitude below 3,000 ft (914 m), into specific patterns designed for both the anticipated threat submarine and the specific water conditions. The maritime patrol aircraft will typically operate below 3,000 ft (914 m) to drop sonobuoys, will sometimes be as low as 400 ft (122 m), then it may climb to several thousand feet after the buoy pattern is deployed. The higher altitude allows monitoring the buoys over a much larger search pattern area. A maritime patrol aircraft TRACKEX usually takes 2 to 4 hours. No torpedoes are fired during this exercise. The Navy proposes to conduct 26 maritime patrol aircraft ASW TRACKEX annually.

Extended Echo Ranging ASW Exercises. This exercise is an at-sea flying event designed to train maritime patrol aircraft crews in the deployment and use of the extended echo ranging sonobuoy systems. This system uses the SSQ-110A as the signal source and the SSQ-77 as the receiver buoy. This activity differs from the maritime patrol aircraft ASW TRACKEX in that the SSQ-110A sonobuoy uses two explosive charges per buoy for the acoustic source. Other active sonobuoys use an electrically generated “ping.” A typical extended echo ranging exercise lasts approximately 6 hours. The aircrew will first deploy 16 to 20 SSQ-110A sonobuoys and 16 to 20 passive sonobuoys in 1 hour. For the next 5 hours, the sonobuoy charges will be detonated, while the extended echo ranging system analyzes the returns for evidence of a submarine. This exercise may or may not include a practice target. In the future, the Navy will be replacing the extended echo range sonobuoys with the multi-static active coherent (MAC) sonobuoys, AN/SSQ-125 formally known as Advanced Extended Echo Ranging (AEER). The Navy proposes to conduct 4 extended echo ranging ASW exercises annually.

ASW TRACKEX (Surface Ship). Surface ships operating in the TMAA would use hull mounted active sonar to conduct ASW Tracking exercises. Typically, this exercise would involve the coordinated use of other ASW assets, including military patrol aircraft, helicopters, and other ships. The Navy proposes to conduct 3 surface ship ASW TRACKEX annually.

ASW TRACKEX (Submarine). During these exercises submarines use passive sonar sensors to search, detect, classify, localize, and track the threat submarine with the goal of developing a firing solution that could be used to launch a torpedo and destroy the threat submarine. However, no torpedoes are fired during this exercise. The Navy proposes to conduct 3 submarine ASW TRACKEX annually.

2.1.4 Sonar Training

The Navy proposes to use various types of active sound sources for purposes such as to determine water depth, locate mines, transmit data, and identify, track, and target submarines. One of the most common active sources is sonar. Sonar uses an underwater transducer or speaker to generate sound waves. The sound waves travel until they encounter an object and are reflected in various directions. Some of the reflected waves return to the hydrophone or receiver, where they are converted back into electric signals, amplified and displayed. A careful interpretation of the reflected sound can provide the direction and distance of the object, as well as its size and speed. This is accomplished through "echo ranging," which measures the time it takes for a sound wave to travel from the transducer, reflect off the object, and return to the receiver. Active sonar is critical for locating and tracking submarines because it provides both bearing (direction) and range (distance) from the detected object. For the purpose of ESA and MMPA compliance, the Navy has segmented active sound sources as defined below into low-, mid-, and high-frequency.

- High-frequency active (HFA) sources operate at frequencies greater than 10 kilohertz (kHz). At higher acoustic frequencies, sound rapidly dissipates in the ocean environment, resulting in short detection ranges, typically less than 5 nm (9.5 km), for systems using this frequency range. For example, high-frequency sonar is used by the Navy primarily for determining water depth, locating mines, and guiding torpedoes which are all short range applications. The HFA sources currently occur in the TMAA and will continue to be used under the Proposed Action.

- Mid-frequency active (MFA) sources operate between 1 kHz and 10 kHz, with sonar detection ranges up to 10 nm (19 km). Because of this detection ranging capability, sonar in this frequency range provides an optimal balance of detection range and resolution and as such is the Navy's primary tool for conducting ASW. Many ASW experiments and exercises have demonstrated that this improved capability for long range detection of adversary submarines before they are able to conduct an attack is essential to U.S. ship survivability.

- Low-frequency sources operate below 1 kHz. Sonar in this frequency range is designed to detect extremely quiet diesel-electric submarines at ranges far beyond the capabilities of MFA sonar. There are currently only two ships in use by the Navy equipped with low-frequency sonar; both are ocean surveillance vessels operated by Military Sealift Command. Use of low-frequency active sonar is not part of the planned training activities considered for the Gulf of Alaska. Use of other low frequency sources (such as the MK-39 Expendable Mobile ASW Training Target (EMATT)) is proposed for use in the TMAA.

Unlike active sound sources, passive sonar or other passive devices only “listen” for sound waves generated or reflected by the subject of interest. Because no sound is introduced into the water when using passive systems, they can only indicate the presence, general direction, and character and movement of the sound source. Passive devices do not, therefore, provide accurate range to the source and cannot be used exclusive of active sources when conducting ASW. The ASW sonar systems that are used with certain classes of surface ships, submarines, helicopters, and fixed-wing military patrol aircraft are identified in Table 4 and described in the following paragraphs.

Table 3. Acoustic systems that may be used by the U.S. Navy in the Gulf of Alaska Temporary Maritime Training Area (Navy 2011).

System[1]	Frequency	Associated Platform	System Use/Description
AN/SQS-53C	Mid	Surface ship sonar (DDG/CG) [2]	Utilized 70% in search mode and 30% in track mode.
AN/SQS-56	Mid	Surface ship sonar (FFG)	Utilized 70% in search mode and 30% in track mode.
AN/SSQ-62 DICASS Sonobuoy	Mid	Helicopter and MPA deployed	12 pings, 30 seconds between pings.
AN/AQS-13 or AN/AQS-22	Mid	Helicopter dipping sonar	AN/AQS-22: 10 pings/dip, 30 seconds between pings)- also used to represent AN/AQS-13.
AN/SSQ-110A Explosive source Sonobuoy	Impulsive	MPA deployed	Contains two 4.1 lb charges.
MK-84 Pinger	High	Submarines, Surface ships and Targets	PUTR target tracking.
PUTR Uplink Transmitter	Mid/High	PUTR	PUTR tracking uplink signal.
MK-39 EMATT	Low	Ship and aircraft deployed	Simulates a target submarine for tracking exercises
AN/BQQ-10	Mid	Submarine Sonar	Submarine hull-mounted sonar (2 pings per hour)
AN/BQS-15	High	Submarine Sonar	Submarine mine detection sonar.
SUS, MK-84	Selectable 3.3 or 3.5 kHz	Limited duration, system is used to communicate between surface ship and submarines	Expendable buoy deployed from aircraft and ships used as a signaling device to communicate with submarines. Operating life of 70 seconds.

[1] System descriptions are describe in Section 5.1

[2] DDG – Guided Missile Destroyer; CG – Guided Missile Cruiser; DICASS – Directional Command-Activated Sonobuoy System; FFG – Fast Frigate;; MPA – Maritime Patrol Aircraft

Sonar Systems Associated with Surface Ships. Guided Missile surface ships (guided missile cruiser, guided missile destroyer, and fast frigates) are equipped with MFA sonar as well as passive sonar for submarine detection and tracking, mine avoidance, and navigation. Guided missile cruisers and destroyers use the SQS-53 and fast frigates use the SQS-56 sonar system. All Navy ships have high-frequency sonar (fathometers) serving as depth finders but these are not currently regulated sound sources.

Sonar Systems Associated with Submarines. Submarines are equipped with high-frequency sonars (BQS-15 or BQQ-24) for use in navigation, detection of ice or other objects overhead, mine avoidance, and as a fathometer. Some submarines are also equipped with a variety of MFA and passive sonar systems that are used to detect and target enemy submarines and surface ships, for mine avoidance, and navigation (Table 4). However, submarines rarely use active sonars (BQQ-10) during ASW or ASUW events and when they do, sonar pulses are very short and directed. Submarines also have high-frequency sonar (fathometers) serving as depth finders, but these are not currently regulated sound sources.

Table 4. Anti-submarine warfare sonar systems and platforms in the Gulf of Alaska temporary maritime activities area (from BE Navy 2010).

System	Associated Platform/Use	Frequency (kHz)
AN/SQS-53	Guided Missile Destroyer and Guided Missile Cruiser hull-mounted sonar	Mid-Frequency
AN/SQS-56	Fast Frigate hull-mounted sonar	Mid-Frequency
AN/BQQ-10	Submarine hull-mounted sonar	Mid-Frequency
AN/AQS-13 or AN/AQS-22	Helicopter dipping sonar	Mid-Frequency
BQS-15	Submarine safety/navigation sonar	High-Frequency
DICASS Sonobuoy (AN/SSQ-62)	Maritime Patrol Aircraft deployed sonobuoys	Mid-Frequency
IEER Sonobuoy (AN/SSQ-110A / AN/SSQ-125 [MAC])	Maritime Patrol Aircraft deployed sonobuoys	Impulsive
MK-39 EMATT	Simulates a target submarine	Low Frequency
PUTR	Portable Undersea Tracking Range	Mid/High-Frequency
MK-84	PUTR tracking target	High Frequency
SUS, MK-84	Expendable buoy deployed from aircraft and ships; operating life 70 seconds	3.3 or 3.5 kHz

Sonar Systems Associated with Aircraft. Aircraft sonar systems that would be deployed in the TMAA include sonobuoys from fixed and rotary wing aircraft and dipping sonar from helicopters. Sonobuoys are expendable devices used by aircraft for the detection of underwater acoustic energy and for conducting vertical water column temperature measurements. The majority of sonobuoys deployed are passive, but some can generate active acoustic signals, as well as listen passively. Helicopters and military patrol aircraft (P-3 or P-8 in approximately 2013) will deploy sonobuoys in the TMAA during an ASW exercise.

The Proposed Action includes use of mid- and high-frequency sonar, including 578 hours of SQS-53 and 52 hours of SQS-56 surface ship sonar, the BQQ-10 (48 hours) and BQS-15 (24 hours) submarine sonar, 266 active SSQ-62 sonobuoys, 192 dips of helicopter dipping sonar, and 80 hours of the AN/SSQ-110A/125 sonobuoy each year (Table 5).

Table 5. Annual sonar hours and sources proposed by the Navy for Gulf of Alaska temporary maritime activities areas (from BE Navy 2010 and draft LOA).

SQS 53 Sonar [a]	SQS-56 Sonar [a]	BQQ-10 Sonar [a]	BQS-15 Sonar [a]	SSQ-62 DICASS Sonobuoy [b]	AQS 22 Dipping Sonar [c]	AN/SSQ-110A/125 (MAC or IEER)
578	52	48	24	266	192	80

[a] *Number of operational hours not total transmission time, representative for all variants of system.*
[b] *Number of buoys.*
[c] *Number of individual use "dips" of the system.*

2.1.5 Non-Sonar Acoustic Training

In addition to the use of mid- and high-frequency sonar, additional non-sonar acoustic sources would be used during training to track and monitor the location of assets and would include components of the PUTR including MK-84 Range Tracking Pingers and Transponders, plus MK-39 EMATT targets and SUS MK-84 signaling devices as shown in Table 6.

Table 6. Non-sonar acoustic sources proposed for use by the Navy in the Gulf of Alaska Temporary training activities area (from BE Navy 2010).

MK-84 Range Tracking Pinger[1]	PUTR Transponder[1]	MK-39 EMATT targets[2]	SUS MK-84 signaling Devices[2]
80	80	12	24

[1] *Number of hours of operation for the PUTR system under average conditions not total transmission time of the components.*
[2] *Number of devices.*

Torpedoes. Torpedoes are the primary ASW weapon used by surface ships, aircraft, and submarines; however, torpedoes will not be used in the TMAA during the proposed training activities.

ASW Training Targets. Training targets are used to simulate target submarines and are equipped with one or a combination of the following devices: (1) acoustic projectors emanating sounds to simulate submarine acoustic signatures, (2) echo repeaters to simulate the characteristics of a particular sonar signal reflected from a specific type of submarine, and (3) magnetic sources to trigger magnetic detectors. The anti-submarine warfare target to be used in the TMAA is the MK-39 expendable mobile ASW training target. The targets are approximately 5 in (13 centimeters [cm]) in diameter, 36 in (91 cm) in length, and weigh 22 pounds (lb) (9 kilogram [kg]). Targets would be deployed from ships, submarines, or aircraft. This is an expendable device which is not recovered. The sounds produced by the targets are relatively quiet and designed to mimic a submarine.

2.1.6 Electronic Combat Training

In general, electronic combat (EC) is intended to control the use of the electromagnetic spectrum and to deny its use by an adversary. Typical EC training activities include threat avoidance training, signals analysis for intelligence purposes, and use of airborne and surface electronic jamming devices to defeat tracking systems.

The EC exercises are conducted to prevent or reduce the effective use of enemy electronic equipment and ensure the continued use of friendly electronic equipment, including command and control capabilities. During EC training, appropriately configured aircraft fly threat profiles against ships so that the ship's crews are trained to detect electronic signatures of various threat aircraft and counter the jamming of the ship's own electronic equipment by the simulated threat.

During these exercises, aircraft, surface ships, and submarines attempt to control critical portions of the electromagnetic spectrum used by threat radars, communications equipment, and electronic detection equipment to degrade or deny the enemy's ability to defend its forces from attack and/or recognize an emerging threat early enough to take the necessary defensive actions. These activities occur within the TMAA. Additionally, this activity can occur in and on the Air Force special use airspace and Army training land. The Navy proposes to conduct 10 EC events annually (Table 1).

Chaff Exercise. Ships, fixed-winged aircraft, and helicopters deploy chaff to disrupt threat targeting and missile guidance radars and to defend against an attack. The chaff exercise trains aircraft in the use and value of chaff to counter an enemy threat. Radio frequency chaff is an electronic countermeasure designed to reflect radar waves and obscure aircraft, ships, and other equipment from radar tracking sources. Chaff is released or dispensed from military vehicles in cartridges or projectiles that contain millions of chaff fibers. Chaff is composed of an aluminum alloy coating on glass fibers of silicon dioxide. These aluminum-coated glass fibers (about 60 percent silica and 40 percent aluminum by weight) range in lengths of 0.8 to 7.5 cm with a diameter of about 40 micrometers. When deployed, a diffuse cloud of fibers undetectable to the human eye is formed. Chaff is a very light material that can remain suspended in air anywhere from 10 minutes to 10 hours. Chaff is employed for a number of different tactical reasons, but the end goal is to create a target from the chaff that will lure enemy radar and weapons systems away from the actual friendly platform.

Chaff may be employed offensively, such as before a major strike to “hide” inbound striking aircraft or ships, or defensively in reaction to being detected by an enemy targeting radar. Defensive chaff training is the most common exercise used for training both ships and aircraft. In most cases, the chaff exercise is training for the ship or aircraft that actually deploys the chaff, but it is also a very important event to “see” the effect of the chaff from the “enemy” perspective so that radar system operators may practice corrective procedures to “see through” the chaff jamming, so exercises are often designed to take advantage of both perspectives. These activities occur within the TMAA. Additionally, this activity can occur in and on the Air Force Special use airspace and Army training land. The Navy proposes to conduct 4 chaff events annually (Table 1).

Counter Targeting. A counter targeting exercise is a coordinated, defensive activity utilizing surface and air assets, that attempts to use jamming and chaff to show a false force presentation to inbound surface-to-surface platforms. During these exercises, electronic attack-6B jamming aircraft will position itself between the carrier strike group assets and the threat and jam the radar systems of potential hostile surface units. Carrier strike group ships will launch chaff to create false targets that saturate the threat radars return, thus masking the true position of the carrier strike group ships. The Navy proposes to conduct 8 counter targeting exercises annually (Table 1).

2.1.7 Naval Special Warfare Training

Naval special warfare (NSW) forces (Sea, Air, Land [SEALs] and Special Boat Units [SBUs]) train to conduct military activities in five special operations mission areas: unconventional warfare, direct action, special reconnaissance, foreign internal defense, and counterterrorism. The NSW training involves specialized tactics, techniques, and procedures, employed in training events that could include insertion/extraction activities using parachutes, rubber boats, or helicopters and other equipment.

Insertion/Extraction. Personnel approach or depart an objective area using various transportation methods and covert or overt tactics depending on the tactical situation. These exercises train forces to insert and extract personnel and equipment day or night. There are a number of different insertion or extraction techniques that are used depending on the mission and tactical situation. Personnel conduct insertion/extraction exercises using helicopters and other equipment. These activities take place in existing Air Force special use airspace and Army training land. The Navy proposes to conduct 20 insertion/extraction activities annually (Table 1).

2.1.8 Strike Warfare Training

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

Air-to-Ground BOMBEX. Air-to-ground bombing exercises consist of fixed-winged strike fighter aircraft that deliver bombs and rockets against land targets, day or night, with the goal of destroying or disabling enemy vehicles, infrastructure, and personnel. Typically, a flight of two to four aircraft will depart the aircraft carrier and fly inland at high altitude (greater than 30,000 ft [9,144 m]). The flight will approach the inland target from an altitude of between 15,000 ft (4,572 m) to less than 3,000 ft (914 m) and will usually establish a racetrack pattern around the target. The pattern is established in a predetermined horizontal and vertical position relative to the target to ensure that all participating aircraft follow the same flight path during their target ingress, ordnance delivery, target egress, and “downwind” profiles. This type of pattern is designed to ensure that only one aircraft will be releasing ordnance at any given time. The typical bomb release altitude is below 3,000 ft (914 m) and within a range of 1,000 yards (yd) (914 m) for unguided munitions or above 15,000 ft (4,572 m) and may be in excess of 10 nm (18 km) for precision-guided munitions. Exercises at night will normally be done with captive carry (no drop) weapons because of safety considerations. Laser designators from the aircraft dropping the bomb, a support aircraft, or ground support personnel are used to illuminate certified targets for use with lasers when using laser-guided weapons. The average time for this exercise is about 1 hour. These activities take place in the inland special use areas of the Air Force and on the Army land ranges. The Navy proposes to conduct 300 sorties annually (Table 1).

Personnel Recovery (PR). Personnel recovery is a strike warfare activity with the purpose of training aircrews to locate, protect, and evacuate downed aviation crew members. In a hostile environment, this exercise becomes a combat search and rescue mission. The activity can include reconnaissance aircraft to find the downed aircrew, helicopters to conduct the rescue, and fighter aircraft to perform close air support to protect both the downed aircrews and the rescue helicopters. These activities can take place throughout the Alaska training area. The Navy proposes to conduct 8 personnel recovery events annually (Table 1).

2.1.9 Other Training

Deck Landing Qualifications (DLQs). Deck landing qualifications provide training for helicopter crews to land on ships underway at sea. Aircrews from the Air Force, Army, and U.S. Coast Guard, who do not normally perform deck landings, use this venue to practice helicopter deck landings onboard naval vessels. For safety, the Navy has strict guidelines and rules on frequency and duration between landings. As this is not a normal activity for Air Force, Army, and U.S. Coast Guard helicopter crews, the number and duration of particular deck landings that occur during a joint training exercise can vary dramatically.

Deck landing qualification activities take place on an underway Navy or U.S. Coast Guard ship. The activities take place both day and night, and could involve more than one helicopter over a period of several hours. The crew that is receiving the training typically departs from a shore facility and flies out to sea to make an approach and landing aboard the ship. After the required number of landings is completed, the helicopter either remains aboard ship or departs for shore. These activities take place in the TMAA. The Navy proposes to conduct 12 of these events annually (Table 1).

*Naval Force Structure***.** The Navy has established policy governing the composition and required mission capabilities of deployable naval units, focused on maintaining flexibility in the organization and training of forces. Central to this policy is the ability of naval forces of any size to operate independently or to merge into a larger naval formation to confront a diverse array of challenges. Thus, individual units may combine to form a Strike Group, and Strike Groups may combine to form a Strike Force. Composition of the Strike Groups and Strike Forces is discussed below.

"Baseline" Naval Force Composition. Navy policy defines the "baseline" composition of deployable naval forces. The baseline is intended as an adaptable structure to be tailored to meet specific requirements. Thus, while the baseline composition of a carrier strike group calls for a specified number of ships, aviation assets, and other forces, a given carrier strike group may include more or fewer units, depending on their mission. The baseline naval force structures established by navy policy for a carrier strike group are: one aircraft carrier; one carrier air wing consisting of four strike fighter squadrons, one electronic combat squadron, two combat helicopter squadrons, and two logistics aircraft; five surface combatant ships where "surface combatant" refers to guided missile cruisers, destroyers, and frigates, and future guided missile destroyers and littoral combat ship platforms; one attack submarine; and one logistic support ship.

2.1.10 New Instrumentation Technology Training

The Navy has identified a specific training instrumentation enhancement to optimize and adequately support required training for all missions and roles assigned to the TMAA. The portable undersea tracking range is a self-contained, portable, undersea tracking capability that employs modern technologies to support coordinated undersea warfare training in a defined area. The system will be capable of tracking submarines, surface ships, weapons, targets, and unmanned underwater vehicles and distribute the data to a data processing and display system, either aboard ship, or at a shore site.

The portable undersea tracking range would be developed to support ASW training in areas where the ocean depth is between 300 and 12,000 ft (91 and 3,657 m) and at least 3 nm (5.5 km) from land. However, for exercises occurring within the Gulf of Alaska, the technology would be deployed solely within the TMAA. This proposed project would temporarily (for the duration of the exercise) instrument an area on the seafloor from 25-100 nm^2 (86-343 km^2) or smaller, and would provide high fidelity crew feedback and scoring of crew performance during ASW training activities. Seven electronics packages, each approximately 3 ft (0.9 m) long by 2 ft (0.6 m) in diameter, would be temporarily installed on the seafloor by a boat, in water depths greater than 600 ft (182 m). The anchors used to keep the electronics packages on the seafloor would be either concrete or sand bags, which would be approximately 1.5 by 1.5 ft (0.45 by 0.45 m) and would weigh approximately 300 pounds. Operation of the portable undersea tracking range requires that underwater participants transmit their locations via pingers. Each package consists of a hydrophone that receives pinger signals, and a transducer that sends an acoustic "uplink" of locating data to the range boat. Each of these packages is powered by a D cell alkaline battery. After the end of the exercise and in accordance with the concept of operations, the PUTR electronic equipment would be recovered and the anchors would remain on the seafloor.

2.2 Proposed MMPA Letter of Authorization

NMFS' Permits Division proposes to issue a Letter of Authorization (LOA) to the Navy to authorize "take" of marine mammals. The take of marine mammals relative to the MMPA would be in the form of exposure to sound or pressure waves in the water at or above levels that NMFS has determined would likely result in harassment of those animals as described in the Federal Register (76 FR 25480, 4 May 2011). In addition to the use of active sonar (exposure to sound) and explosives (exposure to pressure waves), the activities include the operation and movement of vessels that are necessary to conduct the proposed training. The relevant portions of the proposed LOA are set forth on the following pages. The LOA includes ESA-listed and non-listed species of marine mammals.

The Commander, U.S. Pacific Fleet, 250 Makalapa Drive, Pearl Harbor, HI 96860-7000, and persons operating under his authority (i.e., Navy), are authorized to take marine mammals incidental to Navy exercises conducted in the Gulf of Alaska Temporary Maritime Activities Area in accordance with 50 CFR Part 218, Subpart N--Taking Marine Mammals Incidental to U.S. Navy Training in the Gulf of Alaska Temporary Maritime Activities Area (TMAA) subject to the provisions of the Marine Mammal Protection Act (16 U.S.C. 1361 et seq.; MMPA) and the following conditions:

1. This Authorization is valid for the period May 16, 2013, through May 4, 2016.

2. This Authorization is valid only for the unintentional taking of the species of marine mammals and methods of take identified in 50 CFR § 218.122(c) and Condition (5) of this Authorization incidental to the activities specified in 50 CFR § 218.120(c) and Condition (4)(a) of this Authorization and occurring within the Gulf of Alaska TMAA, (as depicted in Figure 1-1 in the Navy's application for the Gulf of Alaska TMAA), which is bounded by a hexagon with the following six corners: 57° 30' N. lat., 141° 30' W. long.; 59° 36' N. lat., 148° 10' W. long.; 58° 57' N. lat., 150° 04' W. long.; 58° 20' N. lat., 151° 00' W. long.; 57º 16' N. lat., 151º 00' W. long.; and 55° 30' N. lat, 142° 00' W. long.

3. This Authorization is valid only if the Holder of the Authorization or any person(s) operating under his authority implements the mitigation, monitoring, and reporting required pursuant to 50 CFR §§ 218.124 & 218.125 and implements the Terms and Conditions of this Authorization.

4. (a) This Authorization is valid for the activities identified below within the estimated annual amounts:

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

(i) AN/SQS-53 (hull-mounted sonar) – 578 hours

(ii) AN/SQS-56 (hull-mounted sonar) – 52 hours

(iii) AN/SSQ-62 (Directional Command Activated Sonobuoy System (DICASS) sonobuoys) – 266 sonobuoys

(iv) AN/AQS-22 (helicopter dipping sonar) – 192 “dips”

(v) AN/BQQ-10 (submarine hull-mounted sonar) – 48 hours

(vi) AN/SSQ – 110A (IEER) – 80 sonobuoys (total combined with MAC)

(vii) AN/SSQ – 125 (MAC) – 80 sonobuoys (total combined with IEER)

(viii) Range Pingers – 80 hours

(ix) SUS MK-84 – 24 devices

(x) PUTR Transponder – 80 hours

(xi) EMATT – 12 devices

(2) The detonation of the underwater explosives indicated in (i) conducted as part of the training exercises indicated in (ii):

(i) Underwater Explosives (Net Explosive Weight (NEW)):

(A) 5” Naval Gunfire (9.5 lbs NEW)

(B) 76 mm rounds (1.6 lbs NEW)

(C) MK-82 (238 lbs NEW)

(D) MK-83 (238 lbs NEW)

(E) MK-83 (574 lbs NEW)

(F) MK-84 (945 lbs NEW)

(G) AN/SSQ-110A (EER/IEER explosive sonobuoy - 5 lbs NEW)

(ii) Training Events:

(A) Surface-to-surface Gunnery Exercises - 12 exercises

(B) Bombing Exercises - 36 exercises

(C) Extended Echo Ranging and Improved Extended Echo Ranging Systems (EER/IEER) – 80 IEER sonobuoy deployments

(D) Missile Exercises – 4 exercises

(b) This authorization is also valid for the activities and sources listed in 4(a) should the amounts (i.e., hours, dips, number of exercises) vary from those estimated in 4(a), provided that the variation does not result in exceeding the amount of take indicated in 5(a), below.

5. (a) The annual incidental take of marine mammals under the activities identified in 4, above, and § 218.120(c) is limited to the species listed in 5(b) and 5(c) below, by the indicated method of take and the indicated number of times (estimated based on the authorized amounts of sound source operation), but with the following allowances for annual variation in activities:

(1) Annual take (a post-calculation/estimation of which must be provided in the 2013 LOA application) of any species of marine mammal may not exceed the amount identified in 5 (b) and 5(c), below, for that species by more than 25 percent.

(2) Annual take total of all marine mammal species combined may not exceed the estimated total, indicated in 5(b) and 5(c), by more than 10 percent.

(3) The total take of any species over the course of five years may not exceed the amounts indicated in 50 CFR 218.122(c)(1), which is 10% above the numbers indicated in 5(b) and 5(c) below multiplied by 5 for each year of the rule. A running calculation/estimation of takes of each species over the course of the years covered by the rule must be maintained.

(b) Level B Harassment:

(1) Mysticetes:

(i) Humpback whale (*Megaptera novaeangliae*) – 1,395 per year

(ii) Fin whale (*Balaenoptera physalus*) – 11,037 per year

(iii) Blue whale (*Balaenoptera musculus*) – 2 per year

(iv) Sei whale (*Balaenoptera borealis*) – 8 per year

(v) Minke whale (*Balaenoptera acutorostrata*) – 681 per year

(vi) Gray whale (*Eschrichtius robustus*) – 388 per year

(vii) North Pacific right whale (*Eubalaena japonica*) – 2 per year

(2) Odontocetes:

(i) Sperm whales (*Physeter macrocephalus*) – 329 per year

(ii) Killer whale (*Orcinus orca*) – 10,649 per year

(iii) Harbor porpoise (*Phocoena phocoena*) – 5,440 per year

(iv) Baird's beaked whales (*Berardius bairdii*) – 487 per year

(v) Cuvier's beaked whales (*Ziphius cavirostris*) – 2,312 per year

(vi) Stejneger's beaked whale (*Mesoplodon stejnegeri*) – 2,312 per year

(vii) Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) – 16,991 per year

(viii) Dall's porpoise (*Phocoenoides dalli*) – 206,374 per year.

(3) Pinnipeds:

(i) Steller sea lion (*Eumetopias jubatus*) – 11,108 per year

(ii) California sea lion (*Zalophus californianus*) – 2 per year

(iii) Harbor seal (*Phoca vitulina richardsi*) – 2 per year

(iv) Northern elephant seal (*Mirounga angustirostris*) – 2,069 per year

(v) Northern fur seal (*Callorhinus ursinus*) – 154,202 per year.

(c) Level A Harassment and/or mortality of no more than 15 beaked whales (total), of any of the species listed in § 218.122(c)(1)(ii)(D) through (F) over the course of the 5-year regulations.

2.3 Mitigation Measures Proposed by the Navy

As required to satisfy the requirements of the MMPA, the Navy proposes to implement measures that would allow their training activities to have the least practicable adverse impact on marine mammal species or stocks (which includes considerations of personnel safety, practicality of implementation, and impact on the effectiveness of the "military readiness activity"). Those measures are provided in this section of this opinion.

2.3.1 Personnel Training—Watchstanders and Lookouts

The Navy proposes to use shipboard lookouts (also referred to as "watchstanders") at all times (day and night) when a ship or surfaced submarine is moving through the water. These individuals would be trained observers of the marine environment. Their duties would include the reporting of 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. Additionally the following standard operating procedures would be followed:

- All commanding officers (COs), executive officers (XOs), lookouts, officers of the deck, junior officers of the deck, maritime patrol aircraft aircrews, and ASW/mine warfare (MIW) helicopter crews will complete the NMFS-approved marine species awareness training (MSAT) by viewing the Navy MSAT digital versatile disk. The MSAT may also be viewed on-line at https://portal.navfac.navy.mil/go/msat. The MSAT training must be reviewed at least annually and again prior to the first use of mid-frequency active (MFA) sonar and/or improved extended echo ranging systems (IEER) during major ASW exercises. This training must be recorded in the individual's training record.
- Navy lookouts will undertake extensive training to qualify as a watchstander in accordance with the lookout training handbook (Naval Education and Training Command [NAVEDTRA] 12968-D).
- Lookout training will include on-the-job instruction under the supervision of a qualified, experienced watchstander. Following successful completion of this supervised training period, lookouts will complete the personal qualification standard program, certifying that they have demonstrated the necessary skills (such as detection and reporting of partially submerged objects). Personnel being trained as lookouts can be counted among required lookouts as long as supervisors monitor their progress and performance.
- Lookouts will be trained in the most effective means to ensure quick and effective communication within the command structure to facilitate implementation of mitigation measures if marine species are spotted.
- Lookouts' ability to detect objects in the water, including marine mammals and sea turtles, is critical to Navy environmental compliance and will be evaluated by Navy and contracted biologists.

2.3.2 Operating Procedures and Collision Avoidance

- Prior to major exercises, a letter of instruction, mitigation measures message or environmental annex to the operational order will be issued to further disseminate the personnel training requirement and general marine species mitigation measures.
- Each CO will make use of marine species detection cues and information to limit interaction with marine species to the maximum extent possible consistent with safety of the ship.
- While underway, surface vessels will have at least two lookouts with binoculars; surfaced submarines will have at least one lookout with binoculars. Lookouts already posted for safety of navigation and man-overboard precautions may be used to fill this requirement. As part of their regular duties, lookouts will watch for and report to the OOD the presence of marine mammals and sea turtles.

- On surface vessels equipped with a MFA sonar, pedestal mounted “Big Eye” (20x110) binoculars will be properly installed and in good working order to assist in the detection of marine mammals in the vicinity of the vessel.
- Personnel on lookout will employ visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook.
- After sunset and prior to sunrise, lookouts will employ night lookout techniques in accordance with the lookout training handbook.
- Personnel on lookout will be responsible for reporting all objects or anomalies sighted in the water (regardless of the distance from the vessel) to the officer of the deck, since any object or disturbance (e.g., trash, periscope, surface disturbance, discoloration) in the water may be indicative of a threat to the vessel and its crew, or indicative of a marine species that may need to be avoided as warranted. Navy environmental compliance relies heavily on the abilities of lookouts to detect and avoid protected species. Therefore, it is critical that lookouts be vigilant in their reporting.
- While in transit, naval vessels will be alert at all times, use extreme caution, and proceed at a “safe speed” so that the vessel can take proper and effective action to avoid a collision with any marine animal and can be stopped within a distance appropriate to the prevailing circumstances and conditions.
- When sea turtles or marine mammals have been sighted in the area, Navy vessels will increase vigilance and take reasonable and practicable actions to avoid collisions and activities that might result in close interaction of naval assets and marine mammals. Actions may include changing speed and/or direction and are dictated by environmental and other conditions (e.g., safety, weather).
- Naval vessels will maneuver to keep at least 1,500 ft (500 yds) away from any observed whale in the vessel's path and avoid approaching whales head-on. These requirements do not apply if a vessel's safety is threatened, such as when change of course will create an imminent and serious threat to a person, vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver. Restricted maneuverability includes, but is not limited to, situations when vessels are engaged in dredging, submerged activities, launching and recovering aircraft or landing craft, minesweeping activities, replenishment while underway and towing activities that severely restrict a vessel's ability to deviate course. Vessels will take reasonable steps to alert other vessels in the vicinity of the whale. Given rapid swimming speeds and maneuverability of many dolphin species, naval vessels would maintain normal course and speed on sighting dolphins unless some condition indicated a need for the vessel to maneuver.

- Floating weeds and kelp, algal mats, clusters of seabirds, and jellyfish are good indicators of marine mammals or sea turtles. Therefore, where these circumstances are present, the Navy will exercise increased vigilance in watching for marine mammals or sea turtles.
- Navy aircraft participating in exercises at sea will conduct and maintain, when operationally feasible and safe, surveillance for marine mammals as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties.
- All vessels will maintain logs and records documenting training operations should they be required for event reconstruction purposes. Logs and records will be kept for a period of 30 days following completion of a major training exercise.

2.3.3 Measures for Specific Training Events

The Navy proposes to apply specific measures for each type of training event to reduce the likelihood of adverse impacts to ESA-listed species. These measures are described below based on the type of training activity.

Mid-Frequency Active Sonar Activities

Active sonar activities would include the implementation of general mitigation measures related to training of Navy personnel and the use of lookout and watchstanders. The Navy would issue and follow operating procedures related to active sonar activities specific to each exercise.

General Maritime Mitigation Measures: Personnel Training

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

General Maritime Mitigation Measures: Lookout and Watchstander Responsibilities

- On the bridge of surface ships, there will always be at least three people on watch whose duties include observing the water surface around the vessel.
- All surface ships participating in ASW training events will, in addition to the three personnel on watch noted previously, have at all times during the exercise at least two additional personnel on watch as marine mammal lookouts.
- Personnel on lookout and officers on watch on the bridge will have at least one set of binoculars available for each person to aid in the detection of marine mammals.
- On surface vessels equipped with MFA sonar, pedestal mounted "Big Eye" (20x110) binoculars will be present and in good working order to assist in the detection of marine mammals in the vicinity of the vessel.
- Personnel on lookout will employ visual search procedures employing a scanning methodology in accordance with the lookout training handbook.
- After sunset and prior to sunrise, lookouts will employ night lookout techniques in accordance with the lookout training handbook.
- Personnel on lookout will be responsible for reporting all objects or anomalies sighted in the water (regardless of the distance from the vessel) to the officer of the deck, since any object or disturbance (e.g., trash, periscope, surface disturbance, discoloration) in the water may be indicative of a threat to the vessel and its crew or indicative of a marine species that may need to be avoided.

Operating Procedures

- A letter of instruction, mitigation measures message, or environmental annex to the operational order will be issued prior to the exercise to further disseminate the personnel training requirement and general marine mammal mitigation measures.
- Commanding officers and officers in charge will make use of marine species detection cues and information to limit interaction with marine species to the maximum extent possible, consistent with safety of the ship.
- All personnel engaged in passive acoustic sonar operation (including aircraft, surface ships, or submarines) will monitor for marine mammal vocalizations and report the detection of any marine mammal to the appropriate watch station for dissemination and appropriate action.
- During MFA sonar operations, personnel will utilize all available sensor and optical systems (such as night vision goggles) to aid in the detection of marine mammals.
- Navy aircraft participating in exercises at sea will conduct and maintain, when operationally feasible and safe, surveillance for marine species of concern as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties.

- Aircraft with deployed sonobuoys will use only the passive capability of sonobuoys when marine mammals are detected within 200 yd (183 m) of the sonobuoy. Only the sonobuoys that are impacted by the mammal presence within 200 yd (183 m) need to be used in passive mode.
- Marine mammal detections will be immediately reported to assigned Aircraft Control Unit for further dissemination to ships in the vicinity of the marine species, as appropriate, where it is reasonable to conclude that the course of the ship will likely result in a closing of the distance to the detected marine mammal.
- Safety Zones—When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) within 1,000 yd (914 m) of the sonar dome or window, the ship or submarine will limit active transmission levels to at least 6 decibels (dB) below normal operating levels. (A 6 dB reduction equates to a 75 percent power reduction. The reason is that decibel levels are on a logarithmic scale, not a linear scale. Thus, a 6 dB reduction results in a power level only 25 percent of the original power.)
- Ships and submarines will continue to limit maximum transmission levels by this 6-dB factor until the animal has been seen to leave the 1,000 yd safety zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 m) beyond the location of the last detection.
- Should a marine mammal be detected within 500 yd (457 m) of the sonar dome, active sonar transmissions will be limited to at least 10 dB below the equipment's normal operating level. Ships and submarines will continue to limit maximum ping levels by this 10-dB factor until the animal has been seen to leave the 500 yd safety zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 m) beyond the location of the last detection.
- Should the marine mammal be detected within 200 yd (183 m) of the sonar dome, active sonar transmissions will cease. Sonar will not resume until the animal has been seen to leave the 200 yd safety zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 m) beyond the location of the last detection.
- Special conditions applicable for dolphins and porpoises only: If, after conducting an initial maneuver to avoid close quarters with dolphins or porpoises, the officer of the deck concludes that dolphins or porpoises are deliberately closing to ride the vessel's bow wave, no further mitigation actions are necessary while the dolphins or porpoises continue to exhibit bow wave riding behavior.
- If the need for power-down should arise as detailed in “Safety Zones” above, the Navy will follow the requirements as though they were operating at 235 dB, the normal operating level (i.e., the first power-down will be to 229 dB, regardless of at what level above 235 dB active sonar was being operated).

- Prior to start up or restart of active sonar, operators will check that the Safety Zone radius around the sound source is clear of marine mammals.
- Active sonar levels (generally)—Navy will operate active sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet tactical training objectives.
- Helicopters will observe/survey the vicinity of an ASW training event for 10 minutes before the first deployment of active (dipping) sonar in the water.
- Helicopters will not dip their active sonar within 200 yd (183 m) of a marine mammal and will cease pinging if a marine mammal closes within 200 yd (183 m) after pinging has begun.
- Submarine sonar operators will review detection indicators of close-aboard marine mammals prior to the commencement of ASW training events involving MFA sonar.
- Night vision goggles will be available to all ships and air crews, for use as appropriate.
- Increased vigilance during major ASW training exercise with active sonar when critical conditions are present.

2.3.4 Surface-to-Surface Gunnery (up to 5-inch explosive rounds)

- Lookouts will visually survey for floating weeds and kelp. Intended impact (i.e., where the Navy is aiming) will not be within 600 yards (yd) (549 m) of known or observed floating weeds and kelp, and algal mats.
- A 600 yd (549 m) radius buffer zone will be established around the intended target.
- From the intended firing position, lookouts will survey the buffer zone for marine mammals prior to commencement and during the exercise as long as practicable.
- For exercises using targets towed by a vessel or aircraft, target-towing vessels/aircraft will maintain a trained lookout for marine mammals, if applicable. If a marine mammal is sighted in the vicinity, the tow aircraft/vessel will immediately notify the firing vessel, which will suspend the exercise until the area is clear.
- The exercise will be conducted only when the buffer zone is visible and marine mammals are not detected within it.

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

- Lookouts will visually survey for floating weeds and kelp, and algal mats. Intended impact will not be within 200 yd (183 m) of known or observed floating weeds and kelp, and algal mats.
- A 200 yd (183 m) radius buffer zone will be established around the intended target.
- From the intended firing position, trained lookouts will survey the buffer zone for marine mammals prior to commencement and during the exercise as long as practicable.

- If applicable, target towing vessels will maintain a lookout. If a marine mammal is sighted in the vicinity of the exercise, the tow vessel will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.
- The exercise will be conducted only when the buffer zone is visible and marine mammals are not detected within the target area and the buffer zone.

2.3.6 Surface-to-Air Gunnery (explosive/non-explosive rounds)

- Vessels will orient the geometry of gunnery exercises in order to prevent military expended materials from falling in the area of sighted marine mammals.
- Vessels will expedite the recovery of any parachute deploying aerial targets to reduce the potential for entanglement of marine mammals.
- Target towing aircraft will maintain a lookout, if applicable. If a marine mammal is sighted in the vicinity of the exercise, the tow aircraft will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.

2.3.7 Air-to-Surface Gunnery (explosive/non-explosive rounds)

- If surface vessels are involved, lookouts will visually survey for floating kelp in the target area.
- Impact will not occur within 200 yd (183 m) of known or observed floating weeds and kelp or algal mats.
- A 200 yd (183 m) radius buffer zone will be established around the intended target.
- If surface vessels are involved, lookout(s) will visually survey the buffer zone for marine mammals prior to and during the exercise.
- Aerial surveillance of the buffer zone for marine mammals will be conducted prior to commencement of the exercise. Aircraft crew/pilot will maintain visual watch during exercises. Release of ordnance through cloud cover is prohibited; aircraft must be able to actually see ordnance impact areas.
- The exercise will be conducted only if marine mammals are not visible within the buffer zone.

2.3.8 Air-to-Surface At-Sea Bombing Exercises (explosive/non-explosive rounds)

- If surface vessels are involved, trained lookouts will survey for floating kelp and marine mammals. Ordnance will not be targeted to impact within 1,000 yd (914 m) of known or observed floating kelp or marine mammals.
- A 1,000 yd (914 m) radius buffer zone will be established around the intended target.

- Aircraft will visually survey the target and buffer zone for marine mammals prior to and during the exercise. The survey of the impact area will be made by flying at 1,500 ft (457 m) or lower, if safe to do so, and at the slowest safe speed. When safety or other considerations require the release of weapons without the releasing pilot having visual sight of the target area, a second aircraft, the ‘‘wingman,’’ shall clear the target area and perform the clearance and observation functions required before the dropping plane may release its weapons. Both planes shall have direct communication to assure immediate notification to the dropping plane that the target area may have been fouled by encroaching animals or people. The clearing aircraft shall assure it has visual site of the target area at a maximum height of 1,500 ft (457 m). The clearing plane shall remain within visual sight of the target until required to clear the area for safety reasons. Survey aircraft shall employ most effective search tactics and capabilities.
- The exercises will be conducted only if marine mammals are not visible within the buffer zone.

2.3.9 Air-to-Surface Missile Exercises (explosive/non-explosive rounds)

- Aircraft will visually survey the target area for marine mammals. Visual inspection of the target area will be made by flying at 1,500 ft (457 m) or lower, if safe to do so, and at slowest safe speed. Firing or range clearance aircraft must be able to actually see ordnance impact areas.
- Explosive ordnance will not be targeted to impact within 1,800 yd (1646 m) of sighted marine mammals.

2.3.10 . Explosive Source Sonobuoys

Pattern Deployment. Crews will conduct visual reconnaissance of the drop area prior to laying their intended sonobuoy pattern. This search will be conducted below 1,500 ft (457 m) at a slow speed, if operationally feasible and weather conditions permit. In dual aircraft operations, crews are allowed to conduct coordinated area clearances.

Crews will conduct a minimum of 30 minutes of visual and aural monitoring of the search area prior to commanding the first post (source/receiver sonobuoy pair) detonation. This 30-minute observation period may include pattern deployment time.

For any part of the briefed pattern where a post (source/receiver sonobuoy pair) will be deployed within 1,000 yd (914 m) of observed marine mammal activity, the Navy will deploy the receiver ONLY and monitor while conducting a visual search. When marine mammals are no longer detected within 1,000 yd (914 m) of the intended post position, the Navy will co-locate the explosive source sonobuoys (AN/SSQ-110A) (source) with the receiver.

When able, Navy crews will conduct continuous visual and aural monitoring of marine mammal activity. This is to include monitoring of aircraft sensors from first sensor placement to checking off-station and out of Radio Frequency (RF) range of these sensors.

Pattern Employment. Aural Detection: If the presence of marine mammals is detected aurally, then that will cue the Navy aircrew to increase the diligence of their visual surveillance. Subsequently, if no marine mammals are visually detected, then the crew may continue multi-static active search.

Visual Detection: If marine mammals are visually detected within 1,000 yd (914 m) of the explosive source sonobuoys (AN/SSQ-110A) intended for use, then that payload will not be detonated. Aircrews may utilize this post once the marine mammals have not been re-sighted for 30 minutes, or are observed to have moved outside the 1,000 yd (914 m) safety buffer.

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

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

Aircrews will only leave posts with unexploded charges in the event of a sonobuoy malfunction, an aircraft system malfunction, or when an aircraft must immediately depart the area due to issues such as fuel constraints, inclement weather, and in-flight emergencies. In these cases, the sonobuoy will self-scuttle using the secondary or tertiary method.

The Navy will ensure all payloads are accounted for. Explosive source sonobuoys (AN/SSQ-110A) that cannot be scuttled will be reported as unexploded ordnance via voice communications while airborne, then upon landing via naval message. Mammal monitoring will continue until out of own-aircraft sensor range.

2.4 Mitigation Requirements

NMFS Permits Division included required mitigation measures in their regulations (76 FR 25480). The Navy is required to implement these measures when conducting training and utilizing the sound sources or explosives (text below is verbatim from MMPA regulation, as such some acronyms or abbreviations may be either unique to this section or repeated from earlier in this opinion). Note that mitigation requirements for sinking exercises appears below, because those requirements are part of the regulation, however, the Navy does not intend to conduct any sinking exercises during the remainder of the MMPA regulation period and they will not be included in the LOA:

(1) Personnel Training:

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

(ii) Navy lookouts will undertake extensive training in order to qualify as a watch stander in accordance with the Lookout Training Handbook (Naval Education and Training Command [NAVEDTRA] 12968–D).

(iii) Lookout training will include on the-job instruction under the supervision of a qualified, experienced lookout. Following successful completion of this supervised training period, lookouts will complete the Personal Qualification Standard Program, certifying that they have demonstrated the necessary skills (such as detection and reporting of partially submerged objects). Personnel being trained as lookouts can be counted among required lookouts as long as supervisors monitor their progress and performance.

(iv) Lookouts will be trained in the most effective means to ensure quick and effective communication within the command structure in order to facilitate implementation of protective measures if marine species are spotted.

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

(vi) All COs, XOs, and officers standing watch on the bridge will have reviewed the Marine Species Awareness Training material prior to a training event employing the use of MFAS/ HFAS.

(2) General Operating Procedures (for all training types):

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

(ii) COs will make use of marine species detection cues and information to limit interaction with marine mammals to the maximum extent possible consistent with safety of the ship.

(iii) While underway, surface vessels will have at least two lookouts with binoculars; surfaced submarines will have at least one lookout with binoculars. Lookouts already posted for safety of navigation and man-overboard precautions shall be used to fill this requirement. As part of their regular duties, lookouts will watch for and report to the officer of the deck the presence of marine mammals.

(iv) On surface vessels equipped with a multi-function active sensor, pedestal mounted ‘‘Big Eye’’ (20×110) binoculars will be properly installed and in good working order to assist in the detection of marine mammals in the vicinity of the vessel.

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

(vi) After sunset and prior to sunrise, lookouts will employ Night Lookouts Techniques in accordance with the Lookout Training Handbook (NAVEDTRA 12968–D).

(vii) While in transit, naval vessels will be alert at all times, use extreme caution, and proceed at a ‘‘safe speed’’, which means the speed at which the CO can maintain crew safety and effectiveness of current operational directives, so that the vessel can take action to avoid a collision with any marine mammal.

(viii) When marine mammals have been sighted in the area, Navy vessels will increase vigilance and take all reasonable actions to avoid collisions and close interaction of naval assets and marine mammals. Such action shall include changing speed and/or direction and are dictated by environmental and other conditions (e.g., safety, weather).

(ix) Navy aircraft participating in exercises at-sea will conduct and maintain surveillance for marine mammals as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties.

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

(xi) Naval vessels will maneuver to keep at least 1,500 ft (500 yd or 457 m) away from any observed whale in the vessel’s path and avoid approaching whales head-on. These requirements do not apply if a vessel’s safety is threatened, such as when change of course will create an imminent and serious threat to a person, vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver. Restricted maneuverability includes, but is not limited to, situations when vessels are engaged in dredging, submerged activities, launching and recovering aircraft or landing craft, minesweeping activities, replenishment while underway and towing activities that severely restrict a vessel’s ability to deviate course. Vessels will take reasonable steps to alert other vessels in the vicinity of the whale. Given rapid swimming speeds and maneuverability of many dolphin species, naval vessels would maintain normal course and speed on sighting dolphins unless some condition indicated a need for the vessel to maneuver.

(3) Operating Procedures (for Antisubmarine Warfare (ASW) Operations):

(i) On the bridge of surface ships, there will always be at least three people on watch whose duties include observing the water surface around the vessel.

(ii) All surface ships participating in ASW training events will have, in addition to the three personnel on watch noted in paragraph (a)(3)(i) of this section, at least two additional personnel on watch as lookouts at all times during the exercise.

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

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

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

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

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

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

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

(x) Safety Zones—When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) within 1,000 yd (914 m) of the sonar dome or window, the ship or submarine will limit active transmission levels to at least 6 decibels (dB) below normal operating levels for that source (i.e., limit to at most 229 dB for AN/SQS–53 and 219 for AN/SQS– 56, etc.).

(A) Ships and submarines will continue to limit maximum transmission levels by this 6–dB factor until the animal has been seen to leave the 1,000-yd (914 m) exclusion zone, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yds (1,829 m) beyond the location of the last detection.

(B) Should a marine mammal be detected within 500 yd (457 m) of the sonar dome, active sonar transmissions will be limited to at least 10 dB below the equipment’s normal operating level (i.e., limit to at most 225 dB for AN/ SQS–53 and 215 for AN/SQS–56, etc.). Ships and submarines will continue to limit maximum ping levels by this 10– dB factor until the animal has been seen to leave the 500-yd (457 m) safety zone (at which point the 6–dB power down applies until the animal leaves the 1,000-yd (914 m) safety zone), has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 m) beyond the location of the last detection.

(C) Should the marine mammal be detected within 200 yd (183 m) of the sonar dome, active sonar transmissions will cease. Sonar will not resume until the animal has been seen to leave the 200-yd (183 m) safety zone (at which point the 10–dB or 6–dB power downs apply until the animal leaves the 500-yd (457 m) or 1,000-yd (914 m) safety zone, respectively), has not been detected for 30 minutes, or the vessel has transited more than 2,000 yd (1,829 m) beyond the location of the last detection.

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

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

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

(xiii) Submarine sonar operators will review detection indicators of close aboard marine mammals prior to the commencement of ASW training events involving MFAS.

(xiv) If the need for power-down should arise (as detailed in § 218.114(a)(3)(x)) when the Navy is operating a hull-mounted or sub-mounted source above 235 dB (infrequent), the Navy will follow the requirements as though they were operating at 235 dB—the normal operating level (i.e., the first power-down will be to 229 dB, regardless of at what level above 235 dB active sonar was being operated).

(4) Sinking Exercise:

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

(ii) An exclusion zone with a radius of 1.0 nm (1.9 km) will be established around each target. An additional buffer of 0.5 nm (0.9 km) will be added to account for errors, target drift, and animal movements. Additionally, a safety zone, which will extend beyond the buffer zone by an additional 0.5 nm (0.9 km), will be surveyed. Together, the zones extend out 2 nm (3.7 km) from the target.

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

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

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

(C) In addition to the over-flights, the exclusion zone will be monitored by passive acoustic means, when assets are available. This passive acoustic monitoring will be maintained throughout the exercise. Additionally, passive sonar onboard submarines shall be utilized to detect any vocalizing marine mammals in the area. The OCE will be informed of any aural detection of marine mammals and will include this information in the determination of when it is safe to commence the exercise.

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

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

(F) If a marine mammal is observed within the exclusion zone, firing will be delayed until the animal is re-sighted outside the exclusion zone, or 30 minutes have elapsed. After 30 minutes, if the animal has not been re-sighted it can be assumed to have left the exclusion zone. The OCE will determine if the marine mammal is in danger of being adversely affected by commencement of the exercise.

(G) During breaks in the exercise of 30 minutes or more, the exclusion zone will again be surveyed for any marine mammal. If marine mammals are sighted within the exclusion zone or buffer zone, the OCE will be notified, and the procedure described above will be followed.

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

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

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

(vi) The exercise will not be conducted unless the exclusion zone and the buffer zone can be adequately monitored visually. Should low cloud cover or surface visibility prevent adequate visual monitoring as described previously, the exercise will be delayed until conditions improved, and all of the above monitoring criteria can be met.

(vii) In the event that any marine mammals are observed to be harmed in the area, a detailed description of the animal will be taken, the location noted, and if possible, photos taken of the marine mammal. This information will be provided to NMFS via the Navy's regional environmental coordinator for purposes of identification (see the draft Stranding Plan for detail).

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

(5) Surface-to-Surface Gunnery (up to 5-inch Explosive Rounds):

(i) For exercises using targets towed by a vessel, target-towing vessels will maintain a trained lookout for marine mammals when feasible. If a marine mammal is sighted in the vicinity, the tow vessel will immediately notify the firing vessel, which will suspend the exercise until the area is clear.

(ii) A 600-yd (585 m) radius buffer zone will be established around the intended target.

(iii) From the intended firing position, trained lookouts will survey the buffer zone for marine mammals prior to commencement and during the exercise as long as practicable. Due to the distance between the firing position and the buffer zone, lookouts are only expected to visually detect breaching whales, whale blows, and large pods of dolphins and porpoises.

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

(6) Surface-to-Surface Gunnery (nonexplosive rounds):

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

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

(iii) If available, target towing vessels will maintain a lookout (unmanned towing vessels will not have a lookout available). If a marine mammal is sighted in the vicinity of the exercise, the tow vessel will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.

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

(7) Surface-to-Air Gunnery (Explosive and Non-explosive Rounds):

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

(ii) Vessels will expedite the attempt to recover any parachute deploying aerial targets to reduce the potential for entanglement of marine mammals.

(iii) Target towing aircraft will maintain a lookout if feasible. If a marine mammal is sighted in the vicinity of the exercise, the tow aircraft will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.

(8) Air-to-Surface Gunnery (Explosive and Non-explosive Rounds):

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

(ii) If surface vessels are involved, lookout(s) will visually survey the buffer zone for marine mammals to and during the exercise.

(iii) Aerial surveillance of the buffer zone for marine mammals will be conducted prior to commencement of the exercise. Aerial surveillance altitude of 500 ft to 1,500 ft (152–456 m) is optimum. Aircraft crew/pilot will maintain visual watch during exercises. Release of ordnance through cloud cover is prohibited; aircraft must be able to actually see ordnance impact areas.

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

(9) Small Arms Training (Grenades, Explosive and Non-explosive Rounds)—Lookouts will visually survey for marine mammals. Weapons will not be fired in the direction of known or observed marine mammals.

(10) Air-to-Surface At-sea Bombing Exercises (explosive bombs and rockets):

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

(ii) A 1,000-yd (914 m) radius buffer zone will be established around the intended target.

(iii) Aircraft will visually survey the target and buffer zone for marine mammals prior to and during the exercise. The survey of the impact area will be made by flying at 1,500 ft (457 m) or lower, if safe to do so, and at the slowest safe speed. When safety or other considerations require the release of weapons without the releasing pilot having visual sight of the target area, a second aircraft, the ‘‘wingman,’’ will clear the target area and perform the clearance and observation functions required before the dropping plane shall release its weapons. Both planes will have direct communication to assure immediate notification to the dropping plane that the target area shall have been fouled by encroaching animals or people. The clearing aircraft will assure it has visual site of the target area at a maximum height of 1,500 ft (457 m). The clearing plane will remain within visual sight of the target until required to clear the area for safety reasons. Survey aircraft will employ most effective search tactics and capabilities.

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

(11) Air-to-Surface At-Sea Bombing Exercises (Non-explosive Bombs and Rockets):

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

(ii) A 1,000-yd (914 m) radius buffer zone will be established around the intended target.

(iii) Aircraft will visually survey the target and buffer zone for marine mammals prior to and during the exercise. The survey of the impact area will be made by flying at 1,500 ft (457 m) or lower, if safe to do so, and at the slowest safe speed. When safety or other considerations require the release of weapons without the releasing pilot having visual sight of the target area, a second aircraft, the ‘‘wingman,’’ will clear the target area and perform the clearance and observation functions required before the dropping plane shall release its weapons. Both planes must have direct communication to assure immediate notification to the dropping plane that the target area shall have been fouled by encroaching animals or people. The clearing aircraft will assure it has visual site of the target area at a maximum height of 1,500 ft (457 m). The clearing plane will remain within visual sight of the target until required to clear the area for safety reasons. Survey aircraft will employ most effective search tactics and capabilities.

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

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

(i) Aircraft will visually survey the target area for marine mammals. Visual inspection of the target area will be made by flying at 1,500 ft (457 m) or lower, if safe to do so, and at the slowest safe speed. Firing or range clearance aircraft must be able to actually see ordnance impact areas.

(ii) Explosive ordnance will not be targeted to impact within 1,800 yd (1646 m) of sighted marine mammals.

(13) Aircraft Training Activities Involving Non-Explosive Devices: Nonexplosive devices such as some sonobuoys and inert bombs involve aerial drops of devices that have the potential to hit marine mammals if they are in the immediate vicinity of a floating target. The exclusion zone (200 yd), therefore, will be clear of marine mammals and around the target location.

(14) Extended Echo Ranging/ Improved Extended Echo Ranging (EER/ IEER):

(i) Crews will conduct visual reconnaissance of the drop area prior to laying their intended sonobuoy pattern. This search will be conducted at an altitude below 500 yd (457 m) at a slow speed, if operationally feasible and weather conditions permit. In dual aircraft operations, crews are allowed to conduct coordinated area clearances.

(ii) Crews will conduct a minimum of 30 minutes of visual and aural monitoring of the search area prior to commanding the first post detonation. This 30-minute observation period shall include pattern deployment time.

(iii) For any part of the briefed pattern where a post (source/receiver sonobuoy pair) will be deployed within 1,000 yd (914 m) of observed marine mammal activity, the Navy will deploy the receiver ONLY and monitor while conducting a visual search. When marine mammals are no longer detected within 1,000 yd (914 m) of the intended post position, the Navy will co-locate the explosive source sonobuoy (AN/ SSQ–110A) (source) with the receiver.

(iv) When operationally feasible, Navy crews will conduct continuous visual and aural monitoring of marine mammal activity. This is to include monitoring of own-aircraft sensors from first sensor placement to checking off station and out of RF range of these sensors.

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

(vi) Visual Detection—If marine mammals are visually detected within 1,000 yd (914 m) of the explosive source sonobuoy (AN/SSQ–110A) intended for use, then that payload will not be detonated. Aircrews shall utilize this post once the marine mammals have not been re-sighted for 30 minutes, or are observed to have moved outside the 1,000-yd (914 m) safety buffer. Aircrews shall shift their multi-static active search to another post, where marine mammals are outside the 1,000-yd (914 m) safety buffer.

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

(viii) Aircrews will only leave posts with unexploded charges in the event of a sonobuoy malfunction, an aircraft system malfunction, or when an aircraft must immediately depart the area due to issues such as fuel constraints, inclement weather, and in-flight emergencies. In these cases, the sonobuoy will self-scuttle using the secondary or tertiary method.

(ix) The Navy will ensure all payloads are accounted for. Explosive source sonobuoys (AN/SSQ–110A) that cannot be scuttled will be reported as unexploded ordnance via voice communications while airborne, then upon landing via naval message.

(x) Marine mammal monitoring will continue until out of aircraft sensor range.

(15) The Navy will abide by the letter of the ‘‘Stranding Response Plan for Major Navy Training Exercises in the GoA TMAA’’ (available at: http:// www.nmfs.noaa.gov/pr/permits/ incidental.htm), which is incorporated herein by reference, to include the following measures:

(i) Shutdown Procedures—When an Uncommon Stranding Event (USE— defined in § 216.271) occurs during a Major Training Exercise (MTE) (as defined in the Stranding Plan, meaning including Multi-strike group exercises, Joint Expeditionary exercises, and Marine Air Ground Task Force exercises in the GoA TMAA), the

Navy will implement the procedures described below.

(A) The Navy will implement a Shutdown (as defined in the Stranding Response Plan for GoA TMAA) when advised by a NMFS Office of Protected Resources Headquarters Senior Official designated in the GoA TMAA Stranding Communication Protocol that a USE (as defined in the Stranding Response Plan for the GoA TMAA) involving live animals has been identified and that at least one live animal is located in the water. NMFS and Navy will communicate, as needed, regarding the identification of the USE and the potential need to implement shutdown procedures.

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

(C) If the Navy finds an injured or dead marine mammal floating at sea during an MTE, the Navy will notify NMFS immediately or as soon as operational security considerations allow. The Navy will provide NMFS with the 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(s) (if alive), and photo or video of the animal(s) (if available). Based on the information provided, NMFS will determine if, and advise the Navy whether a modified shutdown is appropriate on a case-by-case basis.

(D) In the event, following a USE, that: 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 will coordinate (including an investigation of other potential anthropogenic stressors in the area) to determine if the proximity of MFAS/ HFAS activities or explosive detonations, though farther than 14 nm from the distressed animal(s), is likely decreasing the likelihood that the animals return to the open water. If so, NMFS and the Navy will further coordinate to determine what measures are necessary to further minimize that likelihood and implement those measures as appropriate.

(ii) Within 72 hrs of NMFS notifying the Navy of the presence of a USE, the Navy will provide available information to NMFS (per the GoA TMAA Communication Protocol) regarding the location, number and types of acoustic/explosive sources, direction and speed of units using MFAS/HFAS, and marine mammal sightings information associated with training activities occurring within 80 nm (148 km) and 72 hrs prior to the USE event. Information not initially available regarding the 80 nm (148 km) and 72 hrs 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.

(iii) Memorandum of Agreement (MOA)—The Navy and NMFS will develop a MOA, or other mechanism, that will establish a framework whereby the Navy can (and provide the Navy examples of how they can best) assist NMFS with stranding investigations in certain circumstances. (b) [Reserved] § 218.125 Requirements for monitoring and reporting.

(a) General Notification of Injured or Dead Marine Mammals—Navy personnel will ensure that NMFS is notified immediately ((see Communication Plan) or as soon as clearance procedures allow) if an injured, stranded, or dead marine mammal is found during or shortly after, and in the vicinity of, any Navy training exercise utilizing MFAS, HFAS, or underwater explosive detonations. The Navy will provide NMFS with the 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 behavior(s) (if alive), and photo or video of the animal(s) (if available). In the event that an injured, stranded, or dead marine mammal is found by the Navy that is not in the vicinity of, or during or shortly after, MFAS, HFAS, or underwater explosive detonations, the Navy will report the same information as listed above as soon as operationally feasible and clearance procedures allow.

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

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

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

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

(4) Provide NMFS a photo or video of the animal(s), if equipment is available.

(c) The Navy must conduct all monitoring and/or research required under the Letter of Authorization including abiding by the GoA TMAA Monitoring Plan. (http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications)

(d) Report on Monitoring required in paragraph (c) of this section—The Navy will submit a report annually on December 15 describing the implementation and results (through October of the same year) of the monitoring required in paragraph (c) of this section. The Navy will standardize data collection methods across ranges to allow for comparison in different geographic locations.

(e) Sonar Exercise Notification—The Navy will submit to the NMFS Office of Protected Resources (specific contact information to be provided in LOA) either an electronic (preferably) or verbal report within 15 calendar days after the completion of any MTER indicating:

(1) Location of the exercise;

(2) Beginning and end dates of the exercise; and

(3) Type of exercise.

(f) Annual GoA TMAA Report—The Navy will submit an Annual Exercise GoA TMAA Report on December 15 of every year (covering data gathered through October). This report will contain the subsections and information indicated below.

(1) MFAS/HFAS Training Exercises— This section will contain the following information for the following Coordinated and Strike Group Exercises: Joint Multi-strike Group Exercises; Joint Expeditionary Exercises; and Marine Air Ground Task Force GoA TMAA:

(i) Exercise Information (for each exercise):

(A) Exercise designator;

(B) Date that exercise began and ended;

(C) Location;

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

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

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

(G) Total hours of observation by watchstanders;

(H) Total hours of all active sonar source operation;

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

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

(ii) Individual marine mammal sighting info (for each sighting in each exercise):

(A) Location of sighting;

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

(C) Number of individuals;

(D) Calves observed (y/n);

(E) Initial Detection Sensor;

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

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

(H) Wave height (ft); (I) Visibility;

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

(K) Indication of whether animal is <200 yd, 200–500 yd, 500–1,000 yd, 1,000–2,000 yd, or >2,000 yd from sonar source in

(x) above;

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

(M) If source in use (x) is hullmounted, true bearing of animal from ship, true direction of ship's travel, and estimation of animal's motion relative to ship (opening, closing, parallel); and

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

(iii) An evaluation (based on data gathered during all of the exercises) of the effectiveness of mitigation measures designed to avoid exposing marine mammals to MFAS. This evaluation will identify the specific observations that support any conclusions the Navy reaches about the effectiveness of the mitigation.

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

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

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

(3) Sinking Exercises (SINKEXs)— This section will include the following information for each SINKEX completed that year:

(i) Exercise info:

(A) Location;

(B) Date and time exercise began and ended;

(C) Total hours of observation by watchstanders before, during, and after exercise;

(D) Total number and types of rounds expended/explosives detonated;

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

(F) Total hours of passive acoustic search time;

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

(H) Wave height in feet (high, low, and average during exercise); and

(I) Narrative description of sensors and platforms utilized for marine mammal detection and timeline illustrating how marine mammal detection was conducted.

(ii) Individual marine mammal observation during SINKEX (by Navy lookouts) information:

(A) Location of sighting;

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

(C) Number of individuals;

(D) Calves observed (y/n);

(E) Initial detection sensor;

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

(G) Wave height (ft);

(H) Visibility;

(I) Whether sighting was before, during, or after detonations/exercise, and how many minutes before or after;

(J) Distance of marine mammal from actual detonations (or target spot if not yet detonated)—use four categories to define distance:

(1) The modeled injury threshold radius for the largest explosive used in that exercise type in that OPAREA (762 m for SINKEX in the GoA TMAA);

(2) The required exclusion zone (1 nm for SINKEX in the GoA TMAA);

(3) The required observation distance (if different than the exclusion zone (2 nm for SINKEX in the GoA TMAA); and

(4) Greater than the required observed distance. For example, in this case, the observer will indicate if <762 m, from 762 m–1 nm, from 1 nm–2 nm, and > 2 nm.

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

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

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

(4) Improved Extended Echo-Ranging System (IEER) Summary:

(i) Total number of IEER events conducted in the GoA TMAA;

(ii) Total expended/detonated rounds (buoys); and

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

(5) Explosives Summary—The Navy is in the process of improving the methods used to track explosive use to provide increased granularity. To the extent practicable, the Navy will provide the information described below for all of their explosive exercises. Until the Navy is able to report in full the information below, they will provide an annual update on the Navy’s explosive tracking methods, including improvements from the previous year.

(i) Total annual number of each type of explosive exercise (of those identified as part of the ‘‘specified activity’’ in this final rule) conducted in the GoA TMAA; and

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

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

(h) Comprehensive National ASW Report—By June, 2014, the Navy will submit a draft National Report that analyzes, compares, and summarizes the active sonar data gathered (through January 1, 2014) from the watchstanders and pursuant to the implementation of the Monitoring Plans for the Northwest Training Range Complex, the Southern California Range Complex, the Atlantic Fleet Active Sonar Training, the Hawai'i Range Complex, the Mariana Islands Range Complex, and the Gulf of Alaska.

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

2.5 Previous Letter of Authorization

Here we provide information regarding the U.S. Navy's activities under the 2011-2013 LOA and biological opinion. This information was provided by the U.S. Navy in annual exercise reports, monitoring reports, and the ESA consultation request package. We also reviewed the classified reports to verify compliance with previous ESA biological opinions and Incidental Take Statements.

2.5.1 Activities Conducted

The Navy conducted a "Northern Edge" exercise in the Gulf of Alaska TMMA on 13-24 June 2011. Sonar use during the exercise was 67 minutes on a single day. Navy watchstanders observed 3 humpback whales and seven unidentified whales. The closest individual reported to the observing vessel was 1,000 yards which was outside the mitigation zone applicable during active sonar.

2.5.2 Activities Not Conducted

The 2011 biological opinion evaluated several proposed activities that were not conducted. The installation and use of a Portable Undersea Tracking Range (PUTR) were not done during 2011 through 2012. There were no Navy modeled potential marine mammal exposures associated with PUTR.

There were no Sink Exercises (SINKEXs) conducted within the Gulf of Alaska TMAA. There were no Navy modeled potential marine mammal exposures associated with SINKEXs in the Gulf of Alaska TMAA.

No other Navy training occurred within the Gulf of Alaska TMAA from October 2011 through October 2012.

2.5.3 Actual Take of ESA-listed Species

A species-specific post-calculation was conducted by the Navy to estimate potential incidental takes during the periods from May 2011 to October 2011, from October 2011 to October 2012, and combined May 2011- October 2012 (Table 7).

This post-calculation is based on the assumption that use of a given authorized sonar system or explosive event as reported in the classified Exercise Report (Navy 2012a) could potentially generate exposures that result in "takes" under the ESA.

Model limitations as discussed in the Navy's Gulf of Alaska TMAA Environmental Impact Statement/ Overseas Environmental Impact Statement (Navy 2010b) and previous consultation packages do not factor in small scale animal movement, animal avoidance, regional distribution other than potential presence, or Navy mitigation measures or location of actual training in one part of the range vice another.

The post-calculation exposure assessment presented in Table 7 shows that Navy training over the reporting period in the Gulf of Alaska TMAA resulted in substantially fewer animal being "taken" than the number analyzed in the previous biological opinions.

Table 7. Estimated actual take of ESA-listed species based on post exercise calculations by the Navy during training activities that occurred from May 2011 through October 2012 in the Gulf of Alaska Temporary Maritime Training Area (Navy 2012a).

ESA-listed Species	Estimated Annual Incidental Take	Post-calculation Actual Take				
		May – Oct 2011		Oct 2011 – May 2012		Cumulative
		Number	Percent	Number	Percent	Number
Blue Whale	2	0	0%	0	0%	0
Fin Whale	11,037	20	0.18%	0	0%	20
Humpback Whale	1,395	3	0.22%	0	0%	3
North Pacific Right Whale	2	0	0%	0	0%	0
Sei Whale	8	0	0%	0	0%	0
Sperm Whale	329	1	0.30%	0	0%	1
Steller Sea Lion	11,108	21	0.19%	0	0%	21

2.5.4 Monitoring

The Navy-funded Gulf of Alaska TMAA marine mammal compliance monitoring during the previous LOA period included the deployment of two High-frequency Acoustic Recording Packages (HARPs) for Passive Acoustic Monitoring (PAM) from Scripps Institute of Oceanography. The units were bottom-deployed on the shelf (203 m) and slope (900 m) of north central Gulf of Alaska.

These devices (designated HARP-CB and HARP-CA) were placed on the ocean floor to record marine mammal vocalizations and anthropogenic sounds on internal hard drives that must be retrieved during field service calls approximately every 9-10 months based on a 100 percent duty cycle(Navy 2012b).

Both HARPs were deployed on 12 July 2011 and field serviced with data retrieved on 3 May 2012. Data was collected from the HARPs and returned to Scripps for analysis, and the HARPs redeployed at the same shelf and slope locations.

In addition to these two previous HARPs, the Navy also funded a third HARP deployment to obtain passive acoustic data within the offshore Alaska Seamount province (Figure 5-2). On September 8, 2012, this third HARP was deployed at depth along the side of Pratt Seamount (930 m).

Data from all three HARPs will be retrieved in May 2013 and form the basis for the Navy's 2013 Gulf of Alaska TMAA annual Monitoring Report.

For the period through May 2012, over 5,324 hours of passive acoustic data was obtained from HARP-CB, and 432 hours from HARP-CA. After 18 days of recording (7/13/11 – 7/31/11), the shelf instrument (HARP-CA) experienced a malfunction of the low-frequency hydrophone element, introducing electronic noise that prevented detection of marine mammal calls except at very high frequency (Navy 2012b). The Navy reported that it is possible that intense tidal flow and subsequent instrument vibration contributed to the failure of the shelf site hydrophone. The slope instrument (CB) recorded acoustic data for 221 days (7/13/11 – 2/19/12); this recording ended about 80 days earlier than anticipated due to low battery voltage. To improve future data yield, the HARP low frequency hydrophone has been redesigned with sensor redundancy, and lithium batteries are being used to provide additional capacity (Navy 2012b).

The Navy 2012 monitoring report (Navy 2012b) provided the following summary information. Four baleen whale species were detected: blue whales, fin whales, gray whales, and humpback whales. No North Pacific right whale or minke whale sounds were detected in these data. Blue whales were present from July through January with lower numbers in February. Fin whales were detected throughout the year with higher detections from mid-August to late December. Humpback whale acoustic encounters occurred from October to February.

At least six species of odontocetes were detected: killer whale, sperm whale, Stejneger's beaked whale, Baird's beaked whale, Cuvier's beaked whale, and unidentified porpoise (likely Dall's porpoise). Deep diving beaked whales occurred only at the deep site HARP-CB. Sperm whales had much higher detection rates at CB as well. Porpoise clicks were only detected at the shallow shelf site HARP-CA. No Risso's dolphin or Pacific white-sided dolphin echolocation or vocalizations were detected at either site.

Sperm whales were the most frequently heard odontocete species, present during the entire deployment, however, with fewer detections in January and February. Stejneger's beaked whale was the most frequently encountered beaked whale, also present during all months of the deployment with lowest numbers of detections in August. Baird's beaked whale were not detected all of July and August, on few occasions in September, October and February but regularly from November through January. Killer whales occurred sporadically throughout the year with a stronger presence in July and early August. Unidentified porpoise were present with low numbers of detections July, August, and November. They had a sudden increase in presence during October.

Ship noise was more frequently heard at site HARP-CA than HARP-CB. Overall, close ship noise was not a very common anthropogenic sound at either site. No naval mid-frequency active (MFA) sonar events were detected throughout the monitoring period. Echosounder pings (30 kHz) were found at one occasion only at site HARP-CB. Underwater explosions were heard with some regularity at site HARP-CB, only once at site HARP-CA. No potential source of the explosive sounds was identified.

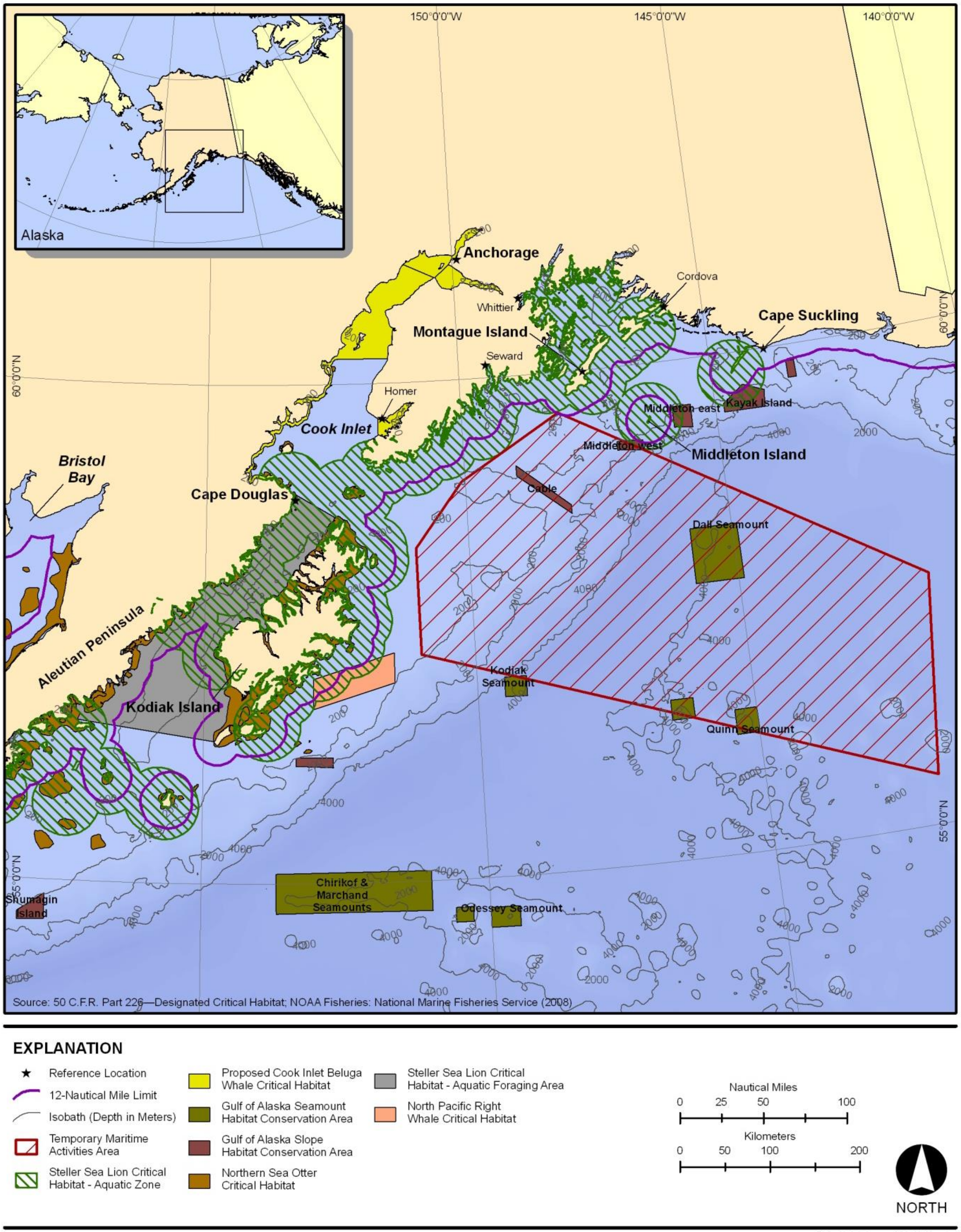
In September 2012, a third HARP was deployed on the Pratt seamount in the offshore Gulf of Alaska seamount province (HARP-P). All three HARPs (HARP-CA, CB, P) will be serviced in May of 2013 and data retrieved for analysis and subsequent reporting to NMFS in the Navy's December 2013 annual monitoring report.

In addition to the May 2013 field service of the existing HARPs, two more HARPs will also be deployed. One will be on Quinn seamount and the other on the shelf within the northeast TMAA (east of Kodiak Island). This will bring the Navy's monitoring commitment within the Gulf of Alaska to five passive acoustic devices. Results from all five HARPs will be provided in the Navy's December 2014 annual monitoring report.

2.6 Action Area

Action area means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR §402.02). Within the northeastern Gulf of Alaska, the TMAA is composed of 42,146 square nautical miles (nm^2) (145,482 square kilometers [km^2]) of surface and subsurface ocean training area and overlying airspace that includes the majority of Warning Area 612 (W-612). Warning Area-612 consists of about 2,256 nm^2 (8,766 km^2) of airspace and is located over Blying Sound towards the northwestern quadrant of the TMAA. A Warning Area may be located over domestic or international waters, or both. When not included as part of the TMAA, W-612, which provides 2,256 nm^2 (8,766 km^2) of Special Use Airspace (SUA), is used by the Air Force and U.S. Coast Guard to fulfill their training requirements. The temporary boundaries of the TMAA form a roughly rectangular area oriented from the northwest to the southeast, approximately 300 nautical miles (nm) (555.6 kilometers [km]) in length by 150 nm (277.8 km) in width, situated south of Prince William Sound and east of Kodiak Island. The TMAA’s northern boundary is located approximately 24 nm (44 km) south of the shoreline of the Kenai Peninsula, which is the largest proximate landmass. The only other shoreline close to the TMAA is Montague Island, which is located 12 nm (24 km) north of the TMAA. The approximate middle of the TMAA is located 140 nm (259 km) offshore.

Training activities proposed by the Navy in the Gulf of Alaska are contained within the TMAA and occur on the surface, in the airspace above (including aircraft flying to and from the TMAA to inland training areas at altitudes above 15,000 feet (ft; [4,572 meters (m)]), and below the surface of the water. Navy training activities in the TMAA would normally occur during the period between April and October. Details regarding the physical environment present in the Gulf of Alaska and TMAA during this timeframe were presented in the Navy's *Marine Resource Assessment for the Gulf of Alaska Operating Area* (MRA)(Navy 2006).



Source: 50 C.F.R. Part 226—Designated Critical Habitat; NOAA Fisheries: National Marine Fisheries Service (2008)

Figure 2. Temporary Maritime Training Area, protected species critical habitat, and habitat conservation areas in the Gulf of Alaska.

3 APPROACH TO THE ASSESSMENT

NMFS uses a series of sequential analyses to assess the effects of Federal actions on endangered and threatened species and designated critical habitat. The first analysis identifies those physical, chemical, or biotic aspects of the proposed actions that are likely to have individual, interactive, or cumulative direct and indirect effect on the environment (the term "potential stressors" is used for these aspects of an action). As part of this step, the spatial extent of any potential stressors is identified, including the degree to which the spatial extent of those stressors may change with time (the spatial extent of these stressors is the "action area" for a consultation).

The second step of the analyses starts by determining whether endangered species, threatened species, or designated critical habitat are likely to occur in the same space and at the same time as these potential stressors. If such co-occurrence is likely, then the nature of that co-occurrence is estimated (these represent our *exposure analyses*). In this step of the analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an Action's effects and the populations or subpopulations those individuals represent.

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

3.1 Risk Analysis for Endangered and Threatened Species

Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of listed species depends on the fate of the populations that comprise them, the viability (that is, the probability of extinction or probability of persistence) of listed species depends on the viability of the populations that comprise the species. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so). Our risk analyses reflect these relationships between listed species and the populations that comprise them, and the individuals that comprise those populations.

Our risk analyses begin by identifying the probable risks the proposed actions are likely to pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those risks to individuals to identify consequences to the populations that include those individuals. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

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

When individual, listed plants or animals are expected to experience reductions in their current or expected future reproductive success, we would expect those reductions to also reduce the abundance, reproduction rates, or growth rates (or increase variance in one or more of these rates) of the populations those individuals represent (see Sterns 1992). Reductions in one or more of these variables (or one of the variables we derive from them) is a *necessary* condition for reductions in a population's viability, which is itself a *necessary* condition for reductions in a species' viability. On the other hand, when listed plants or animals exposed to an Action's effects are *not* expected to experience reductions in fitness, we would not expect the Action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (for example, see Anderson 2000; Mills and Beatty 1979; Sterns 1992). If we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

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

Finally, our assessment tries to determine if changes in population viability are likely to be sufficient to reduce the viability of the species those populations comprise. In this step of our analyses, we use the species' status (established in the *Status of the Species* section of this opinion) as our point of reference. The primary advantage of this approach is that it considers the consequences of the response of endangered and threatened species in terms of fitness costs, which allows us to assess how particular behavioral decisions are likely to influence individual reproductive success (Bejder et al. 2009). Individual-level effects can then be translated into changes in demographic parameters of populations, thus allowing for an assessment of the biological significance of particular human disturbances.

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

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

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

3.2 Risk Analysis for Designated Critical Habitat

Our "destruction or adverse modification" determinations must be based on an action's effects on the conservation value of habitat that has been designated as critical to threatened or endangered species[1]. If an area encompassed in a critical habitat designation is likely to be exposed to the direct or indirect consequences of the proposed action on the natural environment, we ask if primary or secondary constituent elements included in the designation (if there are any)

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

or physical, chemical, or biotic phenomena that give the designated area value for the conservation are likely to respond to that exposure.

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

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

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

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

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

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

3.3 Application of this Approach in this Consultation

The primary stressors associated with the military readiness activities the Navy proposes to conduct in waters on and adjacent to the Gulf of Alaska TMAA consist of:

1. Movement of surface vessels and submarines and the risk of disturbance;
2. Movement of surface vessels and submarines and the risk of collision;
3. Flights and training exercises involving fixed-wing and helicopter aircraft to, from and within the TMAA and the risk of disturbance;
4. Non-explosive ordnance and gunfire and the associated risk of ordnance-related injury or disturbance;
5. Risk of entanglement, ingestion or exposure to the chemical constituents of expended materials;
6. Sound fields produced by active sonar systems and the risk of disturbance or injury; and
7. Sound fields and pressure waves from underwater detonations and the risk of disturbance or injury.

The first step of the analysis evaluates available evidence to determine the likelihood of listed species or critical habitat being exposed to these potential stressors. It is assumed that these stressors pose no risk to listed species or critical habitat if these potential stressors do not co-occur, in space or time, with (1) individuals of endangered or threatened species or units of critical habitat that has been designated for endangered or threatened species; (2) species that are food for endangered or threatened species; (3) species that prey on or compete with endangered or threatened species; or (4) pathogens for endangered or threatened species. The analyses did not identify situations where the proposed training activities are likely to indirectly affect endangered or threatened species by disrupting marine food chains, or by adversely affecting the predators, competitors, or forage base of endangered or threatened species.

3.3.1 Exposure Analysis

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

For this exposure analyses, NMFS generally relies on an action agency's estimates of the number of marine mammals that might be "taken" (as that term is defined for the purposes of the MMPA). In a small number of consultations, however, NMFS has conducted separate analyses to estimate the number of endangered or threatened marine animals that might be exposed to stressors produced by a proposed action to assess the effect of assumptions in an action agency's model on model estimates. For example, NMFS used a model based on components of Hollings' disc equation (Navy 2010a) to independently estimate the number of marine mammals that might be exposed to Navy training activities in a few recent consultations that satisfied the following conditions; first, the sole or primary stressor was hull-mounted mid-frequency active sonar; and second, data were available on the density of endangered or threatened animals in an action area, the ship's speed, the radial distance at which different received levels would be detected from a source given sound speed profiles, and the duration of specific training exercises.

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

In this opinion, we relied on the Navy and NMFS Permits Division exposure estimates of the number of ESA-listed species that might interact with sound fields associated with mid-frequency active sonar in the Gulf of Alaska TMAA because abundance and density data was not available for most species.

This approach was designed to estimate the number of times marine mammals might be "taken" (as that term is defined pursuant to the MMPA) as a result of being exposed to active sonar or underwater detonations during Navy training, which is a subset of the number of animals that might be exposed to those training activities or respond given exposure.

3.3.2 Response Analyses

Once we identified which listed resources were likely to be exposed to active sonar associated with the proposed training activities and the nature of that exposure, we examined the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure. Prior to this consultation, we made several major changes to the conceptual model that forms the foundation for our response analyses. First, we constructed our revised model on a model of animal behavior and behavioral decision-making, which incorporates the cognitive processes involved in behavioral decisions; earlier versions of this model ignored critical components of animal behavior and behavioral decision-making. As a result, our revised model assumes that Navy training activities primarily affect endangered and threatened species by changing their behavior, although we continue to recognize the risks of physical trauma and noise-induced losses in hearing sensitivity (threshold shift). Second, we expanded our 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 as deep dives that involve short-term risks while promoting long-term survival), or changes in social interactions among groups of animals (for example, interactions between a cow and her calf).

3.3.3 Risk Analyses

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 risks to individuals to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the concept of current or expected future reproductive success which, as we described in the preceding sub-section, integrates survival and longevity with current and future reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable response to stressors produced by an Action would reasonably be expected to reduce the individual's current or expected future reproductive success by increasing the individual's likelihood of dying prematurely or having reduced longevity, increasing the age at which individuals become reproductively mature, reducing the age at which individuals stop reproducing, reducing the number of live births individuals produce during any reproductive bout, decreasing the number of times an individual is likely to reproduce over 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 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 plants or animals are *not* likely to experience reductions in their current or expected future reproductive success, we would conclude our assessment.

If we conclude that listed 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 are known to have declined, collapsed, or become extinct in the past as well as a suite of population viability models.

If and when we conduct these analyses, 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.

3.4 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 sound and its effects on marine mammals and other marine life has become available. Many investigators have studied the potential responses of marine mammals and other marine organisms to human-generated sounds in marine environments or have integrated and synthesized the results of these studies (Bowles 1994; Croll et al. 2001b; Frankel and Clark 1998; Gisiner et al. 2006; McCauley and Cato. 2001; Norris 1994; NRC 2000; NRC 2005;

Richardson et al. 1995; Southall et al. 2007; Tyack 2007; Tyack and Clark 2000; Wright et al. 2007).

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

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

Despite the information that is available, this assessment involved a large amount of uncertainty about the basic hearing capabilities of marine mammals; how marine mammals use sounds as environmental cues, how they perceive acoustic features of their environment; the importance of sound to the normal behavioral and social ecology of marine mammals; the mechanisms by which human-generated sounds affect the behavior and physiology (including the non-auditory physiology) of marine mammals, and the circumstances that are likely to produce outcomes that have adverse consequences for individual marine mammals and marine mammal populations (see NRC 2000 for further discussion of these unknowns).

3.5 Treatment of "Cumulative Impacts"

Over the past few years, several organizations have argued that several of our previous biological opinions on the Navy's use of active sonar failed to consider the "cumulative impact" (in the NEPA sense of the term) of active sonar on the ocean environment and its organisms, particularly endangered and threatened species and critical habitat that has been designated for them. In each instance, we have had to explain how section 7 consultations and biological opinions consider "cumulative impacts" (in the NEPA sense of the term). We reiterate that explanation in this sub-section.

The U.S. Council on Environmental Quality defined "cumulative effects" (which we refer to as "cumulative impacts" to distinguish between NEPA and ESA uses of the same term) as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency

(Federal or non-federal) or person undertakes such other actions" (40 CFR §1508.7) (CEQ 1997).

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

A critical question is what effects are being accumulated? When native vegetative communities in terrestrial ecosystems are being converted to multiple housing projects, it would be a relatively simple matter to accumulate the acreage disturbed or destroyed. When chemical pollutants are discharged into a river or stream from non-point sources, it becomes much harder to identify which chemicals are likely to accumulate and how plants or animals are likely to respond to that accumulation. With ephemeral stimuli such as active sonar or underwater detonations, the stressor (the sound or pressure wave) disappears moments after it is introduced into the environment; as a result, it is not likely to accumulate in any meaningful way. What might accumulate, however, are physical, physiological, behavioral, or social consequences of animals that are exposed to those sounds or pressure waves multiple times.

In practice we address "cumulative impacts" by focusing on individual organisms, which integrate the environments they occupy or interact with indirectly over the course of their lives. In our assessments, we think in terms of the biotic or ecological "costs" of exposing endangered and threatened individuals to a single stressor, a sequence of single stressors, or a suite of stressors (or "stress regime"). At the level of individual organisms, these "costs" consist of incremental reductions in the current or expected future reproductive success of the individuals that result from exposing those individuals to one or more stressors. The "costs" of those exposures might be immediately significant for an organism's reproductive success (for example, when an individual dies or loses one of its young) or the "costs" might become significant only over time. The costs of synergistic interactions between two stressors or a sequence of stressors would be expected to be higher than the "costs" incurred without the synergism; the "costs" of antagonistic interactions would be expected to be lower than the "costs" incurred without the antagonism.

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

4 STATUS OF LISTED RESOURCES

This section identifies the ESA-listed species that occur within the Gulf of Alaska that may be affected by the Navy's training activities in the TMAA. It then summarizes the biology and ecology of those species and what is known about their life histories in the Gulf of Alaska TMAA. The species occurring within the action area that may be affected by the Proposed Action are listed in Table 8, along with their ESA listing status.

Table 8. Species listed under the Federal Endangered Species Act (ESA) under NMFS jurisdiction that may occur in the Gulf of Alaska Temporary Maritime Activities Area (TMAA).

Species	ESA Status	Designated Critical Habitat	Recovery Plan
Marine Mammals - Cetaceans			
Blue Whale (*Balaenoptera musculus*)	Endangered 35 FR 18319	None Designated	07/1998 - -
Fin Whale (*Balaenoptera physalus*)	Endangered 35 FR 18319	None Designated	71 FR 38385
Humpback Whale (Megaptera novaeangliae)	Endangered 35 FR 18319	None Designated	55 FR 29646
North Pacific Right Whale (*Eubalaena japonica*)	Endangered 73 FR 12024	Designated 4/8/08 73 FR 19000	None
Sei Whale (*Balaenoptera borealis*)	Endangered 35 FR 18319	None Designated	None
Sperm Whale (*Physeter macrocephalus*)	Endangered 35 FR 18619	None Designated	12/28/10 75 FR 81584
Cook Inlet Beluga Whale (*Delphinapterus leucas*)	Endangered 73 FR 62919	Proposed 12/2/09 74 FR 63080	Draft 70 FR 12853
Marine Mammals - Pinnipeds			
Steller Sea Lion–Western (*Eumetopias jubatus*)	Endangered 62 FR 24345	Designated 8/27/93 58 FR 45269	3/2008
Steller Sea Lion–Eastern (*Eumetopias jubatus)*	Threatened 55 FR 49204	Designated 8/27/93 58 FR 45269	3/2008
Sea Turtles			
Leatherback Turtle (*Dermochelys coriacea*)	Endangered 61 FR 17	Proposed 1/5/10 75 FR 319	5/22/98 63 FR 28359
Loggerhead Turtle (*Caretta caretta*)	Proposed Endangered 3/16/10 75 FR 12598	Proposed 3/16/10 75 FR 12598	5/22/98 63 FR 28359
Green Turtle (*Chelonia mydas*)	Endangered 43 FR 32800	Designated 9/2/98 63 FR 46693	5/22/98 63 FR 28359
Olive Ridley Turtle (*Lepidochelys olivacea*)	Endangered 1/2/96 61 FR 17	None Designated	5/22/98 63 FR 28359

Fish			
Chinook Salmon (*Oncorhynchus tshawytscha*)	Threatened/ Endangered	Designated Multiple	Some ESUs
Coho Salmon (*Oncorhynchus kisutch*)	Threatened/ Endangered	Varies	None
Chum Salmon (*Oncorhynchus keta*)	Threatened	Designated 9/2/05 70 FR 52630	05/2007 - -
Sockeye Salmon (*Oncorhynchus nerka*)	Threatened/ Endangered	Designated Multiple	1 of 2 ESUs 74 FR 25706
Steelhead Trout (*Oncorhynchus mykiss*)	Threatened/ Endangered	Designated Multiple	Some DPSs
Pacific Eulachon/smelt (*Thaleichthys pacificus*)	Threatened	Proposed 1/5/11 76 FR 515	None

4.1 Species Not Considered Further in this Opinion

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

4.1.1 Cook Inlet Beluga Whale

The likelihood of a Cook Inlet beluga whale (*Delphinapterus leucas*) occurring in the TMAA is extremely low. Only 28 sightings of beluga whales in the Gulf of Alaska have been reported from 1936 to 2000 (Laidre 2000). The nearest beluga whales to the TMAA are in Cook Inlet with a 2008 abundance estimate of 375 whales in the Cook Inlet stock (73 FR 62919).

To identify Cook Inlet beluga habitat use, particularly in winter, NMFS researchers placed satellite positioning tags on 18 beluga whales between 1999 and 2002. Those tagged whales remained in Cook Inlet, indicating that belugas occupy Cook Inlet year round and do not display the seasonal migrations that northern beluga populations display (Hobbs et al. 2005). Given the best scientific information available, NMFS determined the Cook Inlet beluga whales comprised a DPS which is confined to waters of Cook Inlet, and does not include beluga whales found in Yakutat or other Gulf of Alaska waters beyond Cook Inlet. Thus, the range of Cook Inlet beluga whale DPS has been defined as the waters of Cook Inlet north of a line from Cape Douglas to Cape Elizabeth (72 FR 19854, April 20, 2007).

In October 2008, the Cook Inlet beluga whale distinct population segment was listed as endangered under the ESA (73 FR 62919, October 22, 2008). Prior to listing, the population had been designated as depleted under the MMPA. Cook Inlet is approximately 70 nm (129.6 km) from the nearest edge of the TMAA and the Cook Inlet beluga whales do not leave the waters of Cook Inlet. Based on this information, it is highly unlikely for a Cook Inlet beluga whale to be present in the action area. Consequently, this distinct population segment will not be considered in the remainder of this analysis.

4.1.2 Chelonid Sea Turtles

All sea turtles are listed as endangered or threatened under the ESA. There are seven living species of sea turtles from two taxonomic families, the Cheloniidae (hard-shelled sea turtles; six species) and the Dermochelyidae (leatherback turtles; one species). Five species of sea turtles occur in the North Pacific: leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricate*) and olive ridley (*Lepidochelys olivacea*). However, only four species have been observed in Alaska waters between 1960 and 1998: the leatherback, loggerhead, green, and olive ridley (ADFG 2011; Hodge and Wing 2000).

Members of the Cheloniidae family (loggerhead, green, hawksbill, olive ridley sea turtles) typically occur in the warm, subtropical areas of the Pacific such as southern California and Hawai′i; therefore, the Gulf of Alaska is considered beyond their normal range of occurrence because of cold water temperatures. The ocean waters of the TMAA have an average sea surface temperature in summer in the upper 100 m (328 ft) of approximately 51.8 degrees Fahrenheit (°F) (11 degrees Celsius [°C]). Most hard-shell turtles seek optimal seawater temperatures near 65°F and are cold-stressed at seawater temperatures below 50°F (Davenport 1997). At temperatures below 15°C, green and ridley sea turtles become semidormant, hardly move and come to the surface at intervals up to 3 hours (Milton and Lutz 2003). Loggerhead sea turtles exposed to excessive low temperatures have experienced abrupt failure in pH homeostasis and a sharp increase in blood lactate levels (Milton and Lutz 2003). At 10°C loggerhead sea turtles were lethargic and “floated” (Milton and Lutz 2003).

In Alaska, only 9 green sea turtle occurrences, 2 olive ridley occurrences, and 2 loggerheads were documented between 1960 and 2006 (Hodge and Wing 2000; Navy 2006). Therefore, although sightings of sea turtles from the Chelonidae family have been documented in Alaska, most of these involve individuals that were either cold-stressed, likely to become cold-stressed, or already deceased (Hodge and Wing 2000; McAlpine et al. 2002). Thus, the TMAA is considered to be outside the normal range for sea turtle species of the Cheloniidae family and this family of sea turtles is not considered for further analysis.

4.2 Species Considered Further in this Opinion

The remainder of this section 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 training activities the Navy proposes to conduct in waters in the Gulf of Alaska TMAA. Each narrative presents 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. A summary of information on the threats to the species and the species' status given those threats is provided as points of reference for the subsequent jeopardy determinations. That is, NMFS relies 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, information on the diving and social behavior of the different marine mammal species is presented because that behavior helps determine whether aerial and ship board surveys are likely to detect each species. A summary of information on the vocalizations and hearing of the marine mammals and sea turtle species is provided because that background information lays the foundation for our assessment of how the different species are likely to respond to sounds produced by sonar and detonations.

More detailed background information on the status of these species and critical habitat can be found in a number of published documents including status reviews, recovery plans for the blue whale (NMFS 1998b), fin whale (NMFS 2010b), fin and sei whale (NMFS 1998a), humpback whale (NMFS 1991), right whale (NMFS 2004), sperm whale (NMFS 2010c), a status report on large whales prepared by Perry et al. (1999a) and the status review and recovery plan for the leatherback sea turtle (NMFS and USFWS 1998; NMFS and USFWS 2007). Richardson et al. (1995) and Tyack (2000) provide detailed analyses of the functional aspects of cetacean communication and their responses to active sonar. Finally, Croll et al. (1999b), NRC (2000; 2003; 2005), and Richardson and Wursig (1995) provide information on the potential and probable effects of active sonar on the marine animals considered in this opinion.

4.2.1 Blue Whale

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

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

Distribution

Blue whales are found along the coastal shelves of North America and South America (Clarke 1980b; Donovan 1984; Rice 1998). In the western North Atlantic Ocean, blue whales are found from the Arctic to at least the mid-latitude waters of the North Atlantic (CETAP 1982; Gagnon and Clark 1993; Wenzel et al. 1988; Yochem and Leatherwood 1985). Blue whales have been observed frequently off eastern Canada, particularly in waters off Newfoundland, during the winter. In the summer months, they have been observed in Davis Strait (Mansfield 1985), the Gulf of St. Lawrence (from the north shore of the St. Lawrence River estuary to the Strait of Belle Isle), and off eastern Nova Scotia (Sears 1987a). In the eastern North Atlantic Ocean, blue whales have been observed off the Azores Islands, although Reiner et al. (1996) do not consider them common in that area.

In 1992, the Navy conducted an extensive acoustic survey of the North Atlantic Ocean using the Integrated Underwater Surveillance System’s fixed acoustic array system (Clark 1995). Concentrations of blue whale sounds were detected in the Grand Banks off Newfoundland and west of the British Isles. In the lower latitudes, one blue whale was tracked acoustically for 43 days, during which time the animal traveled 1400 nautical miles around the western North Atlantic from waters northeast of Bermuda to the southwest and west of Bermuda (Gagnon and Clark 1993).

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

In the eastern tropical Pacific Ocean, the Costa Rica Dome appears to be important for blue whales based on the high density of prey (euphausiids) available in the Dome and the number of blue whales that appear to reside there (Reilly and Thayer 1990). Blue whales have been sighted in the Dome area in every season of the year, although their numbers appear to be highest from June through November.

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

Blue whales have also been reported year-round in the northern Indian Ocean, with sightings in the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca (Mizroch et al. 1984). The migratory movements of these whales are unknown.

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

Population Structure

For this and all subsequent species, the term "population" refers to groups of individuals whose patterns of increase or decrease in abundance over time are determined by internal dynamics (births resulting from sexual interactions between individuals in the group and deaths of those individuals) rather than external dynamics (immigration or emigration). This definition is a reformulation of definitions articulated by 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 (Barlow 1995; Gilpatrick et al. 1997; Mizroch et al. 1984; Ohsumi and Masaki 1972). For example, studies of the blue whales that winter off Baja California and in the Gulf of

California suggest that these whales are morphologically distinct from blue whales of the western and central North Pacific (Gilpatrick et al. 1997), although these differences might result from differences in the productivity of their foraging areas more than genetic differences (Barlow et al. 1997; Calambokidis et al. 1990; Sears 1987b).

In addition, a population of blue whales that has distinct vocalizations inhabits the northeast Pacific from the Gulf of Alaska to waters off Central America (Gregr et al. 2000; Mate et al. 1998; Stafford 2003). We assume that this population is the one affected by the activities considered in this opinion.

Natural Threats

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

Anthropogenic Threats

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

From 1889 to 1965, whalers killed about 5,761 blue whales in the North Pacific Ocean (Hill et al. 1999). From 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). Evidence of a population decline was seen in the catch data from Japan. In 1912, whalers captured 236 blue whales; in 1913, 58 blue whales; in 194, 123 blue whales; from 1915 to 1965, the number of blue whales captured declined continuously (Mizroch et al. 1984). In the eastern North Pacific, whalers killed 239 blue whales off the California coast in 1926. And, in the late 1950s and early 1960s, Japanese whalers killed 70 blue whales per year off the Aleutian Islands (Mizroch et al. 1984).

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

In 1980, 1986, 1987, and 1993, ship strikes have been implicated in the deaths of blue whales off California (Barlow 1997). More recently, Berman-Kowalewski et al. (2010) reported that between 1988 and 2007, 21 blue whale deaths were reported along the California coast, typically one or two cases annually. In addition, several photo-identified blue whales from California waters were observed with large scars on their dorsal areas that may have been caused by ship strikes. Studies have shown that blue whales respond to approaching ships in a variety of ways, depending on the behavior of the animals at the time of approach, and speed and direction of the approaching vessel. While feeding, blue whales react less rapidly and with less obvious avoidance behavior than whales that are not feeding (Sears 1983). Within the St. Lawrence Estuary, blue whales are believed to be affected by large amounts of recreational and commercial vessel traffic. Blue whales in the St. Lawrence appeared more likely to react to these vessels when boats made fast, erratic approaches or sudden changes in direction or speed (Edds and Macfarlane 1987).

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

Status and Trends

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

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

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

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

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

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

Diving and Social Behavior

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

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

Vocalization and Hearing

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

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

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

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low-frequency) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995). Nevertheless, data reported by Melcón et al. (Melcon et al. 2012) demonstrates that blue whales hear, respond to and change their behavior in response to sounds in the mid-frequency range at received levels below 120 dB SPL (re: 1 µPa). For this outcome to have occurred, it was necessary for the blue whales to hear and devote attentional resources to the sonar, despite its high frequency (relative to their putative hearing sensitivity) and its low received level.

Critical Habitat

NMFS has not designated critical habitat for blue whales.

4.2.2 Fin Whale

The fin whale, *Balaenoptera physalus* (Linnæus 1758), is a well-defined, cosmopolitan species of baleen whale (Gambell 1985a).

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

Distribution

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

In the Southern Hemisphere, fin whales are distributed broadly south of 50° S in the summer and migrate into the Atlantic, Indian, and Pacific Oceans in the winter, along the coast of South America (as far north as Peru and Brazil), Africa, and the islands in Oceania north of Australia and New Zealand (Gambell 1985a).

Fin whales are common off the Atlantic coast of the United States in waters immediately off the coast seaward to the continental shelf (about the 1,000-fathom contour). In this region, they tend to occur north of Cape Hatteras where they accounted for about 46 percent of the large whales observed in surveys conducted between 1978 and 1982. During the summer months, fin whales in this region tend to congregate in feeding areas between 41°20'N and 51°00'N, from shore seaward to the 1,000-fathom contour.

In the North Pacific Ocean, fin whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska; in the eastern Pacific, they occur south to California; in the western Pacific, they occur south to Japan. Fin whales in the eastern Pacific winter from California south; in the western Pacific, they winter from the Sea of Japan, the East China and Yellow Seas, and the Philippine Sea (Gambell 1985a).

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

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

Regardless of how different authors structure the fin whale population, mark-recapture studies have demonstrated that individual fin whales migrate between management units (Mitchell 1974;

Sigurjonsson et al. 1989), which suggests that these management units are not geographically isolated populations.

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

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

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

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. 2008; Lien 1994; Perkins and Beamish 1979; Waring et al.

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

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

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

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

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

Status and Trends

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

The status and trend of fin whale populations is largely unknown. Over 26,000 fin whales were harvested between 1914-1975 (Braham 1991 as cited in Perry et al. 1999a). NMFS estimates roughly 3,000 individuals occur off California, Oregon, and Washington based on ship surveys in summer/autumn of 1996, 2001, and 2005, of which estimates of 283 and 380 have been made for Oregon and Washington alone (Barlow 2003; Barlow and Taylor 2001; Forney 2007). Barlow (2003) noted densities of up to 0.0012 individuals/km^2 off Oregon and Washington and up to 0.004 individuals/km^2 off California.

Fin whales were extensively hunted in coastal waters of Alaska as they congregated at feeding areas in the spring and summer (Mizroch et al. 2009). There has been little effort in the Gulf of Alaska since the cessation of whaling activities to assess abundance of large whale stocks. Fin whale calls have been recorded year-round in the Gulf of Alaska, but are most prevalent from August-February (Moore et al. 1998; Moore et al. 2006). Zerbini et al. (2006) sighted fin whales south of the Kenai Peninsula, and calculated a density of 0.008/km^2 (see Table 4, Block 1 in Zerbini et al. 2006). Waite (2003) recorded 55 fin whale sightings on effort, with several occurring within the TMAA. Rone et al. (2010) recorded 24 sightings of 64 fin whales during a 10-day cruise in the TMAA in April 2009. Density for the inshore stratum was estimated at 0.012/km^2, while density in the offshore stratum was estimated at 0.009/km^2 (Rone et al. 2010). A combined regional, year-round density for the Gulf of Alaska TMAA was estimated by the Navy at 0.010/km^2 (Navy 2010a).

Diving and Social Behavior

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

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

Vocalization and Hearing

Fin whales produce a variety of low-frequency sounds in the 10-200 Hz range (Edds 1988; Thompson et al. 1992; Watkins 1981a; Watkins et al. 1987). Typical vocalizations are long, patterned pulses of short duration (0.5-2 s) in the 18-35 Hz range, but only males are known to produce these (Clark et al. 2002; Patterson and Hamilton 1964). Richardson et al. (1995) reported the most common sound as a 1 s vocalization of about 20 Hz, occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. Au (2000) reported moans of 14-118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34-150 Hz, and songs of 17-25 Hz (Cummings and Thompson 1994; Edds 1988; Watkins 1981a). Source levels for fin whale vocalizations are 140-200 dB re 1µPa-m (see also Clark and Gagnon 2004; as compiled by Erbe 2002b). The source depth of calling fin whales has been reported to be about 50 m (Watkins et al. 1987).

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

Direct studies of fin whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995). Nevertheless, data reported by Melcón et al. (Melcon et al. 2012) demonstrates that blue whales hear, respond to and change their behavior in response to sounds in the mid-frequency range at received levels below 120 dB SPL (re: 1 µPa). For this outcome to have occurred, it was necessary for the blue whales to hear and devote attentional resources to the sonar, despite its high frequency (relative to their putative hearing sensitivity) and its low received level. Given the similarities between fin and blue whales, it is possible that fin whales would also hear mid-frequency sounds and may respond to those sounds.

Critical Habitat

NMFS has not designated critical habitat for fin whales.

4.2.3 Humpback Whale

Humpback whales (*Megaptera novaeangliae*) are distinguished from other whales in the same Family (Balaenopteridae) by extraordinarily long flippers (up to 5 m or about 1/3 total body length), a more robust body, fewer throat grooves (14-35), more variable dorsal fin, and utilization of very long (up to 30 min.), complex, repetitive vocalizations (songs) (Payne and McVay 1971) during courtship. Their grayish-black baleen plates, approximately 270-440 on each side of the jaw, are intermediate in length (6570 cm) to those of other baleen whales. Humpbacks in different geographical areas vary somewhat in body length, but maximum recorded size is 18m (Winn and Reichley 1985).

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

Distribution

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

Population Structure

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

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

Separate feeding groups of humpback whales are thought to inhabit western U.S. and Canadian waters, with the boundary between them located roughly at the U.S./Canadian border. The southern feeding ground ranges between 32°-48°N, with limited interchange with areas north of Washington State (Calambokidis et al. 2004; Calambokidis et al. 1996). Humpback whales feed along the coasts of Oregon and Washington from May-November, with peak numbers reported May-September, when they are the most commonly reported large cetacean in the region (Calambokidis and Chandler. 2000; Calambokidis et al. 2004; Dohl 1983; Green et al. 1992). Off Washington State, humpback whales concentrate between Juan de Fuca Canyon and the outer edge of the shelf break in a region called "the Prairie," near Barkley and Nitnat canyons, in the Blanco upwelling zone, and near Swiftsure Bank (Calambokidis et al. 2004). Humpback whales also tend to congregate near Heceta Bank off the coast of Oregon (Green et al. 1992). Additional data suggest that further subdivisions in feeding groups may exist, with up to six feeding groups present between Kamchatka and southern California (Witteveen et al. 2009).

Humpback whales primarily feed along the shelf break and continental slope (Green et al. 1992; Tynan et al. 2005). Although humpback whales were common in inland Washington State waters in the early 1900s, severe hunting throughout the eastern North Pacific has diminished their numbers and few recent inshore sightings have been made (Calambokidis et al. 1990; Scheffer and Slipp 1948).

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 whales annually in the Bering Sea/Aleutian Islands sablefish longline fishery. This estimation is not considered reliable. Observers have not been assigned to a number of fisheries known to interact with the Central and Western North Pacific stocks of humpback whale. In addition, the Canadian observation program is also limited and uncertain (Angliss and Allen 2009).

More humpback whales are killed in collisions with ships than any other whale species except fin whales (Jensen and Silber 2003). Along the Pacific coast, a humpback whale is known to be killed about every other year by ship strikes (Barlow et al. 1997). Of 123 humpback whales that stranded along the Atlantic coast of the U.S. between 1975 and 1996, 10 (8.1 percent) showed evidence of collisions with ships (Laist et al. 2001). Between 1999 and 2005, there were 18 reports of humpback whales being struck by vessels along the Atlantic coast of the U.S. and the Maritime Provinces of Canada (Cole et al. 2005; Nelson et al. 2007). Of these reports, 13 were confirmed as ship strikes and in seven cases, ship strike was determined to be the cause of death. In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship strike appear to be largely ignored (Vanderlaan et al. 2008). However, new rules for seasonal (June through December) slowing of vessel traffic to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are expected to reduce the chance of humpback whales being hit by ships by 9 percent.

Organochlorines, including PCB and DDT, have been identified from humpback whale blubber (Gauthier et al. 1997). Higher PCB levels have been observed in Atlantic waters versus Pacific waters along the United States and levels tend to increase with individual age (Elfes et al. 2010).

Although humpback whales in the Gulf of Maine and off Southern California tend to have the highest PCB concentrations, overall levels are on par with other baleen whales, which are generally lower than odontocete cetaceans (Elfes et al. 2010). As with blue whales, these contaminants are transferred to young through the placenta, leaving newborns with contaminant loads equal to that of mothers before bioaccumulating additional contaminants during life and passing the additional burden to the next generation (Metcalfe et al. 2004). Contaminant levels are relatively high in humpback whales as compared to blue whales. Humpback whales feed higher on the food chain, where prey carry higher contaminant loads than the krill that blue whales feed on.

Status and Trends

Humpback whales were originally listed as endangered in 1970 (35 FR 18319), and this status remains under the ESA.

North Pacific. The pre-exploitation population size may have been as many as 15,000 humpback whales, and current estimates are 6,000-8,000 whales (Calambokidis et al. 2009; Rice 1978). It is estimated that 15,000 humpback whales resided in the North Pacific in 1905 (Rice 1978). However, from 1905 to 1965, nearly 28,000 humpback whales were harvested in whaling operations, reducing the number of all North Pacific humpback whale to roughly 1,000 (Perry et al. 1999a). Population estimates have risen over time from 1,407-2,100 in the 1980s to 6,010 in 1997 (Baker 1985; Baker and Herman 1987; Calambokidis et al. 1997; Darling and Morowitz 1986). Based on surveys between 2004 and 2006, Calambokidis et al. (2008) estimated that the number of humpback whales in the North Pacific consisted of about 18,300 whales, not counting calves. Because estimates vary by methodology, they are not directly comparable and it is not clear which of these estimates is more accurate or if the change from 1,407 to 18,300 is the result of a real increase or an artifact of model assumptions. Tentative estimates of the eastern North Pacific stock suggest an increase of 6-7 percent annually, but fluctuations have included negative growth in the recent past (Angliss and Outlaw 2005).

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

Social Behavior

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

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

Vocalization and Hearing

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

Critical Habitat

NMFS has not designated critical habitat for humpback whales.

4.2.4 North Pacific Right Whale

The northern right whale, *Eubalaena japonica* (Lacépède 1818), is a large baleen whale. Adults are generally between 45 and 55 feet in length and can weigh up to 70 tons. Females are larger than males. The distinguishing features of right whales include a stocky body, generally black coloration (although some individuals have white patches on their undersides), lack of a dorsal fin, large head (about 1/4 of the body length), strongly bowed margin of the lower lip, and callosities on the head region. Two rows of long (up to about eight feet in length), dark baleen plates hang from the upper jaw, with about 225 plates on each side. The tail is broad, deeply notched, and all black with smooth trailing edge. Many basic life history parameters of North Pacific right whales are unknown.

While no reproductive data are known for the North Pacific, studies of North Atlantic right whales suggest calving intervals of two to seven years and growth rates that are likely dependent on feeding success (Best et al. 2001; Burnell 2001; Cooke et al. 2001; Kenney 2002; Knowlton et al. 1994). It is presumed that right whales calve during mid-winter (Clapham et al. 2004). Western North Pacific sightings have been recorded along Japan, the Yellow Sea, and Sea of Japan (Best et al. 2001), areas that are speculated to be important breeding and calving areas. A lifespan of up to 70 years can be expected based upon North Atlantic right whale data.

Distribution

Very little is known of the distribution of right whales in the North Pacific and very few of these animals have been seen in the past 20 years. Historical whaling records indicate that right whales ranged across the North Pacific north of 30° N latitude and occasionally as far south as 20° N, with a bimodal distribution longitudinally favoring the eastern and western North Pacific and occurring infrequently in the central North Pacific (Gregr and Coyle 2009; Josephson et al. 2008; Maury 1853; Scarff 1986; Townsend 1935). North Pacific right whales summered in the North Pacific and southern Bering Sea from April or May to September, with a peak in sightings in coastal waters of Alaska in June and July (Klumov 2001; Maury 1853; Omura et al. 1969; Townsend 1935). North Pacific right whale summer range extended north of the Bering Strait (Omura et al. 1969). However, they were particularly abundant in the Gulf of Alaska from 145° to 151°W, and apparently concentrated in the Gulf of Alaska, especially south of Kodiak Islands and in the eastern Aleutian Islands and southern Bering Sea waters (Berzin and Rovnin 1966; Braham and Rice 1984).

Current information on the seasonal distribution of right whales is spotty. In the eastern North Pacific, this includes sightings over the middle shelf of the Bering Sea, Bristol Bay, Aleutian and Pribilof Islands (Goddard and Rugh 1998; Hill and DeMaster 1998; Perryman et al. 1999; Wade et al. 2006; Waite et al. 2003). More southerly records indicate occurrence along Hawai′i, California, Washington, and British Columbia (Herman et al. 1980; Scarff 1986). However, records from Mexico and California may suggest historical wintering grounds in offshore southern North Pacific latitudes (Brownell Jr. et al. 2001; Gregr and Coyle 2009).

Population Structure

All North Pacific right whales constitute a single population.

Natural Threats

Right whales have been subjects of killer whale attacks and, because of their robust size and slow swimming speed, tend to fight killer whales when confronted (Ford and Reeves 2008). Similarly, mortality or debilitation from disease and red tide events are not known, but have the potential to be significant problems in the recovery of right whales because of their small population size.

Anthropogenic Threats

Whaling for North Pacific right whales was discontinued in 1966 with the IWC whaling moratorium. However, North Pacific right whales remain at considerable risk of extinction. These include but are not limited to the following: (1) life history characteristics such as slow growth rate, long calving intervals, and longevity; (2) distorted age structure of the population and reduced reproductive success; (3) strong depensatory or Allee effects; (4) habitat specificity or site fidelity; and (5) habitat sensitivity. However, the proximity of the other known right whale habitats to shipping lanes (e.g., Unimak Pass) suggests that collisions with vessels may also represent a threat to North Pacific right whales (Elvin and Taggart 2008).

Climate change may have a dramatic effect on survival of North Pacific right whales. Right whale life history characteristics make them very slow to adapt to rapid changes in their habitat (see Reynolds et al. 2002). They are also feeding specialists that require exceptionally high densities of their prey (see Baumgartner and Mate. 2003). Zooplankton abundance and density in the Bering Sea has been shown to be highly variable, affected by climate, weather, and ocean processes and in particular ice extent (Baier and Napp 2003; Napp and G. L. Hunt 2001). The largest concentrations of copepods occurred in years with the greatest southern extent of sea ice (Baier and Napp 2003). It is possible that changes in ice extent, density and persistence may alter the dynamics of the Bering Sea shelf zooplankton community and in turn affect the foraging behavior and success of right whales. No data are available for the western North Pacific.

Gillnets were implicated in the death of a right whale off the Kamchatka Peninsula (Russia) in October of 1989. No other incidental takes of right whales are known to have occurred in the North Pacific. Based on the available records, the estimated annual mortality rate incidental to U.S. commercial fisheries approaches zero whales per year from this stock. Therefore, the annual human-caused mortality level is considered to be insignificant and approaching a zero mortality and serious injury rate (Angliss and Outlaw 2008).

Status and Trends

The Northern right whale was originally listed as endangered in 1970 (35 FR 18319), and this status remained since the inception of the ESA in 1973. The early listing included both the North Atlantic and the North Pacific populations, although subsequent genetic studies conducted by Rosenbaum (Rosenbaum et al. 2000) resulted in strong evidence that the North Atlantic and North Pacific right whales are separate species. Following a comprehensive status review, NMFS concluded that Northern right whales are indeed two separate species. In March 2008, NMFS published a final rule listing North Pacific and North Atlantic right whales as separate species (73 FR 12024).

Very little is known about right whales in the eastern North Pacific, which were severely depleted by commercial whaling in the 1800s (Brownell Jr. et al. 2001). At least 11,500 individuals were taken by American whalers in the early- to mid-19th century, but harvesting continued into the 20th century (Best 1987). Illegal Soviet whaling took 372 individuals between 1963 and 1967 (Brownell Jr. et al. 2001). In the last several decades there have been markedly fewer sightings due to a drastic reduction in number, caused by illegal Soviet whaling in the 1960s (Doroshenko 2000). Previous estimates of the size of the right whale population in the Pacific Ocean range from a low of 100-200 (Braham and Rice 1984) to a high of 220-500 (Berzin 1978). The current population size of right whales in the North Pacific is likely fewer than 1,000 animals (NMFS 2006b).

Abundance estimates and other vital rate indices in both the eastern and western North Pacific are not well established. Where such estimates exist, they have very wide confidence limits. Previous estimates of the size of the right whale population in the Pacific Ocean range from a low of 100-200 to a high of 220-500 (Berzin 1978; Braham and Rice 1984). Although Hill and DeMaster (1998) argued that it is not possible to reliably estimate the population size or trends of right whales in the North Pacific, Reeves et al. (Reeves and Kenney 2003) concluded that North Pacific right whales in the eastern Pacific Ocean exist as a small population of individuals while the western population of right whales probably consists of several hundred animals, although Clapham et al. (Clapham et al. 2005) placed this population at likely under 100 individuals. Brownell et al. (Brownell Jr. et al. 2001) reviewed sighting records and also estimated that the abundance of right whales in the western North Pacific was likely in the low hundreds.

Scientists participating in a recent study utilizing acoustic detection and satellite tracking identified 17 right whales (10 males and 7 females) in the Bearing Sea, which is almost threefold the number seen in any previous year in the last four decades (Wade et al. 2006). These sightings increased the number of individual North Pacific right whales identified in the genetic catalog for the eastern Bering Sea to 23. Amidst the uncertainty of the eastern North Pacific right whale's future, the discovery of females with calves provides hope that this endangered population may still possess the capacity to recover (Wade et al. 2006). Available age composition of the North Pacific right whale population indicates that most individuals are adults (Kenney 2002). Length measurements for two whales observed off California suggest at least one of these whales was not yet sexually mature and two calves have been observed in the Bering Sea (Carretta et al. 1994; Wade et al. 2006). However, to date, there is no evidence of reproductive success (i.e., young reared to independence) in the eastern North Pacific. No data are available for the western North Pacific.

Acoustic monitoring for right whales was carried out via autonomous hydrophones in 2000-2001 near Kodiak Island, and right whale calls were recorded in August and early September (Mellinger et al. 2004; Moore et al. 2006).

Diving

Very little is known about North Pacific right whale diving abilities. Dives of 5 to 15 min or even longer have been reported for North Atlantic right whales. Observations of North Atlantic right whales found that the average depth dive was strongly correlated with both the average depth of peak copepod abundance and the average depth of the bottom mixed layer's upper surface. North Atlantic right whale feeding dives are characterized by a rapid descent from the surface to a particular depth between 262 and 574 ft (80 and 175 m), remarkable fidelity to that depth for 5 to 14 min, and then rapid ascent back to the surface. Right whale dive patterns in the Great South Channel region east of Cape Cod are closely correlated with the horizontal and vertical distributions and movements of dense patches of their zooplankton prey (Winn et al. 1995). Longer surface intervals have been observed for reproductively active females and their calves (Navy 2006).

Social Behavior

Historical concentrations of sightings in the Bering Sea together with some recent sightings indicate that this region, together with the Gulf of Alaska, may represent an important summer habitat for eastern North Pacific right whales (Brownell Jr. et al. 2001; Clapham et al. 2004; Goddard and Rugh 1998; Scarff 1986; Shelden et al. 2005). Few sighting data are available from the eastern North Pacific, with a single sighting of 17 individuals in the southeast Bering Sea being by far the greatest known occurrence (Wade et al. 2006). Some further sightings have occurred in the northern Gulf of Alaska (Wade et al. 2006). Recent eastern sightings tend to occur over the continental shelf, although acoustic monitoring has identified whales over abyssal waters (Mellinger et al. 2004). It has been suggested that North Pacific right whales have shifted their preferred habitat as a result of reduced population numbers, with oceanic habitat taking on a far smaller component compared to shelf and slope waters (Shelden et al. 2005).

Historical sighting and catch records provide the only information on possible migration patterns for North Pacific right whales (Omura 1958; Omura et al. 1969; Scarff 1986). During summer, whales have been found in the Gulf of Alaska, along both coasts of the Kamchatka Peninsula, the Kuril Islands, the Aleutian Islands, the southeastern Bering Sea, and in the Okhotsk Sea. Fall and spring distribution was the most widely dispersed, with whales occurring in mid-ocean waters and extending from the Sea of Japan to the eastern Bering Sea. In winter, right whales have been found in the Ryukyu Islands (south of Kyushu, Japan), the Bonin Islands, the Yellow Sea, and the Sea of Japan. Whalers never reported winter calving areas in the North Pacific and where calving occurs remains unknown (Clapham et al. 2004; Gregr and Coyle 2009; Scarff 1986). North Pacific right whales probably migrate north from lower latitudes in spring and may occur throughout the North Pacific from May through August north of 40° N from marginal seas to the Gulf of Alaska and Bering Sea, although absence from the central North Pacific has been argued due to inconsistencies in whaling records (Clapham et al. 2004; Josephson et al. 2008). This follows generalized patterns of migration from high-latitude feeding grounds in summer to more temperate, possibly offshore waters, during winter (Braham and Rice 1984; Clapham et al. 2004; Scarff 1986).

Critical Habitat

In July 2006, NMFS designated two areas as critical habitat for right whales in the North Pacific (71 FR 38277). The areas encompass about 36,750 square miles of marine habitat, which include feeding areas within the Gulf of Alaska and the Bering Sea that support the species. The primary constituent element to this critical habitat is the presence of large copepods and oceanographic factors that concentrate the prey of North Pacific right whales. At present, this primary constituent element (PCE) has not been significantly degraded due to human activity. However, significant concern has been voiced regarding the impact that oceanic contamination of pollutants may have on the food chain and consequent bioaccumulation of toxins by marine predators. Changes due to global warming have also been raised as a concern that could affect the distribution or abundance of copepod prey for several marine mammals, including right whales.

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 1985b).

Population Structure

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

North Pacific. Some mark-recapture, catch distribution, and morphological research indicate more than one population may exist – one between 155°-175° W, and another east of 155° W (Masaki 1976; Masaki 1977). Sei whales have been reported primarily south of the Aleutian Islands, in Shelikof Strait and waters surrounding Kodiak Island, in the Gulf of Alaska, and inside waters of southeast Alaska and south to California to the east and Japan and Korea to the west (Leatherwood et al. 1982; Nasu 1974). Sightings have also occurred in Hawaiian waters (Smultea et al. 2010). Sei whales have been occasionally reported from the Bering Sea and in low numbers on the central Bering Sea shelf (Hill and DeMaster 1998). Whaling data suggest that sei whales do not venture north of about 55°N (Gregr et al. 2000). Masaki (1977) reported sei whales concentrating in the northern and western Bering Sea from July-September, although other researchers question these observations because no other surveys have reported sei whales in the northern and western Bering Sea. Harwood (1987) evaluated Japanese sighting data and concluded that sei whales rarely occur in the Bering Sea. Harwood (1987) reported that 75-85 percent of the North Pacific population resides east of 180°. During winter, sei whales are found from 20°-23° N (Gambell 1985b; Masaki 1977). Considering the many British Columbia whaling catches in the early to mid 1900s, sei whales have clearly utilized this area in the past (Gregr et al. 2000; Pike and Macaskie 1969).

Reproductive activities for sei whales occur primarily in winter. Gestation is about 12.7 months, calves are weaned at 6-9 months, and the calving interval is about 2-3 years (Gambell 1985b; Rice 1977). Sei whales become sexually mature at about age 10 (Rice 1977).

Natural Threats

The foraging areas of right and sei whales in the western North Atlantic Ocean overlap and both whales feed preferentially on copepods (Mitchell 1975).

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

Anthropogenic Threats

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

Sei whales, because of their offshore distribution and relative scarcity in U.S. Atlantic and Pacific waters, probably have a lower incidence of entrapment and entanglement than fin whales. Data on entanglement and entrapment in non-U.S. waters are not reported systematically. Heyning and Lewis (1990) made a crude estimate of about 73 rorquals killed/year in the southern California offshore drift gillnet fishery during the 1980s. Some of these may have been fin whales instead of sei whales. Some balaenopterids, particularly fin whales, may also be taken in the drift gillnet fisheries for sharks and swordfish along the Pacific coast of Baja California, Mexico (Barlow et al. 1997). Heyning and Lewis (1990) suggested that most whales killed by offshore fishing gear do not drift far enough to strand on beaches or to be detected floating in the nearshore corridor where most whale-watching and other types of boat traffic occur. Thus, the small amount of documentation may not mean that entanglement in fishing gear is an insignificant cause of mortality. Observer coverage in the Pacific offshore fisheries has been too low for any confident assessment of species-specific entanglement rates (Barlow et al. 1997). The offshore drift gillnet fishery is the only fishery that is likely to take sei whales from this stock, but no fishery mortalities or serious injuries to sei whales have been observed. Sei whales, like other large whales, may break through or carry away fishing gear. Whales carrying gear may die later, become debilitated or seriously injured, or have normal functions impaired, but with no evidence recorded.

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

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

Status and Trends

The sei whale was originally listed as endangered in 1970 (35 FR 18319), and this status remained since the inception of the ESA in 1973. Table 6 provides estimates of historic and current abundance for ocean regions.

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). Matsuoka et al. (Matsuoka et al. 2012) in a summer 2011 North Pacific survey noted that sei whale was the third most common baleen whale observed, with a total of 38 sightings (73 adults and 2 calves) of sei whales observed.

Diving

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

Social Behavior

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

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

Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100-600 Hz range with 1.5 s duration and tonal and upsweep calls in the 200-600 Hz range of 1-3 s durations (McDonald et al. 2005). Differences may exist in vocalizations between ocean basins (Rankin et al. 2009). Vocalizations from the North Atlantic consisted of paired sequences (0.5-0.8 sec, separated by 0.4-1.0 sec) of 10-20 short (4 msec) FM sweeps between 1.5-3.5 kHz (Richardson et al. 1995).

Critical Habitat

The NMFS has not designated critical habitat for sei whales.

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 (13607 kg). Adult males, however, reach about 52 feet (16 m) and may weigh as much as 45 tons (40823 kg).

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

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

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

Distribution

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

Population Structure

There is no clear understanding of the global population structure of sperm whales (Dufault et al. 1999). Recent ocean-wide genetic studies indicate low, but statistically significant, genetic diversity and no clear geographic structure, but strong differentiation between social groups (Lyrholm and Gyllensten 1998; Lyrholm et al. 1996; Lyrholm et al. 1999). The IWC currently recognizes four sperm whale stocks: North Atlantic, North Pacific, northern Indian Ocean, and Southern Hemisphere (Dufault et al. 1999; Reeves and Whitehead 1997). The NMFS recognizes six stocks under the MMPA- three in the Atlantic/Gulf of Mexico and three in the Pacific (Alaska, California-Oregon-Washington, and Hawai'i; (Perry et al. 1999b; Waring et al. 2004). Genetic studies indicate that movements of both sexes through expanses of ocean basins are common, and that males, but not females, often breed in different ocean basins than the ones in which they were born (Whitehead 2003). Sperm whale populations appear to be structured socially, at the level of the clan, rather than geographically (Whitehead 2003; Whitehead 2008).

Sperm whales are found throughout the North Pacific and are distributed broadly in tropical and temperate waters to the Bering Sea as far north as Cape Navarin in summer, and occur south of 40^{o} N in winter (Gosho et al. 1984; Miyashita et al. 1995 as cited in Carretta et al. 2005; Rice 1974). Sperm whales are found year-round in Californian and Hawaiian waters (Barlow 1995; Dohl 1983; Forney et al. 1995; Shallenberger 1981). They are seen in every season except winter (December-February) in Washington and Oregon (Green et al. 1992).

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 and inaccurate killings by Soviet whaling fleets between 1947 and 1973. In the Southern Hemisphere, these whalers killed an estimated 100,000 whales that they did not report to the IWC (Yablokov et al. 1998), with smaller harvests in the Northern Hemisphere, primarily the North Pacific, that extirpated sperm whales from large areas (Yablokov 2000). Additionally, Soviet whalers disproportionately killed adult females in any reproductive condition (pregnant or lactating) as well as immature sperm whales of either gender.

Following a moratorium on whaling by the IWC, significant whaling pressures on sperm whales were eliminated. However, sperm whales are known to have become entangled in commercial fishing gear and 17 individuals are known to have been struck by vessels (Jensen and Silber 2004). Whale-watching vessels are known to influence sperm whale behavior (Richter et al. 2006).

In U.S. waters in the Pacific, sperm whales have been incidentally taken only in drift gillnet operations, which killed or seriously injured an average of nine sperm whales per year from 1991-1995 (Barlow et al. 1997).

Interactions between sperm whales and longline fisheries in the Gulf of Alaska have been reported since 1995 and are increasing in frequency (Hill and DeMaster 1998; Hill et al. 1999; Rice 1989). Between 2002 and 2006, there were three observed serious injuries (considered mortalities) to sperm whales in the Gulf of Alaska from the sablefish longline fishery (Angliss and Outlaw 2008). Sperm whales have also been observed in Gulf of Alaska feeding off longline gear (for sablefish and halibut) at 38 of the surveyed stations (Angliss and Outlaw 2008). Recent findings suggest sperm whales in Alaska may have learned that fishing vessel propeller cavitation (as gear is retrieved) is 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. Table 7 contains historic and current estimates of sperm whales by region. Sperm whale populations probably are undergoing the dynamics of small population sizes, which is a threat in and of itself. In particular, the loss of sperm whales to directed Soviet whaling likely inhibits recovery due to the loss of adult females and their calves, leaving sizeable gaps in demographic and age structuring (Whitehead and Mesnick 2003).

There are approximately 76,803 sperm whales in the eastern tropical Pacific, eastern North Pacific, Hawai′i, and western North Pacific (Whitehead 2002a). Minimum estimates in the eastern North Pacific are 1,719 individuals and 5,531 in the Hawaiian Islands (Carretta et al. 2007). The tropical Pacific is home to approximately 26,053 sperm whales and the western North Pacific has approximately 29,674 (Whitehead 2002a). There was a dramatic decline in the number of females around the Galapagos Islands during 1985-1999 versus 1978-1992 levels, likely due to migration to nearshore waters of South and Central America (Whitehead and Mesnick 2003).

Sperm whales are sighted off Oregon in every season except winter (Green et al. 1992). However, sperm whales are found off California year-round (Barlow 1995; Dohl 1983; Forney et al. 1995), with peak abundance from April to mid-June and from August to mid-November (Rice 1974). Barlow (Barlow 2003) reported mean group sizes of 2.0–11.8 during surveys off the western U.S. Barlow (Barlow 2003) estimated that 440 and 52 sperm whales occurred in Oregonian and Washingtonian waters, depending upon year and area, supported by densities of 0.0002 to 0.0019 individuals/km^2.

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.

Sperm whales appear to feed regularly throughout the year (NMFS 2006a). It is estimated they consume about 3-3.5 percent of their body weight daily (Lockyer 1981). They seem to forage mainly on or near the bottom, often ingesting stones, sand, sponges, and other non-food items (Rice 1989). A large proportion of a sperm whale's diet consists of low-fat, ammoniacal, or luminescent squids (Clarke 1980a; Clarke 1996; Martin and Clarke 1986). While sperm whales feed primarily on large and medium-sized squids, the list of documented food items is fairly long and diverse. Prey items include other cephalopods, such as octopi, and medium- and large-sized demersal fishes, such as rays, sharks, and many teleosts (Angliss and Lodge 2004; Berzin 1972; Clarke 1977; Clarke 1980a; Rice 1989). The diet of large males in some areas, especially in high northern latitudes, is dominated by fish (Rice 1989). In some areas of the North Atlantic, however, males prey heavily on the oil-rich squid *Gonatus fabricii*, a species also frequently eaten by northern bottlenose whales (Clarke and Pascoe 1997).

Diving

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

Unlike other cetaceans, there is a preponderance of dive information for this species, most likely because it is the deepest diver of all cetacean species so generates a lot of interest. Sperm whales feed on large and medium-sized squid, octopus, rays and sharks, on or near the ocean floor (Clarke 1986; Whitehead 2002b). Some evidence suggests that they do not always dive to the bottom of the sea floor (likely if food is elsewhere in the water column), but that they do generally feed at the bottom of the dive. Davis et al. (2007) report that dive-depths (100-500 m) of sperm whales in the Gulf of California overlapped with depth distributions (200-400 m) of jumbo squid, based on data from satellite-linked dive recorders placed on both species, particularly during daytime hours. Their research also showed that sperm whales foraged throughout a 24-hour period, and that they rarely dove to the sea floor bottom (>1000 m). The most consistent sperm whale dive type is U-shaped, during which the whale makes a rapid descent to the bottom of the dive, forages at various velocities while at depth (likely while chasing prey) and then ascends rapidly to the surface. There is some evidence that male sperm whales, feeding at higher latitudes during summer months, may forage at several depths including <200 m, and utilize different strategies depending on position in the water column (Teloni et al. 2007).

Social Behavior

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

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

Sperm whales have a strong preference for waters deeper than 1,000 m (Reeves and Whitehead 1997; Watkins and Schevill 1977), although Berzin (1971) reported that they are restricted to waters deeper than 300 m. While deep water is their typical habitat, sperm whales are rarely found in waters less than 300 m in depth (Clarke 1956; Rice 1989). Sperm whales have been observed near Long Island, New York, in water between 40-55 m deep (Scott and Sadove 1997). When they are found relatively close to shore, sperm whales are usually associated with sharp increases in topography where upwelling occurs and biological production is high, implying the presence of a good food supply (Clarke 1956). Such areas include oceanic islands and along the outer continental shelf.

Sperm whales are frequently found in locations of high productivity due to upwelling or steep underwater topography, such as continental slopes, seamounts, or canyon features (Jaquet 1996; Jaquet and Whitehead 1996). Cold-core eddy features are also attractive to sperm whales in the Gulf of Mexico, likely because of the large numbers of squid that are drawn to the high concentrations of plankton associated with these features (Biggs et al. 2000; Davis et al. 2000b; 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 (Gregr and Trites 2001) reported that female sperm whales off British Columbia were relatively unaffected by the surrounding oceanography. However, Tynan et al. (2005) reported increased sperm whales densities with strong turbulence associated topographic features along the continental slope near Heceta Bank. Two noteworthy strandings in the region include an infamous incident (well publicized by the media) of attempts to dispose of a decomposed sperm whale carcass on an Oregon beach by using explosives. In addition, a mass stranding of 47 individuals in Oregon occurred during June 1979 (Norman et al. 2004; Rice et al. 1986).

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

Vocalization and Hearing

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

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

Critical Habitat

NMFS has not designated critical habitat for sperm whales.

4.2.7 Steller Sea Lion

The Steller sea lion, also known as the northern sea lion, is the largest member of the Otariid (eared seal) family. Steller sea lions exhibit sexual dimorphism, in which adult males are noticeably larger than females and further distinguished by a thick mane of coarse hair. Adult males may be up to 10-11 ft (3-3.4 m) in length and can weigh up to 2,500 lbs (1,120 kg). Females are smaller than males, at 7.5-9.5 ft (2.5-3.0 m) in length and weigh up to 770 lbs (350 kg). The coats of adult males and females are light blonde to reddish brown and slightly darker on the chest and abdomen. The light coloration is still visible when the body is wet, which is different from many pinniped species. Like other pinnipeds, their coat of fur "molts" every year. Both sexes also have long whitish whiskers, or vibrissae, on their muzzle. The flippers and other hairless parts of the skin are black. The fore-flippers are broader and longer than the hind-flippers and are the primary means of locomotion in water. On land, sea lions, unlike "true" seals, can turn their hind flippers forward for walking.

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

Distribution

Steller sea lions' range includes portions of the Gulf of Alaska TMAA. Steller sea lions are distributed mainly around the coasts to the outer continental shelf along the North Pacific Ocean rim from northern Hokkaiddo, Japan through the Kuril Islands and Okhotsk Sea, Aleutian Islands and central Bering Sea, southern coast of Alaska and south to California. The population is divided into the Western and the Eastern "distinct population segments" (DPSs) at 144° West longitude (Cape Suckling, Alaska). The Western DPS includes Steller sea lions that reside in the central and western Gulf of Alaska, Aleutian Islands, as well as those that inhabit the coastal waters and breed in Asia (e.g., Japan and Russia). The Eastern DPS includes sea lions living in southeast Alaska, British Columbia, California, and Oregon. The boundary between the Western

DPS and the Eastern DPS approximately bisects the TMAA, although the TMAA is located offshore of the main habitat/foraging areas. Steller sea lions do not migrate, but they often disperse widely outside of the breeding season (Loughlin 2002). Steller sea lions are gregarious animals that often travel or haul out in large groups of up to 45 individuals (Keple 2002). At sea, groups usually consist of females and subadult males; adult males are usually solitary while at sea (Loughlin 2002). An area of high occurrence extends from the shore to the 273-fathom (500-m) depth. For the Gulf of Alaska, foraging habitat is primarily shallow, nearshore, and continental shelf waters 4.3 to 13 nm (8 to 24 km) offshore with a secondary occurrence inshore of the 3,280 ft (1,000 m) isobath, and a rare occurrence seaward of the 3,280 ft (1,000 m) isobath. Steller sea lions have been sighted foraging in the middle of the Gulf of Alaska (Navy 2006). The April 2009 survey in the Gulf of Alaska TMAA encountered two groups of Steller sea lions (Rone et al. 2010).

Western DPS Population Structure

The minimum abundance estimate for the Western DPS of Steller sea lions is 38,988 individuals (Angliss and Allen 2009). Given the wide dispersal of individuals, the Western DPS may occur in the Gulf of Alaska (Angliss and Outlaw 2008; Navy 2006; NMFS 2008b), with about 70 percent of the population living in Alaskan waters. Between 2000 and 2004, the Western DPS increased at a rate of approximately 3 percent per year (Fritz and Stinchcomb 2005). Despite incomplete surveys conducted in 2006 and 2007, the available data indicate that the Western Steller sea lion DPS has been stable since 2004 (when the last complete assessment was done). The revised Steller Sea Lion Recovery Plan (NMFS 2008b) contains recovery criteria to change the listing of the Western DPS from endangered to threatened (“down-listing”) and to remove it from the list of species requiring ESA protection (delist).

Eastern DPS Population Structure

The minimum abundance estimate for the Eastern DPS is estimated at 45,095 to 55,832 (Angliss and Allen 2009). The Eastern DPS has increased at an annual rate of approximately 3 percent since at least the late 1970s (Pitcher et al. 2007) and may be a candidate for removal from the list of threatened and endangered species (NMFS 2008b).

Natural Threats

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

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

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

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

Anthropogenic Threats

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

Although not well documented, there is little doubt that numbers of Steller sea lions were greatly reduced in many locations by these activities (NMFS 2008b). Commercial hunting and predator control activities have been discontinued and no longer affect this DPS. In contrast to the Western DPS, which is experiencing potential human-related threats from competition with fisheries (potentially high), incidental take by fisheries (low), and toxic substances (medium) no threats to continued recovery were identified for the Eastern DPS. Although several factors affecting the Western DPS also affect the Eastern DPS (e.g., environmental variability, killer whale predation, toxic substances, disturbance, shooting), these threats do not appear to be at a level sufficient to keep the Eastern DPS from continuing to recover, given the long term sustained growth of the population as a whole (NMFS 2008b).

Western DPS Status and Trend

The Steller sea lion was initially listed as a threatened species under the ESA on April 5, 1990 (55 FR 12645). In 1997, based on demographic and genetic dissimilarities, we designated two DPSs of Steller sea lions under the ESA: A Western DPS and an Eastern DPS (62 FR 24345, 62 FR 30772). Due to persistent decline, the Western DPS was reclassified as endangered. The Western DPS includes animals at and west of Cape Suckling, Alaska (144°W).

The Steller sea lion is designated as depleted under MMPA. A final revised species recovery plan addresses both the Eastern and Western DPSs (NMFS 2008b).

Eastern DPS Status and Trend

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

Rookeries of the Eastern DPS occur along the coasts of Oregon and California (NMFS 2008b). The Steller sea lion is designated as depleted under MMPA. A final revised species recovery plan addresses both the Western and Eastern DPSs (NMFS 2008b).

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

Diving

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

Social Behavior

Steller sea lions are colonial breeders. Adult males, also known as bulls, establish and defend territories on rookeries to mate with females. Bulls become sexually mature between 3 and 8 years of age, but typically are not large enough to hold territory successfully until 9 or 10 years old. Mature males may go without eating for 1-2 months while they are aggressively defending their territory. Females typically reproduce for the first time at 4 to 6 years of age, usually giving birth to a single pup each year. At birth, pups are about 3.3 ft (1 m) in length and weigh 35-50 lbs (16-22.5 kg). Adult females, also known as cows, stay with their pups for a few days after birth before beginning a regular routine of alternating foraging trips at sea with nursing their pups on land. Female Steller sea lions use smell and distinct vocalizations to recognize and create strong social bonds with their newborn pups. Pups have a dark brown to black "lanugo" coat until 4 to 6 months old, when they molt to a lighter brown. By the end of their second year, pups are the same color as adults. Females usually mate again with males within 2 weeks after giving birth. Males can live to be up to 20 years old, while females can live to be 30.

Vocalization and Hearing

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

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

Western DPS Critical Habitat

In 1993, NMFS published a final rule to designate critical habitat for Steller sea lions (58 FR 45269). There is no Critical Habitat for Steller sea lions in the Gulf of Alaska TMAA. For the Western DPS, Critical Habitat for aquatic zones located (west of 144°W longitude) extend 20 nm (37 km) seaward in state and federally managed waters. None of the aquatic zones are located within the boundaries of the TMAA.

Eastern DPS Critical Habitat

In 1993, NMFS published a final rule to designate critical habitat for Steller sea lions (58 FR 45269). There is no Critical Habitat for Steller sea lions in the Gulf of Alaska TMAA. For the Eastern DPS, the Critical Habitat aquatic zones (located east of 144°W longitude) extend 3,000 ft (0.9 km) seaward in state and federally managed waters from the baseline or basepoint of each major rookery. None of this Critical Habitat is in the vicinity of the TMAA.

4.2.8 Leatherback Sea Turtle

The leatherback sea turtle is the largest turtle and the largest living reptile in the world. Mature leatherbacks can be as long as six and a half feet (2 m) and weigh an average of 660 to 880 lbs (900 kg) (Eckert et al. 2012). The leatherback is the only species of 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 (Eckert et al. 2012). 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.

Every 2-4 years, female leatherback sea turtles lay, on average, 6 clutches of 60-100 eggs each nesting season on sandy, tropical and temperate beaches (Eckert et al. 2012). After approximately 60 days, leatherback hatchlings emerge from the nest (Eckert et al. 2012). Hatchling have white striping along the ridges of their carapace and on the margins of the flippers emerge. Leatherback hatchlings are approximately 55-65 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) (Eckert et al. 2012).

Leatherback sea turtles lack the crushing chewing plates characteristic of sea turtles that feed on hard-bodied prey (Pritchard 1971). Instead, they have pointed tooth-like cusps and sharp edged jaws that are adapted for a diet of soft-bodied pelagic (open ocean) prey, such as jellyfish and salps. A leatherback's mouth and throat also have backward-pointing spine-like papillae that help retain such gelatinous prey.

Distribution

Leatherback sea turtles are widely distributed throughout the oceans of the world. Found from 71°N to 47°S, it has the most extensive range of any adult turtle (Eckert 1995). The species is found in four main regions of the world: the Pacific, Atlantic, and Indian Oceans, and the

Caribbean Sea. Leatherbacks also occur in the Mediterranean Sea, although they are not known to nest there. The four main regional areas may further be divided into nesting aggregations. Leatherback turtles are found on the western and eastern coasts of the Pacific Ocean, with nesting aggregations in Mexico and Costa Rica (eastern Pacific) and Malaysia, Indonesia, Australia, the Solomon Islands, Papua New Guinea, Thailand, and Fiji (western Pacific). In the Atlantic Ocean, leatherback nesting aggregations have been documented in Gabon, Sao Tome and Principe, French Guiana, Suriname, and Florida. In the Caribbean, leatherbacks nest in the U.S. Virgin Islands and Puerto Rico. In the Indian Ocean, leatherback nesting aggregations are reported in India and Sri Lanka and KwaZulu Natal, South Africa.

Leatherback sea turtles have been documented in Alaska waters as far north as approximately 60º latitude (approximately 50 miles north of the northern edge of the TMAA) and as far west in the Gulf of Alaska as the Aleutian Islands (Eckert 1993). In contrast with other sea turtles, leatherback sea turtles have physiological, thermoregulatory adaptations such as a counter-current heat exchange system, high fat content, and large body size that allow for the conservation of body heat which enable them to maintain body core temperatures well above the ambient water temperatures (Eckert 1993; Greer et al. 1973; Hughes et al. 1998; James and Mrosovsky 2004; Pritchard 1971). The leatherback's thick carapace contributes to their thermal tolerance and enables this species to forage in water temperatures far lower than the leatherback's core body temperature (Bostrom et al. 2010). In an analysis of available sightings (Eckert 2002), researchers found that leatherback turtles with carapace lengths smaller than 100 cm (39 inches) were sighted only in waters 79 ºF or warmer, while adults were found in waters as cold as 32ºF to 59ºF off Newfoundland (Goff and Lien 1988). As a result of their increased thermal tolerance, leatherbacks are more capable of surviving for extended periods of time in cooler waters than the hard-shelled sea turtles (Bleakney 1965; Lazell Jr. 1980).

Although leatherback turtles are expected to be present within the Gulf of Alaska TMAA, they are likely few in number given the TMAA is near the northern edge of the known extent of their Pacific range (Eckert 1993; Navy 2010c). No numbers or density estimates are available for leatherback turtles in the TMAA, but given their distribution patterns based on water temperature elsewhere (Eckert 1993) the number of leatherback sea turtles in the Gulf of Alaska is likely very low .

Population Structure

Leatherback 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 leatherback sea turtles is usually based on the distribution of their nesting aggregations.

Natural Threats

The various habitat types leatherback sea turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural threats. The beaches on which leatherback sea turtles nest and the nests themselves are threatened by hurricanes and tropical storms as well as storm surges, sand accretion, and rainfall that are associated with hurricanes. Hatchlings have many predators including: crabs, ants, herons, gulls, pigs, dogs, lizards, dogfish, and sharks among others. Larger leatherbacks, including adults, are killed or injured by sharks, killer whales and other large, marine predators.

Anthropomorphic Threats

Leatherback sea turtles are impacted by several human activities, including fisheries in which leatherbacks are caught as bycatch or become entangled in gear (e.g., gillnets, longlines, lobster pots, weirs), direct harvest, egg collection, the destruction and degradation of nesting and coastal habitat, boat collisions, and ingestion of marine debris.

The foremost threat is the interaction of leatherback turtles with fisheries. Spotila (2004) concluded that a conservative estimate of annual leatherback fishery-related mortality (from longlines, trawls and gillnets) in the Pacific Ocean during the 1990s is 1,500 animals. He estimates that this represented about a 23 percent mortality rate (or 33 percent if most mortality was focused on the East Pacific population). Spotila (2000) asserts that most of the mortality associated with the Playa Grande nesting site was fishery related.

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

In the Pacific Ocean, between 1,000 and 1,300 leatherback sea turtles are estimated to have been captured and killed in longline fisheries in 2000 (Lewison et al. 2004). Shallow-set longline fisheries based out of Hawai'i are estimated to have captured and killed several hundred leatherback sea turtles before they were closed in 2001. When they were re-opened in 2004, with substantial modifications to protect sea turtles, these fisheries were estimated to have captured and killed about 1 or 2 leatherback sea turtles each year. Between 2004 and 2008, shallow-set fisheries based out of Hawai'i are estimated to have captured about 19 leatherback sea turtles, killing about 5 of these sea turtles. A recent biological opinion on these fisheries expected this rate of interaction and deaths to continue into the foreseeable future. Leatherback sea turtles have also been and are expected to continue to be captured and killed in the deep-set based longline fisheries based out of Hawai'i and American Samoa.

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

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

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

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

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

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 and Trends

The leatherback turtle was listed under the Endangered Species Act as endangered throughout its range in 1970. There is a recovery plan for this species (NMFS and USFWS 1998).

Leatherback turtles are considered critically endangered by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2010) and are protected by the Convention on International Trade in Endangered Species (CITES).

The Pacific Ocean leatherback population is generally smaller in size than that in the Atlantic Ocean. Because adult female leatherbacks frequently nest on many different beaches, nesting population estimates and trends are especially difficult to monitor. In the Pacific, the IUCN notes that most leatherback nesting populations have declined more than 80 percent. In other areas of the leatherback's range, observed declines in nesting populations are not as severe, and some population trends are increasing or stable. In the Atlantic, available information indicates that the largest leatherback nesting population occurs in French Guiana, but the trends are unclear. Some Caribbean nesting populations appear to be increasing, but these populations are very small when compared to those that nested in the Pacific less than 10 years ago. Nesting trends on U.S. beaches have been increasing in recent years.

Diving

The leatherback is the deepest diving sea turtle, with a recorded maximum depth of 4,200 ft. (1,280 m), although most dives are much shallower (usually less than 820 ft. [249.9 m]) (Hays et al. 2004; Houghton et al. 2008; Sale et al. 2006). Leatherback turtles primarily feed on gelatinous zooplankton such as cnidarians (jellyfish and siphonophores) and tunicates (salps and pyrosomas) (Bjorndal 1997; NMFS and USFWS 1998). The leatherback dives day and night and spends short periods of time on the surface between dives (Eckert et al. 1989; Southwood et al. 1999). Typical dive durations averaged 6.9 to 14.5 minutes (min) per dive, with a maximum of 42 min (Eckert et al. 1996). Sea turtles typically remain submerged for several minutes to several hours depending upon their activity state (Standora et al. 1984). Long periods of submergence hamper detection and confound census efforts. During migrations or long distance movements, leatherbacks maximize swimming efficiency by traveling within 15 ft (5 m) of the surface (Eckert 2002).

Social Behavior

Male leatherbacks do not return to land after they hatch from their nests whereas mature females return to land only to lay eggs (Spotila 2004). Aside from this brief terrestrial period, which lasts approximately three months during egg incubation and hatching, leatherback turtles are rarely encountered out of the water. Hatchling leatherbacks are pelagic, but nothing is known about their distribution during the first 4 years of life (Musick and Limpus 1997).

The Pacific coast of Mexico is generally regarded as the most important leatherback breeding ground in the world, although nesting on Pacific beaches under U.S. jurisdiction has always been rare (NMFS and USFWS 1998). Based on a single aerial survey in 1980 of Michoacán, Guerrero, and Oaxaca, and on published and anecdotal data, Pritchard (Pritchard) estimated that 30,000 females nested annually in these three Mexican states. Lower-density nesting was (and still is) reported farther north in Jalisco (NMFS and USFWS 1998) and in Baja California, where the northernmost eastern Pacific nesting sites are found (Fritts et al. 1982). Leatherbacks nest along the western coast of Mexico from November to February, although some females arrive as early as August (NMFS and USFWS 1998), and in Central America from October to February (Lux et al. 2003). This species nests primarily on beaches with little reef or rock offshore. On these types of beaches erosion reduces the probability of nest survival. To compensate, leatherbacks scatter their nests over large geographic areas and lay on average two times as many clutches as other species (Eckert 1987). Females may lay up to nine clutches in a season (although six is more common), and the incubation period is 58–65 days. At Playa Grande, Costa Rica, and in French Guiana, the mean inter-nesting period was 9 days (Lux et al. 2003). Post-nesting adults appear to migrate along bathymetric contours from 656 to 11,483 ft (200 to 3,500 m) (Morreale et al. 1994), and most of the eastern Pacific nesting stocks migrate south (NMFS and USFWS 1998). Other principal nesting sites in the Pacific Ocean indicate that gene flow between eastern and western Pacific nesting populations is restricted (Dutton et al. 2005; Dutton et al. 2006; Dutton et al. 1999; Dutton et al. 1996; Dutton et al. 2003).

Hearing and Sound Production

Sea turtles do not have an external ear pinnae or eardrum. Instead, they have a cutaneous layer and underlying subtympanal fatty layer that functions as a tympanic membrane (TM). Sound passes through the subtympanal fatty layer to the air-filled middle ear (containing the stapes, or columella) and into the inner ear and cochlea (Ridgway et al. 1969). Sea turtles are capable of detecting both vibratory (via bone conduction) and acoustic stimuli (Lenhardt et al. 1983; Lenhardt et al. 1985). While the biological significance of hearing remains unstudied, it is hypothesized that sea turtles may use sound for navigation, locating prey, avoiding predators, and general environmental awareness (Dow Piniak et al. 2012b)

Studies of hearing of sea turtles have shown that green, loggerhead, Kemp's ridley, hawksbill, and leatherback sea turtles detect low frequency acoustic and vibratory stimuli underwater and in air. Vibratory and aerial tones produced cochlear responses in three juvenile green turtles between 50 and 2,000 Hz (Ridgway et al. 1969). Ridgway concluded that green turtles likely have a useful hearing range of 60 to 1,000 Hz, but have greatest sensitivity from 200-700 Hz.

More recent research has measured hearing by collecting behavioral audiograms or by recording auditory evoked potentials (AEPs). AEPs are electrical responses of the central auditory nervous system produced when the auditory system is stimulated by a detectable sound (Au and Hastings 2010). Bartol and Ketten (2006) measured auditory brainstem responses (ABRs, or short latency AEPs) 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 AEPs 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 (Dow Piniak et al. 2012b). Vibratory stimuli delivered directly to the tympanun produced AEP responses in loggerheads between 250 and 750 Hz (Moein Bartol et al. 1999), and underwater tones elicited behavioral responses to frequencies between 50 and 800 Hz and AEP 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.

Measurements of ABRs in response to aerial stimuli in partially submerged juvenile Kemp's ridleys documented hearing between 100 and 500 Hz, with maximum sensitivity between 100 and 200 hz (Moein Bartol and Ketten 2006), Aerial and underwater acoustic stimuli elicited AEP responses between and 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).

Recent research measuring AEPs 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). Given the lack of TTS information for leatherbacks, the potential for TTS among leatherback turtles must be classified as unknown but would likely follow those of other sea turtles.

For exposures to impulsive sound, a study on the effects of air guns on sea turtle behavior also suggests that sea turtles are most likely to respond to low-frequency sounds (McCauley et al. 2000). Loggerhead sea turtles will avoid air-gun arrays at 2 km and at 1 km, with received levels of 166 dB re 1 µPa-m and 175 dB re 1 µPa, respectively (McCauley et al. 2000). The sea turtles' response was consistent: above a level of about 166 dB re 1 µPa, the sea turtles noticeably increased their swimming activity. Above 175 dB re 1 µPa, their behavior became more erratic, possibly indicating that they were agitated (McCauley et al. 2000).

Nesting leatherback turtles have been recorded producing sounds (sighs or belch-like sounds) up to 1,200 Hz with most energy ranging from 300 to 500 Hz (Cook and Forrest 2005). These noises are guttural exhalations made during the nesting process. There is no evidence that turtles generate audible sounds for communication, navigation, or foraging (as in marine mammals).

Critical Habitat

Critical habitat was designated in 1998 for leatherback turtles in coastal waters adjacent to Sandy Point, St. Croix, U.S. Virgin Islands. In 2007, NMFS received a petition to revise the critical habitat designations. NMFS published a 90-day finding on the petition in December 2007.

On 26 January 2012, we revised the critical habitat for the leatherback sea turtle by designating 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) (77 FR 4170).

4.2.9 Chinook Salmon

Chinook salmon are the largest of any salmon, with adults often exceeding 40 pounds (18 kg); individuals over 120 pounds (54 kg) have been reported. Chinook mature at about 36 inches and 30 pounds. Chinook salmon have a blue-green back with silver flanks at sea, with small black spots on both lobes of the tail, and black pigment along the base of the teeth. Adults migrate from a marine environment into the freshwater streams and rivers of their birth in order to mate (called anadromy). They spawn only once and then die (called semelparity).

Juvenile Chinook may spend from 3 months to 2 years in freshwater before migrating to estuarine areas as smolts and then into the ocean to feed and mature. Chinook salmon remain at sea for 1 to 6 years (more commonly 2 to 4 years), with the exception of a small proportion of yearling males (called jack salmon) which mature in freshwater or return after 2 or 3 months in salt water. They feed on terrestrial and aquatic insects, amphipods, and other crustaceans while young, and primarily on other fishes when older.

There are different seasonal (i.e., spring, summer, fall, or winter) "runs" in the migration of Chinook salmon from the ocean to freshwater, even within a single river system. These runs have been identified on the basis of when adult Chinook salmon enter freshwater to begin their spawning migration. However, distinct runs also differ in the degree of maturation at the time of river entry, the temperature and flow characteristics of their spawning site, and their actual time of spawning. Freshwater entry and spawning timing are believed to be related to local temperature and water flow regimes.

Two distinct types or races among Chinook salmon have evolved. One race, described as a "stream-type" Chinook, is found most commonly in headwater streams of large river systems. Stream-type Chinook salmon have a longer freshwater residency, and perform extensive offshore migrations in the central North Pacific before returning to their birth, or natal, streams in the spring or summer months. Stream-type juveniles are much more dependent on freshwater stream ecosystems because of their extended residence in these areas. A stream-type life history may be adapted to areas that are more consistently productive and less susceptible to dramatic changes in water flow. At the time of saltwater entry, stream-type (yearling) smolts are much larger, averaging 3 to 5.25 inches (73-134 mm) depending on the river system, than their ocean-type (subyearling) counterparts, and are therefore able to move offshore relatively quickly.

The second race, called the "ocean-type" Chinook, is commonly found in coastal streams in North America. Ocean-type Chinook typically migrate to sea within the first three months of life, but they may spend up to a year in freshwater prior to emigration to the sea. They also spend their ocean life in coastal waters. Ocean-type Chinook salmon return to their natal streams or rivers as spring, winter, fall, summer, and late-fall runs, but summer and fall runs predominate. Ocean-type Chinook salmon tend to use estuaries and coastal areas more extensively than other pacific salmonids for juvenile rearing. The evolution of the ocean-type life history strategy may have been a response to the limited carrying capacity of smaller stream systems and unproductive watersheds, or a means of avoiding the impact of seasonal floods. Ocean-type Chinook salmon tend to migrate along the coast. Populations of Chinook salmon south of the Columbia River drainage appear to consist predominantly of ocean-type fish.

Distribution

The Chinook salmon's historical range in North America extended from the Ventura River in California to Point Hope, Alaska. The natural freshwater range for Chinook salmon extends throughout the Pacific Rim of North America. This species has been identified from the San Joaquin River in California to the Mackenzie River in northern Canada (Healey 1991). The oceanic range encompasses Washington, Oregon, California, throughout the north Pacific Ocean, and as far south as the U.S./Mexico border (PFMC 2000). The majority of stream-type Chinook stocks are found in Alaska, north of 56°N and ocean-type Chinook are more common near the center of the species range (Healey 1991).

Early life history stages for Chinook occur in freshwater but juveniles and adults utilize marine habitats within the Gulf of Alaska. Juvenile Chinook prefer coastal areas (less than 55 km) throughout California, Oregon, and Washington, north to the Strait of Georgia and the Inland Passage, Alaska. The majority of marine juveniles are found within 28 km of the coast (PFMC 2000). They tend to concentrate around areas of pronounced coastal upwelling. Populations originating north of Cape Blanco, Oregon migrate north to the Gulf of Alaska, while populations originating south of Cape Blanco migrate south and west into the waters off California and Oregon (PFMC 2000).

Chinook salmon spawning in rivers south of the Rogue River in Oregon rear in marine waters off California and Oregon, whereas, salmon spawning in rivers north of the Rogue River migrate north and west along the Pacific coast. These migrations are important from a management perspective since fish from Oregon, Washington, British Columbia, and Alaska have the potential of being harvested in the Gulf of Alaska.

Status and Trends

NMFS identified 17 ESUs of Chinook (*Oncorhynchus tshawytscha*) salmon in Washington, Oregon, Idaho, and California. Each ESU is treated as a separate species under the ESA (NMFS 2005). Of these ESUs, two are endangered (Sacramento River winter-run and Upper Columbia River spring-run), seven are threatened (Snake River spring/summer-run, Snake River fall-run, Central Valley spring-run, California coastal, Puget Sound, Lower Columbia River, and Upper Willamette River), and one is listed as a species of concern (Central Valley fall-and late fall-run)(70 FR 37160). The remaining seven ESUs were found to not warrant listing under the ESA (NMFS 2005).

In recent years, some populations have shown encouraging increases in population size. Population trends for specific ESUs can be found in the 2005 status review report for Pacific salmon and steelhead (NMFS 2006).

Habitat Preferences

Chinook salmon are found in freshwater to euhaline waters from the surface to depths of 820 ft (250 m) depending on life stage. They spawn in rivers at depths ranging from the surface to 33 ft (10 m) with a preferred depth of greater than 0.8 ft (0.24 m) for spring and fall salmon and greater than 1.0 ft (0.30 m) for summer salmon (Beauchamp et al. 1983). The depth of the redd is inversely related to water velocity (PFMC 2000). Juvenile Chinook range from the surface to 3.9 ft (1.2 m) while inhabiting streams, lakes, sloughs, and rivers and continue to stay near the surface during their initial marine stages (Beauchamp et al. 1983) Pacific Fishery Management Council 2000). After juveniles have advanced past the initial marine phase, they prefer depths ranging from 98 to 230 ft (30 to 70 m) and are often associated with bottom topography (PFMC 2000). Late juveniles and adults may be pelagic, neustonic, or semi-demersal/semi-pelagic (PFMC 2000).

Chinook salmon may be found in water temperatures ranging from 32° to 79°F (0° to 26°C) but this varies depending on lifestage and activity (MBC 1987). Adult Chinook salmon prefer water temperatures less than 57°F (14°C) but can survive in deep pools in the summer with surface temperatures of 73°F (23°C) (Beauchamp et al. 1983; PFMC 2000). Chinook cannot spawn at temperatures above 72°F (22°C) (Beauchamp et al. 1983). Ideal spawning temperatures range from 42° to 57°F (5.6° to 13.9°C) but spawning can occur from 40° to 64°F (4.4° to 18.0°C) (Beauchamp et al. 1983). The primary food source for Chinook salmon in freshwater habitats is postulated to be adult and larval insects (Healey 1991). Diets vary considerably from estuary to estuary but Chinook utilize a wide range of prey including: gammarid amphipods, insects, mysids, isopods, copepods, and fish larvae (Beauchamp et al. 1983; Healey 1991). As Chinook grow and move into marine environments, their diets shift to consist of crab zoea, rockfish, Pacific sand lance, eulachon, herring, anchovy, copepods, euphausiids, cephalopods, isopods, and amphipods (Beauchamp et al. 1983).

Critical Habitat

Critical habitat has been designated for all nine listed ESUs of Chinook salmon. However, there is no designated critical habitat in the TMAA for Chinook salmon.

4.2.10 Coho Salmon

Coho salmon (*Oncorhynchus kisutch*) have dark metallic blue or greenish backs with silver sides and a light belly and there are small black spots on the back and upper lobe of the tail while in the ocean. The gumline in the lower jaw has lighter pigment than does the Chinook salmon. Spawning fish in inland rivers are dark with reddish-maroon coloration on the sides. Adult coho salmon may measure more than 2 feet (61 cm) in length and can weigh up to 36 pounds (16 kg). However, the average weight of adult coho is 8 pounds (3.6 kg)

Coho salmon adults migrate from a marine environment into freshwater streams and rivers of their birth in order to mate (called anadromy). They spawn only once and then die (called semelparity). Adults return to their stream of origin to spawn and die, usually at around three years old. Some precocious males known as "jacks" return as two-year-old spawners. Spawning males develop a strongly hooked snout and large teeth. Females prepare several redds (nests) where the eggs will remain for six to seven weeks until they hatch.

As the time for migration to the sea approaches, juvenile coho salmon lose their parr marks, a pattern of vertical bars and spots useful for camouflage, and gain the dark back and light belly coloration used by fish living in open water. Their gills and kidneys also begin to change at this time so that they can process salt water. In their freshwater stages, coho feed on plankton and insects, and switch to a diet of small fishes as adults in the ocean.

Distribution

Coho salmon are found in freshwater drainages from Monterey Bay, California north along the west coast of North America to Alaska, around the Bering Sea south through Russia to Hokkaido, Japan. Oceanic lifestages can be found from Camalu Bay, Baja California north to Point Hope, Alaska and from there, south to Korea (Sandercock 1991). In the northeastern Pacific, coho can be found south of 40°N, but only in the coastal waters of the California Current. Juvenile coho are generally found within 32 nm (60 km) of the Washington, Oregon, and California coasts, but the majority are found within 20 nm (37 km) (PFMC 2000).

Tagging studies have shown coho originating from Washington and Oregon as far north as 60°N latitude, and originating from California as far north as 58°N latitude (PFMC 2000).

Oregon coho have been taken in offshore waters near Kodiak Island in the northern Gulf of Alaska. Westward migration of coho salmon appears to extend beyond the EEZ beginning at approximately 45°N latitude off the coast of Oregon (PFMC 2000). In strong upwelling years, coho salmon are more dispersed offshore, whereas in weak upwelling years they concentrate near submarine canyons and areas of consistent upwelling. Offshore, juvenile coho are generally found in waters over the continental shelf, ranging from 23 to 46 mi (37 to 74 km) from shore. Adult coho may enter freshwater as early as July in Alaska and as late as December or January in California (PFMC 2000; Sandercock 1991). Summer-run coho may enter rivers exceptionally early (spring or early summer; (PFMC 2000). Larger rivers have a wider range of entry times than smaller systems (PFMC 2000).

Status and Trends

There are currently seven ESUs of coho salmon in Washington, Oregon, and California (NMFS 2005). Of these ESUs, one is endangered (Central California Coast), and three are threatened (Northern California-Southern Oregon Coasts, Lower Columbia River and Oregon Coast) (NMFS 2005)(70 FR 37160).

Coho salmon are considered to be particularly vulnerable to anthropogenic activities such as timber harvesting, mining, and road building since they have an extended residency in freshwater environments (streams, ponds, and lakes). Catch rates for coho salmon in Alaska are at historically high levels, and most stocks are rated as stable (Navy 2006). They are not listed on the IUCN Red List of Threatened Species (IUCN 2010) or by CITES.

The long-term trend for the listed ESUs is still downward, although there was one recent good year with an increasing trend in 2001 (NMFS 2005).

Habitat Preferences

Coho salmon are found in fresh water to euhaline water at depths ranging from the surface to 820 ft (250 m). In marine environments, both juveniles and adults stay within 33 ft (10 m) of the surface unless water conditions are considerably warm (Emmett et al. 1991). Adult coho need a minimum water depth of 7 in (18 cm) to spawn (Laufle et al. 1986). Fry and smolt prefer variable depths with fry ranging from 12 to 48 in (0.3 to 1.2 m), generally associated with submerged riffle areas. Avoidance of strong currents and predators seems to be the most important factor in determining habitat for young fish (Laufle et al. 1986; PFMC 2000).

Critical Habitat

Critical habitat has been designated for the four listed ESUs. Critical habitat has been proposed for the Lower Columbia River ESU, but not finalized (76 FR 1392). However, there is no designated critical habitat in the TMAA for the coho salmon.

4.2.11 Chum Salmon

Second only to Chinook salmon in adult size, chum salmon (*Oncorhynchus keta*) individuals have been reported up to 3.6 feet (1.1 m) and 46 pounds (20.8 kg). However, average weight is around 8 to 15 pounds (3.6 to 6.8 kg).

Chum salmon are best known for the enormous canine-like fangs and striking body color of spawning males (a calico pattern, with the front two-thirds of the flank marked by a bold, jagged, reddish line and the posterior third by a jagged black line). Females are less flamboyantly colored and lack the extreme dentition of the males. Ocean stage chum salmon are metallic greenish-blue along the back with black speckles. They closely resemble both sockeye and coho salmon at this stage. As chum salmon enter fresh water, their color and appearance changes dramatically. Both sexes develop a "tiger stripe" pattern of bold red and black stripes.

In order to mate, chum salmon adults migrate from a marine environment into the freshwater streams and rivers of their birth (called anadromy). They spawn only once and then die (called semelparity). Unlike most species that rear extensively in fresh water, chum salmon form schools, presumably to reduce predation. Chum salmon feed on insects and marine invertebrates while in rivers. As adults, their diet consists of "copepods", fishes, "mollusks", squid and "tunicates".

Age at maturity appears to follow a latitudinal trend in which a greater number of fish mature at a later age in the northern portion of the species' range. Most chum salmon mature and return to their birth stream to spawn between 3 and 5 years of age, with 60 to 90 percent of the fish maturing at 4 years of age. The species has only a single form (sea-run) and does not reside in fresh water. As the time for migration to the sea approaches, juvenile chum salmon lose their parr marks (vertical bars and spots useful for camouflage). They then gain the dark back and light belly coloration used by fish living in open water. They seek deeper water and avoid light; their gills and kidneys begin to change so that they can process salt water.

Distribution

Chum salmon have the largest range of natural geographic and spawning distribution of all the Pacific salmon species (Pauley et al. 1988). Historically, in North America, chum salmon occur from Monterey, California to the Arctic coast of Alaska and east to the Mackenzie River which flows into the Beaufort Sea. Present spawning populations are now found only as far south as Tillamook Bay on the northern Oregon coast (Salo 1991). Juvenile chum occur along the coast of North America and Alaska in a band that extends out to 19 nm (36 km) (Salo 1991). Chum salmon are more dependent on estuaries and marine waters than the other Pacific salmon species with the exception of ocean-type Chinook salmon (Salo 1991).

Early life history stages for chum salmon occur in freshwater but juveniles and adults utilize marine habitats within the Gulf of Alaska. Juvenile chum migrations follow the Gulf of Alaska coastal belt to the north, west, and south during their first summer at sea (Salo 1991). While overall migrations patterns of juvenile chum salmon within the Gulf of Alaska are understood, nearshore residency times and offshore migrations patterns are still unclear (Salo 1991). Migrations of immature fish during the late summer/fall and winter occur in a broad southeasterly fashion, primarily south of 50°N and east of 155°W in the Gulf of Alaska. During the spring and early summer, chum salmon migrate to the north and west (Salo 1991). Maturing fish destined for North American streams are widely distributed throughout the Gulf of Alaska during the spring and summer (Salo 1991).

Status and Trends

There are currently four ESUs of chum, two of which (Hood Canal Summer-run and the Columbia River) have been designated as threatened (70 FR 37161). The Puget Sound/Strait of Georgia and Pacific Coast ESUs have not yet warranted a designation of threatened or endangered (NMFS 2005). They are not listed on the IUCN Red List of Threatened Species (IUCN 2010) or by CITES.

Chum salmon may historically have been the most abundant of all Pacific salmonids. Seven of 16 historical spawning populations in the Hood River ESU are extinct. Recently some of these populations have shown encouraging increases in numbers, but the 2005 status review report shows that the population trend overall is a 6 percent decline per year. In the Columbia River, historical populations reached hundreds of thousands to a million adults each year. In the past 50 years, the average has been a few thousand a year. Currently, it is thought that 14 of the 16 spawning populations in the Columbia River ESU are extinct. About 500 spawners occur in the ESU presently, and the long-term trend is flat (NMFS 2005).

Habitat Preferences

Chum salmon are found in fresh water to euhaline water at depths ranging from the surface to 820 ft (250 m). Juveniles are primarily epipelagic and are found from the surface down to 312 ft (95 m) (Emmett et al. 1991). Chum salmon are found at a wide range of temperatures from 37° to 72°F (3° to 22°C) but prefer temperatures from 47° to 60°F (8.3° to 15.6°C) (Pauley et al. 1988). Eggs, alevins, fry, and parr inhabit freshwater while juveniles and adults are anadromous (Salo 1991). Juveniles and adults are found over a variety of substrates (Emmett et al. 1991).

Chum salmon fry feed on chironomid larvae if they spend extended periods in fresh water (Emmett et al. 1991). Juveniles initially feed on harpacticoid copepods and gammarid amphipods in shallow waters but may also prey upon terrestrial insects and small crustaceans (Emmett et al. 1991). Food limitations may cause juveniles to shift to more pelagic prey such as calanoid copepods, hyperiid amphipods, crustacean larvae, and larvaceans (Emmett et al. 1991). In marine environments, juveniles and subadults feed on euphausiids, squids, pteropods, and fishes (Emmett et al. 1991).

Critical Habitat

Critical habitat has been designated for the two listed ESUs of chum salmon. However, there is no designated critical habitat in the TMAA for the Chum salmon.

4.2.12 Sockeye Salmon

Sockeye Salmon (*Oncorhynchus nerka*) often have a bluish back and silver sides, giving rise to another common name, "bluebacks." The name "sockeye" is thought to have been a corruption of the various Indian tribes' word "sukkai." The size of an adult returning to spawn may measure up to 2.8 feet (86 cm) in length and weigh an average of 8 pounds (3.6 kg). The adult spawners are unique in appearance. They typically turn bright red, with a green head; hence they are commonly called "red" salmon in Alaska.

Adults migrate from a marine environment into freshwater streams and rivers or lakes of their birth in order to mate (called anadromy). They spawn only once and then die (called semelparity). Sockeye salmon exhibit a wide variety of life history patterns that reflect varying dependency on the freshwater environment. With the exception of certain river-type and sea-type populations, the vast majority of sockeye salmon spawn in or near lakes, where the juveniles rear for 1 to 3 years prior to migrating to sea. For this reason, the major distribution and abundance of large sockeye salmon stocks are closely related to the location of rivers that have accessible lakes in their watersheds for juvenile rearing.

Females spawn in 3 to 5 redds (nests) over a couple of days. Hatching usually occurs after 6 to 9 weeks. Most sockeye salmon fry then rear in lakes where they feed on aquatic insects and "plankton". As the time for migration to the sea approaches for the anadromous forms, the juvenile loses its parr marks, which are a pattern of vertical bars and spots useful for camouflage.

They then gain the dark back and light belly coloration used by fish living in open water. During this time their gills and kidneys begin to change so that they can process salt water. These "smolts", as they are called, initially stay close to the shore and feed on insects and plankton. Once they move offshore, their diet turns mainly to "amphipods", "copepods", squid, and some fishes. Most sockeye salmon stay at sea for two years, returning to spawn in their fourth year, but some may be five or six years old when they spawn.

Distribution

Spawning populations of sockeye salmon occur from the Sacramento River in California, north to Kotzebue Sound, but commercially important stocks range from the Columbia River to the Kuskokwim River in the Bering Sea (Burgner 1991). Their oceanic distribution ranges throughout the Pacific Ocean from the Bering Sea south to approximately 45°N (Burgner 1991).

Early life history stages for sockeye salmon occur in lakes and streams but juveniles and adults utilize marine habitats within the Gulf of Alaska and vicinity. Seaward migrations in Alaska begin in mid-May in association with salinity gradients. Soon after entering the ocean, juvenile sockeye salmon (excluding those from Bristol Bay) begin moving north into the Gulf of Alaska where they remain along the coastal belt until late-fall or early-winter. They then disperse offshore moving west and south (Emmett et al. 1991). In the Gulf of Alaska sockeye move north during the spring and summer then south and west during the winter (Emmett et al. 1991). Ocean residency for sockeye salmon is 1 to 4 years (Pauley et al. 1989).

Status and Trends

There are currently seven ESUs of sockeye salmon described by NMFS (NMFS 2005). The Snake River and Ozette lake ESUs are designated “endangered” and “threatened” respectively (70 FR 37160). Currently, the remaining ESUs do not warrant an ESA listing (NMFS 2005). The sockeye salmon is considered a species of “least concern” by the IUCN Red List of Threatened Species (IUCN 2010). They are not listed by CITES as protected.

Sockeye salmon are considered to be the third most abundant of the seven species of Pacific salmon; however, the Snake river ESU has remained at very low levels of only a few hundred fish. There have been recent increases in the number of hatchery reared fish returning to spawn. The size of the Ozette Lake ESU is also small, but increasing through hatcheries (NMFS 2005).

Habitat Preferences

Sockeye salmon are found in freshwater to euhaline waters. Young smolts tend to inhabit the upper part of the water column (Pauley et al. 1989). Little information exists on the vertical distribution of sockeye salmon at sea; however, research suggests that they are found from the surface to a depth of 30 m with a preferred depth from 0 to 15 m (Burgner 1991). Sockeye are found over a wide variety of temperatures (Burgner 1991). They may be found in temperatures ranging from 0 to 25°C but this varies by lifestage. Young sockeye prefer water temperatures between 12 and 14°C. Optimum temperature for adult sockeye has been estimated at 15°C and they avoid temperatures above 18°C (Pauley et al. 1989).There seems to be little correlation between high seas distribution of sockeye and surface salinity (Burgner 1991). There are no habitat preferences for juveniles rearing in lakes or adults in the marine environment (Pauley et al. 1989).

Critical Habitat

Critical habitat has been designated for the two listed ESUs of sockeye salmon. However, there is no designated critical habitat in the TMAA for the sockeye salmon.

4.2.13 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. Steelhead trout can reach up to 55 pounds (25 kg) in weight and 45 inches (120 cm) in length, though average size is much smaller.

They are a unique species; individuals develop differently depending on their environment. While all *O. mykiss* hatch in gravel-bottomed, fast-flowing, well-oxygenated rivers and streams, some stay in fresh water all their lives. These fish are called rainbow trout. The steelhead that migrate to the ocean develop a much more pointed head, become more silvery in color, and typically grow much larger than the rainbow trout that remain in fresh water.

Adults migrate from a marine environment into the freshwater streams and rivers of their birth in order to mate (called anadromy). Unlike other Pacific salmonids, they can spawn more than one time (called iteroparity). Migrations can be hundreds of miles. Young animals feed primarily on zooplankton. Adults feed on aquatic and terrestrial insects, mollusks, crustaceans, fish eggs, minnows, and other small fishes (including other trout).

Maximum age is about 11 years. Males mature generally at two years and females at three. Juvenile steelhead may spend up to seven years in freshwater before migrating to estuarine areas as smolts and then into the ocean to feed and mature. They can then remain at sea for up to three years before returning to freshwater to spawn. Some populations actually return to freshwater after their first season in the ocean, but do not spawn, and then return to the sea after one winter season in freshwater. Timing of return to the ocean can vary, and even within a stream system there can be different seasonal runs.

Steelhead can be divided into two basic reproductive types, stream-maturing or ocean-maturing, based on the state of sexual maturity at the time of river entry and duration of spawning migration. The stream-maturing type (summer-run steelhead in the Pacific Northwest and northern California) enters freshwater in a sexually immature condition between May and October and requires several months to mature and spawn. The ocean-maturing type (winter-run steelhead in the Pacific Northwest and northern California) enters freshwater between November and April, with well-developed gonads, and spawns shortly thereafter. Coastal streams are dominated by winter-run steelhead, whereas inland steelhead of the Columbia River basin are almost exclusively summer-run steelhead.

Adult female steelhead will prepare a redd (or nest) in a stream area with suitable gravel type composition, water depth, and velocity. The adult female may deposit eggs in 4 to 5 "nesting pockets" within a single redd. The eggs hatch in 3 to 4 weeks.

Distribution

Steelhead trout are found from central California to the Bering Sea and Bristol Bay coastal streams of Alaska. Steelhead smolts can be found in the nearshore marine environment from April to June (Busby et al. 1996). While early life history stages of the steelhead are found only in freshwater habitats, the later life history stages of the anadromous life form (i.e., juveniles and adults) utilize the marine environment in the Gulf of Alaska and vicinity. In the spring, Alaskan steelhead smolts leave their natal streams and enter the ocean where they reside for 1 to 3 years before returning to spawn. Populations may return in July (summer-run) or in August, September, and October (fall-run). Summer returns are rare in Alaska and are only found in a few southeast Alaska streams. Fall-run steelhead are much more common in Alaska, north of Frederick Sound, and are found in rivers, such as the Anchor, Nahu, Karluk, and Situk. Steelhead also exhibit spring runs (April, May, and June), but they are predominately found in southeast Alaska (Navy 2006).

Status and Trends

There are currently 15 Distinct Population Segments (DPSs) identified for steelhead trout in Washington, Oregon, Idaho, and California(NMFS 2005). Eleven of these DPSs have designations of either endangered or threatened. The Southern California DPS is designated as endangered (71 FR 834). The DPSs listed as threatened include the Upper Columbia River, Snake River Basin, Middle Columbia River, Lower Columbia River, Upper Willamette River, South-Central California Coast, Central California Coast, Northern California, California Central Valley(71 FR 834), and Puget Sound (72 FR 2673-22). They are not listed on the IUCN Red List of Threatened Species (IUCN 2010) or by CITES.

Little quantitative abundance information exists for most of these historic populations. The Russian River supports the largest spawning population of Central California Coast Steelhead, but its population is believed to have declined seven-fold since the mid-1960s (NMFS 2005).

Although data were relatively limited, analyses in 1996 and 2005 suggested (1) population abundances were low relative to historical estimates, (2) recent trends were downward, and (3) summer-run steelhead abundance was “very low” (NMFS 2005).

Habitat Preferences

Steelhead trout are found in fresh water to euhaline water at depths ranging from the surface to 656 ft (200 m). Water temperatures vary with lifestage; 50°F (10°C) is optimum with an upper limit of 75°F (24°C) (Pauley et al. 1986). Eggs, alevins, fry, and parr inhabit freshwater, while juveniles and adults may be anadromous or may remain in freshwater. Juveniles and adults occur over a wide variety of substrates and there seems to be no correlation between substrate and distribution.

Critical Habitat

Critical habitat has been designated for the listed DPSs of steelhead with the exception of the Puget Sound DPS, for which critical habitat has been proposed, but not finalized (76 FR 1392). However, there is no designated critical habitat in the TMAA for the steelhead trout.

4.2.14 Threats to Salmon and Steelhead

Water storage, withdrawal, conveyance, and diversions for agriculture, flood control, domestic, and hydropower purposes have greatly reduced or eliminated historically accessible habitat and/or resulted in direct entrainment mortality of juvenile salmonids. Modification of natural flow regimes has resulted in increased water temperatures, changes in fish community structures, and depleted flows necessary for migration, spawning, rearing, flushing of sediments from spawning gravels, gravel recruitment and transport of large woody debris. Physical features of dams, such as turbines and sluiceways, have resulted in increased mortality of both adults and juvenile salmonids. Attempts to mitigate adverse impacts of these structures have to date met with limited success.

Natural resource use and extraction leading to habitat modification can have significant direct and indirect impacts to salmon populations. Land use activities associated with logging, road construction, urban development, mining, agriculture, and recreation have significantly altered fish habitat quantity and quality. Associated impacts of these activities include: alteration of streambanks and channel morphology; alteration of ambient stream water temperatures; degradation of water quality; reduction in available food supply; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of spawning gravels and large woody debris; removal of riparian vegetation resulting in increased stream bank erosion; and increased sedimentation input into spawning and rearing areas resulting in the loss of channel complexity, pool habitat, suitable gravel substrate, and large woody debris. Studies indicate that in most western states, about 80 to 90 percent of the historic riparian habitat has been eliminated. Further, it has been estimated that during the last 200 years, the lower 48 United States have lost approximately 53 percent of all wetlands. Washington and Oregon's wetlands have been estimated to have been diminished by one third, while it is estimated that California has experienced a 91 percent loss of its wetland habitat.

The degree of spatial and temporal connectivity between and within watersheds is an important consideration for maintaining aquatic riparian ecosystem functions. Loss of this connectivity and complexity, such as the loss of deep pool habitats, has contributed to the decline of salmon. In Washington, the number of large, deep pools in National Forest streams has decreased by as much as 58 percent due to sedimentation and loss of pool-forming structures such as boulders and large wood. Similarly, in Oregon, the abundance of large, deep pools on private coastal lands has decreased by as much as 80 percent.

Salmon have been, and continue to be, an important target species for recreational fisheries throughout their range. During periods of decreased habitat availability, the impacts of recreational fishing on native anadromous stocks may be heightened. Commercial fishing on unlisted, healthier stocks has caused adverse impacts to weaker stocks of salmon, and illegal high seas driftnet fishing in past years may have also been partially responsible for declines in salmon abundance. However, such fisheries cannot account for the total declines in salmon abundance in North America.

Introduction of non-native species and modification of habitat have resulted in increased predator populations and salmonid predation in numerous river and estuarine systems. Piscivorous birds such as terns and cormorants, and pinnipeds such as sea lions and harbor seals are examples of potential salmon predators. Marine predation is also of concern in areas of dwindling salmon run-size. In general, predation rates on salmon are considered by most investigators to be an insignificant contribution to the large declines observed in west coast populations. However, predation may significantly influence salmonid abundance in some local populations when other prey are absent and physical conditions, such as narrow river mouths or human-made barriers such as fishing locks, lead to the concentration of adult and juvenile salmonids.

Natural environmental conditions have served to exacerbate the problems associated with degraded and altered riverine and estuarine habitats. Recent floods and persistent drought conditions have reduced already limited spawning, rearing, and migration habitat. Furthermore, climatic shifts over a decadal time scale appear to have resulted in decreased ocean productivity which may exacerbate degraded freshwater habitat conditions to some degree. Environmental conditions such as these have gone largely unnoticed until recently, when salmonid populations have reached critical low levels.

In an attempt to mitigate for lost habitat and reduced fisheries, extensive hatchery programs have been implemented throughout the range of salmon on the west coast. While some of these programs have been successful in providing fishing opportunities, the impacts of these programs on wilds stock are not well understood. Competition, genetic introgression, and disease transmission resulting from hatchery introductions may significantly impact the production and survival of wild salmon. Commercial and recreational fisheries targeting stronger stocks supported by hatchery production may inadvertently result in adverse impacts to weaker, wild stocks. Furthermore, collection and utilization of wild fish for broodstock purposes may result in additional negative impacts to small or dwindling natural populations.

4.2.15 Hearing in Salmon and Steelhead

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

The lateral line system of a fish allows for sensitivity to sound (Hastings and Popper 2005). This system is a series of receptors along the body of the fish that detects water motion relative to the fish that arise from sources within a few body lengths of the animal. The sensitivity of the lateral line system is generally from below 1 Hz to a few hundred Hz (Coombs and Montgomery 1999; Popper and Schilt 2009). The only study on the effect of exposure to sound on the lateral line system (conducted on one freshwater species) suggests no effect on these sensory cells by intense pure tone signals (Hastings et al. 1996).

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

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

4.2.16 Pacific Eulachon (southern population)

Eulachon, *Thaleichthys pacificus*, (commonly called smelt, candlefish, or hooligan) are a small, anadromous fish from the eastern Pacific Ocean. They are distinguished by the large canine teeth on the vomer, a bone in the roof of the mouth, and 18 to 23 rays in the anal fin. Like Pacific salmon they have an adipose fin; it is sickle-shaped. The paired fins are longer in males than in females. All fins have well-developed breeding tubercles (raised tissue "bumps") in ripe males, but these are poorly developed or absent in females. Adult coloration is brown to blue on the back and top of the head, lighter to silvery white on the sides, and white on the ventral surface; speckling is fine, sparse, and restricted to the back. They feed on plankton but only while at sea.

Eulachon typically spend 3 to 5 years in saltwater before returning to freshwater to spawn from late winter through mid spring. During spawning, males have a distinctly raised ridge along the middle of their bodies. Eggs are fertilized in the water column. After fertilization, the eggs sink and adhere to the river bottom, typically in areas of gravel and coarse sand. Most eulachon adults die after spawning. Eulachon eggs hatch in 20 to 40 days. The larvae are then carried downstream and are dispersed by estuarine and ocean currents shortly after hatching. Juvenile eulachon move from shallow nearshore areas to mid-depth areas. Within the Columbia River Basin, the major and most consistent spawning runs occur in the mainstem of the Columbia River as far upstream as the Bonneville Dam, and in the Cowlitz River.

Distribution

Eulachon is an anadromous species that spawns in the lower portions of certain rivers draining into the northeastern Pacific Ocean ranging from Northern California to the southeastern Bering Sea in Bristol Bay, Alaska (NMFS 2010a; Schultz and DeLacy 1935). Eulachon have been described as “common” in Grays Harbor and Willapa Bay on the Washington coast, “abundant” in the Columbia River, “common” in Oregon’s Umpqua River, and “abundant” in the Klamath River in northern California. They have been described as “rare” in Puget Sound and Skagit Bay in Washington; Siuslaw River, Coos Bay, and Rogue River in Oregon; and Humboldt Bay in California (Emmett et al. 1991). However, Hay and McCarter (Hay and McCarter 2000) and Hay (2002) identified 33 eulachon spawning rivers in British Columbia and 14 of these were classified as supporting regular yearly spawning runs.

The southern population of Pacific eulachon consists of populations spawning in rivers south of the Nass River in British Columbia, Canada, to, and including, the Mad River in California (75 FR 13012).

Population Structure

The southern population of Pacific eulachon consists of several ‘‘core populations’’ that include populations in the Columbia and Fraser Rivers with smaller populations in several other river systems in Canada, including the Nass and Skeena Rivers. Within the Columbia River Basin, the major and most consistent spawning runs return to the mainstem of the Columbia River (from just upstream of the estuary, river mile 25, to immediately downstream of Bonneville Dam, river mile 146) and in the Cowlitz River. Periodic spawning also occurs in the Grays, Skamokawa, Elochoman, Kalama, Lewis, and Sandy rivers (tributaries to the Columbia River). Historically, there may have been a population in the Klamath River (75 FR 13012).

Natural Threats

Eulachon have numerous avian predators including harlequin ducks, pigeon guillemots, common murres, mergansers, cormorants, gulls, and eagles. Marine mammals such as humpback whales, orcas, dolphins, Steller sea lions, California sea lions, northern fur seals, harbor seals, and beluga whales are known to feed on eulachon. During spawning runs, bears and wolves have been observed consuming eulachon. Fishes that prey on eulachon include white sturgeon, spiny dogfish, sablefish, salmon sharks, arrowtooth flounder, salmon, Dolly Varden charr, Pacific halibut, and Pacific cod. In particular, eulachon and their eggs seem to provide a significant food source for white sturgeon in the Columbia and Fraser Rivers (75 FR 13012).

Anthropogenic Threats

Southern eulachon are primarily threatened by increasing temperatures in the marine, coastal, estuarine, and freshwater environments of the Pacific Northwest that are at least causally related to climate change; dams and water diversions, water quality degradation, dredging operations in the Columbia and Fraser Rivers; commercial, recreational, and subsistence fisheries in Oregon and Washington that target eulachon; and bycatch in commercial fisheries.

Eulachon are particularly vulnerable to capture in shrimp fisheries in the United States and Canada as the marine areas occupied by shrimp and eulachon often overlap. In Oregon, the bycatch of various species of smelt (including eulachon) has been as high as 28 percent of the total catch of shrimp by weight (Hannah and Jones 2007). There are directed fisheries in Alaska state waters for eulachon in Upper Cook Inlet, the Copper River area, and in southeast Alaska. There has been little commercial activity in recent years, due to either lack of interest or closures resulting from concerns over diminished spawning runs, but there is potential for substantial amounts of harvest (Ormseth and Vollenweider 2007).

Status

The southern population of eulachon was listed as threatened on 18 March 2010 (75 FR 13012). Critical habitat has been proposed for this species (76 FR 515).

Vocalizations and Hearing

We do not have specific information on hearing in eulachon, but we assume that they are hearing generalists whose hearing sensitivities would be similar to salmon. Species in the family Salmonidae have similar auditory systems and hearing sensitivities (Popper 1977; Popper et al. 2007) (Wysocki et al. 2007). Most of the data available on this group resulted from studies of the hearing capability of Atlantic salmon (*Salmo salar*), which is a "hearing generalist" with a relatively poor sensitivity to sound (Hawkins and Johnstone 1978). Based on the information available, we assume that the eulachon considered in this consultation have hearing sensitivities ranging from less than 100 Hz to about 580 Hz (Hawkins and Johnstone 1978) (Knudsen et al. 1992; Knudsen et al. 1994; Popper 2008).

4.3 Climate Change

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

The IPCC estimated that average global land and sea surface temperature has increased by 0.6°C (±0.2) since the mid-1800s, with most of the change occurring since 1976. This temperature increase is greater than what would be expected given the range of natural climatic variability recorded over the past 1,000 years (Crowley 2000). The IPCC reviewed computer simulations of the effect of greenhouse gas emissions on observed climate variations that have been recorded in the past and evaluated the influence of natural phenomena such as solar and volcanic activity. Based on their review, the IPCC concluded that natural phenomena are insufficient to explain the increasing trend in land and sea surface temperature, and that most of the warming observed over the last 50 years is likely to be attributable to human activities (IPCC 2001). Climatic models estimate that global temperatures would increase between 1.4 to 5.8°C from 1990 to 2100 if humans do nothing to reduce greenhouse gas emissions (IPCC 2001). These projections identify a suite of changes in global climate conditions that are relevant to the future status and trend of endangered and threatened species (Table 9).

Climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the foreseeable future (Houghton 2001; IPCC 2001; Parry et al. 2007). The direct effects of climate change would result in increases in atmospheric temperatures, changes in sea surface temperatures, changes in patterns of precipitation, and changes in sea level. Oceanographic models project a weakening of the thermohaline circulation resulting in a reduction of heat transport into high latitudes of Europe, an increase in the mass of the Antarctic ice sheet, and a decrease in the Greenland ice sheet, although the magnitude of these changes remain unknown.

The indirect effects of climate change would result from changes in the distribution of temperatures suitable for calving and rearing calves, the distribution and abundance of prey, and the distribution and abundance of competitors or predators. For example, variations in the recruitment of krill (*Euphausia superba*) and the reproductive success of krill predators have been linked to variations in sea-surface temperatures and the extent of sea-ice cover during the winter months. Although the IPCC (2001) did not detect significant changes in the extent of Antarctic sea-ice using satellite measurements, Curran (2003) analyzed ice-core samples from 1841 to 1995 and concluded Antarctic sea ice cover had declined by about 20 percent since the 1950s.

Table 9. Phenomena associated with projections of global climate change including levels of confidence associated with projections (adapted from IPCC 2001 and Campbell-Lendrum Woodruff 2007).

Phenomenon	Confidence in Observed Changes (observed in the latter 20th Century)	Confidence in Projected Changes (during the 21st Century)
Higher maximum temperatures and a greater number of hot days over almost all land areas	Likely	Very likely
Higher minimum temperatures with fewer cold days and frost days over almost all land areas	Very likely	Very likely
Reduced diurnal temperature range over most land areas	Very likely	Very likely
Increased heat index over most land areas	Likely over many areas	Very likely over most areas
More intense precipitation events	Likely over many mid- to high-latitude areas in Northern Hemisphere	Very likely over many areas
Increased summer continental drying and associated probability of drought	Likely in a few areas	Likely over most mid-latitude continental interiors (projections are inconsistent for other areas)
Increase in peak wind intensities in tropical cyclones	Not observed	Likely over some areas
Increase in mean and peak precipitation intensities in tropical cyclones	Insufficient data	Likely over some areas

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

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

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

Climate-mediated changes in the distribution and abundance of keystone prey species like krill and climate-mediated changes in the distribution of cephalopod populations worldwide is likely to affect marine mammal populations as they re-distribute throughout the world's oceans in search of prey. Blue whales, as predators that specialize in eating krill, seem likely to change their distribution in response to changes in the distribution of krill (for example, see Payne et al. 1990; Payne 1986); if they did not change their distribution or could not find the biomass of krill necessary to sustain their population numbers, their populations seem likely to experience declines similar to those observed in other krill predators, which would cause dramatic declines in their population sizes or would increase the year-to-year variation in population size; either of these outcomes would dramatically increase the extinction probabilities of these whales.

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

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

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

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

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

4.4 Environmental Baseline

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

A number of human activities have contributed to the current status of populations of large whales, sea turtles, salmon, and eulachon in the action area. Some of those activities, most notably commercial whaling, occurred extensively in the past, ended, and no longer appear to affect these whale populations, although the effects of these reductions likely persist today. Other human activities are ongoing and appear to continue to affect populations of endangered and threatened whales, sea turtles and salmon. The following discussion summarizes the principal phenomena that are known to affect the likelihood that these endangered and threatened species will survive and recover in the wild.

4.4.1 Natural Mortality

Natural mortality rates in cetaceans, especially large whale species, are largely unknown. Although factors contributing to natural mortality cannot be quantified at this time, there are a number of suspected causes, including parasites, predation, red tide toxins and ice entrapment. For example, the giant spirurid nematode (*Crassicauda boopis*) has been attributed to congestive kidney failure and death in some large whale species (Lambertsen 1986). A well-documented observation of killer whales attacking a blue whale off Baja, California proves that blue whales are at least occasionally vulnerable to these predators (Tarpy 1979). Other stochastic events, such as fluctuations in weather and ocean temperature affecting prey availability, may also contribute to large whale natural mortality.

Sea turtles are also affected by disease and environmental factors. Turtles can be injured by predators such as birds, fish, and sharks (George 1997). Hypothermic or cold stunning occurs when a turtle is exposed to cold water for a period of time. Cold stunned turtles often have decreased salt gland function which may lead to plasma electrolyte imbalance and a lowered immune response (George 1997).

Changes in the abundance of salmonid populations are substantially affected by changes in the freshwater and marine environments. Evidence suggests that marine survival of salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hollowed et al. 2001; Lehodey et al. 2006; Mantua and Hare 2002). This phenomenon has been referred to as the Pacific Decadal Oscillation. Also, large-scale climatic regimes, such as El Niño, appear to affect changes in ocean productivity and influence local environmental rainfall patterns that can result in drought and fluctuating flows. During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years and very low stream flows. In more recent years, severe flooding has adversely affected some stocks. The listed salmon species included in this opinion are affected by this broad environmental cycle; thus, the survival and recovery of these species will depend on their ability to persist through periods of low natural survival rates.

Natural predators include birds, killer whales, and sea lions. Researchers estimated that Caspian terns nesting on Crescent Island, Washington, located below the confluence of the Snake and Columbia Rivers, consumed several hundred thousand juvenile salmonids each year of the study (679,000 smolts in 2001; 95 percent confidence interval (CI): 533,000-825,000 smolts) than in 2000 (465,000 smolts in 2000; 95 percent CI: 382,000-547,000 smolts) (Antolos et al. 2005) and 7 to 15 million outmigrating smolts during 1998 (Collis et al. 2002; Maranto et al. 2010). Field observations of predation and stomach contents of stranded killer whales collected over a 20-year period documented 22 species of fish and 1 species of squid in the diet of resident-type killer whales; 12 of these are previously unrecorded as prey of *O. orca*. Despite the diversity of fish species taken, resident whales have a clear preference for salmon prey. In field observations of feeding, 96 percent of fish taken were salmonids. Six species of salmonids were identified from prey fragments, with chinook salmon being the most common (Ford et al. 1998). Steller sea lions shift diet composition in response to changes in prey availability of pollock (*Theragra chalcogramma*), hake (*Merluccius productus*), herring (*Clupea pallasi*) and salmon (*Oncorhynchus spp*.) (Sigler et al. 2009).

4.4.2 Human-Induced Mortality

Large whale population numbers in the proposed action areas have historically been impacted by commercial exploitation, mainly in the form of whaling. Prior to current prohibitions on whaling, such as the International Whaling Commission's 1966 moratorium, most large whale species had been depleted to the extent it was necessary to list them as endangered under the Endangered Species Act of 1966. For example, from 1900 to 1965 nearly 30,000 humpback whales were captured and killed in the Pacific Ocean with an unknown number of additional animals captured and killed before 1900 (Perry et al. 1999a). Sei whales are estimated to have been reduced to 20 percent (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific (Tillman 1977). In addition, 9,500 blue whales were reported killed by commercial whalers in the North Pacific between 1910-1965 (Ohsumi and Wada 1972); 46,000 fin whales between 1947-1987 (Rice 1984); and 25,800 sperm whales (Barlow et al. 1997). North Pacific right whales once numbered 11,000 animals but commercial whaling has now reduced their population to 29-100 animals (Wada 1973).

Entrapment and entanglement in commercial fishing gear is one of the most frequently documented sources of human-caused mortality in large whale species and sea turtles. For example, in 1978, Nishimura and Nakahigashi (1990) estimated that 21,200 turtles, including greens, leatherback turtles, loggerheads, olive ridleys and hawksbills, were captured annually by Japanese tuna longliners in the Western Pacific and South China Sea, with a reported mortality of approximately 12,300 turtles per year. Using commercial tuna longline logbooks, research vessel data and questionnaires, Nishimura and Nakahigashi (1990) estimated that for every 10,000 hooks in the Western Pacific and South China Sea, one turtle is captured, with a mortality rate of 42 percent.

NMFS has observed 3,251 sets, representing approximately 3,874,635 hooks (data from February 1994 through December 31, 1999). The observed entanglement rate for sperm whales would equal about 0.31 whales per 1,000 sets or 0.0002 per 1,000 hooks. At those rates, we would expect about 200 sperm whales entanglements per 1,000 sets. However, only one sperm whale has been entangled in this gear; as a result, NMFS believes that the estimated entanglement rate substantially overestimates a sperm whale's actual probability of becoming entangled in this gear and the potential hazards longline gear poses to sperm whales.

Collisions with commercial ships are an increasing threat to many large whale species, particularly as shipping lanes cross important large whale breeding and feeding habitats or migratory routes. The number of observed physical injuries to humpback whales as a result of ship collisions has increased in Hawaiian waters (Glockner-Ferrari et al. 1987). On the Pacific coast, a humpback whale is probably killed about every other year by ship strikes (Barlow *et al*. 1997). From 1996-2002, eight humpback whales were reported struck by vessels in Alaskan waters. In 1996, a humpback whale calf was found stranded on Oahu with evidence of vessel collision (propeller cuts; NMFS unpublished data). From 1994 to 1998, two fin whales were presumed to have been killed in ship strikes.

Despite these reports, the magnitude of the risks ship traffic poses to large whales on or around the Gulf of Alaska TMAA is difficult to quantify or estimate. We struggle to estimate the number of whales that are killed or seriously injured in ship strikes within the territorial seas and the Exclusive Economic Zone of the continental United States and have virtually no information on interactions between ships and commercial vessels in the western North Pacific Ocean. With the information available, we assume that interactions occur but we cannot estimate the number of interactions or their significance to the endangered whales of the western North Pacific Ocean.

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

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

The marine mammals that occur in the action area are regularly exposed to several sources of natural and anthropogenic sounds. Anthropogenic noises that could affect ambient noise arise from the following general types of activities in and near the sea, any combination of which can contribute to the total noise at any one place and time. These noises include transportation, dredging, construction; oil, gas, and mineral exploration in offshore areas; geophysical (seismic) surveys; sonars; explosions; and ocean research activities (Richardson et al. 1995).

Noise in the marine environment has received a lot of attention in recent years and is likely to continue to receive attention in the foreseeable future. Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (Jasny et al. 2005; NRC 1994; NRC 2000; NRC 2003; NRC 2005; Richardson et al. 1995). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003). The military uses sound to test the construction of new vessels as well as for naval operations. In some areas where oil and gas production takes place, noise originates from the drilling and production platforms, tankers, vessel and aircraft support, seismic surveys, and the explosive removal of platforms (NRC 2003). Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Baker et al. 1983; Bauer and Herman 1986; Hall 1982; Krieger and Wing 1984), but the long-term effects, if any, are unclear or not detectable.

Carretta et al.(2001) and Jasny et al. (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate.

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

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 ambient noise frequency spectrum and level can be predicted fairly accurately for most deep-water areas based primarily on known shipping traffic density and wind state (wind speed, Beaufort wind force, or sea state) (Urick 1983). For frequencies between 100 and 500 Hz, Urick (1983) has estimated the average deep water ambient noise spectra to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas.

In contrast to deep water, ambient noise levels in shallow waters (i.e., coastal areas, bays, harbors, etc.) are subject to wide variations in level and frequency depending on time and location. The primary sources of noise include distant shipping and industrial activities, wind and waves, and marine animals (Urick 1983). At any given time and place, the ambient noise level is a mixture of these noise types. In addition, sound propagation is also affected by the variable shallow water conditions, including the depth, bottom slope, and type of bottom. Where the bottom is reflective, the sound levels tend to be higher than when the bottom is absorptive.

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).

Several investigators have studied the effects of whale watch vessels on marine mammals (Amaral and Carlson 2005; Au and Green 2000; Corkeron 1995; Erbe 2002b; Felix 2001; Magalhaes et al. 2002; Richter et al. 2006; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams et al. 2002). The whale's behavioral responses to whale watching vessels depended on the distance of the vessel from the whale, vessel speed, vessel direction, vessel noise, and the number of vessels. The whales' responses changed with these different variables and, in some circumstances, the whales did not respond to the vessels, but in other circumstances, whales changed their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions.

4.4.3 The Impact of the Baseline on Listed Resources

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

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

Recent attention has focused on the emergence of a wide number of anthropogenic sound sources 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.

Few of the anthropogenic phenomena in the Gulf of Alaska TMAA that represent potential risks to whales in the Action 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 the region. The second line of evidence consists of reports that suggest that the response of whales to many of the anthropogenic activities in the Action Area 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.

Gauthier and Sears (1999), Weinrich et al. (1992), Clapham and Mattila (1993), Clapham et al. (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 even a minimal response.

At the same time, several lines of evidence suggest that these human activities might be greater consequences for individual whales (if not for whale populations). Several investigators reported behavioral responses to close approaches that suggest that individual whales might experience stress responses. Baker et al. (1983) described two responses of whales to vessels, including: (1) "horizontal avoidance" of vessels 2,000 to 4,000 meters away characterized by faster swimming and fewer long dives; and (2) "vertical avoidance" of vessels from 0 to 2,000 meters away during which whales swam more slowly, but spent more time submerged. Watkins (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 Hawai′i. They noted changes in respiration, diving, swimming speed, social exchanges, and other behavior correlated with the number, speed, direction, and proximity of vessels. Results were different depending on the social status of the whales being observed (single males when compared with cows and calves), but humpback whales generally tried to avoid vessels when the vessels were 0.5 to 1.0 kilometer from the whale. Smaller pods of whales and pods with calves seemed more responsive to approaching vessels.

Baker et al. (1983) and Baker and Herman (1986) 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. 1985). 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 distances 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 the 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 (2004a) concluded that the significance of disturbance was a function of the distance of humans to the animals, the number of humans making the close approach, and the frequency of the approaches. These results would suggest that the cumulative effects of the various human activities in the action area would be greater than the effects of the individual activity. None of the existing studies examined the potential effects of numerous close approaches on whales or gathered information on levels of stress-related hormones in blood samples that are more definitive indicators of stress (or its absence) in animals.

There is mounting evidence that wild animals respond to human disturbance in the same way that they respond to predators (Beale and Monaghan 2004a; Frid 2003; Frid and Dill 2002; Gill and Sutherland 2001; Romero 2004). These responses manifest themselves as stress responses (in which an animal perceives human activity as a potential threat and undergoes physiological changes to prepare for a flight or fight response or more serious physiological changes with chronic exposure to stressors), interruptions of essential behavioral or physiological events, alteration of an animal’s time budget, or some combinations of these responses (Frid and Dill 2002; Romero 2004; Sapolsky 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).

The information available does not allow us to assess the actual or probable effects of natural and anthropogenic phenomena on threatened or endangered species in the action area. The age composition, gender ratios, population abundance, and changes in that abundance over time remain unknown for threatened and endangered species in the action area of this consultation. Without this information or some surrogate information, it would be difficult, if not impossible, to reliably assess the impact of the activities identified in this *Environmental Baseline* on threatened and endangered species in the action area.

5 EFFECTS OF THE PROPOSED ACTION

'Effects of the action' means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR §402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. This effects' analyses section is organized as stressor – exposure – response – risk assessment framework.

The ESA does not define "harassment" nor has NMFS defined this term, pursuant to the ESA, through regulation. However, the MMPA defines "harassment" as "any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering" [16 U.S.C. 1362(18)(A)]. For military readiness activities, this definition of "harassment" has been amended to mean, in part, "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behaviors are abandoned or significantly altered" (Public Law 106-136, 2004).

For the purposes of this consultation, "harassment" is defined such that it corresponds to the MMPA and U.S. Fish and Wildlife Service's definitions: "an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents." NMFS is particularly concerned about changes in animal behavior that are likely to result in animals that fail to feed, fail to breed successfully, or fail to complete their life history because those changes may have adverse consequences for populations of those species.

Recent Navy consultation applications, Draft Environmental Impact Statements, and proposed MMPA regulations for testing and training activities contain proposed acoustic criteria and thresholds that would, if adopted, represent changes from the criteria and thresholds currently employed by NMFS in incidental take authorizations and associated biological opinions for Navy military readiness activities. The revised thresholds are based on evaluations of recent scientific studies (see (Finneran et al. 2010a; Finneran et al. 2010b; Finneran and Schlundt. 2011; Southall et al. 2008; Tyack et al. 2011).

The proposed new criteria and thresholds based on the Finneran and Tyack studies have recently been made available for public comment (77 FR 60678 and 77 FR 60679), and the public comments are still being evaluated. Until that process is complete, it is not appropriate to apply the new criteria and thresholds in any take authorization or associated biological opinion.

Each potential stressor associated with the activities the Navy proposes is discussed in greater detail below, followed by the results of NMFS' exposure analyses, which are designed to determine whether endangered or threatened individuals or designated critical habitat are likely to be exposed to the potential stressor. Those analyses are followed by the results of the response analyses.

This section concludes with an *Integration and Synthesis of Effects* that integrates information presented in the *Status of the Species* and *Environmental Baseline* sections of this opinion with the results of the exposure and response analyses to estimate the probable risks the proposed action poses to endangered and threatened species.

5.1 Potential Stressors

The potential stressors associated with the military readiness activities the Navy proposes to conduct in the TMAA consist of:

1) Movement of surface vessels and submarines involved in training activities with the associated risk of disturbance;
2) Movement of surface vessels and submarines involved in training activities with the associated risk of collision with protected species;
3) Aircraft flights and training exercises involving fixed-wing and helicopter aircraft to and from the TMAA as well as within the TMAA and the associated risk of disturbance;
4) Nonexplosive ordnance and gunfire and the associated risks of ordnance-related materials and disturbance;
5) Expended materials, including chemicals released from sonobuoys, parachutes, training targets, chaff, and sea flares or dye markers;
6) Sound fields produced by the low-, mid-, and high-frequency active sonar systems that would be employed during the training activities and the risk of disturbance or injury; and
7) Sound fields and pressure waves produced by the underwater detonations the Navy would employ during training activities and the risk of disturbance or injury.

5.1.1 Disturbance from Movement of Surface Vessels and Submarines

The presence and movement of vessels represent a source of acute and chronic disturbance for marine mammals. The underwater noise generated by vessels may disturb animals when the animal perceives that an approach has started and during the course of the interaction. Free-ranging cetaceans may engage in avoidance behavior when surface vessels move toward them. The combination of the physical presence of a surface vessel and the underwater noise generated by the vessel, or an interaction between the two may result in behavioral modifications of animals in the vicinity of the vessel or submarine (Goodwin and Cotton. 2004; Lusseau 2006). Several authors, however, suggest that the noise generated by the vessels is probably an important contributing factor to the responses of cetaceans to the vessels (Blane and Jaakson 1994; Evans et al. 1992; Evans et al. 1994), so we may not be able to treat the effects of vessel traffic as independent of engine and other sounds associated with the vessels.

5.1.2 Collision with Surface Vessels and Submarines

The movement of surface and subsurface vessels in waters that also might be occupied by endangered or threatened marine mammals and sea turtles (although the risk of striking sea turtles or fishes is smaller than the risk of striking endangered marine mammals) pose collision or ship strike hazards to those species. The size of the ships involved in the proposed training activities would range from 362 feet (a nuclear submarine) to 1,092 feet (for a nuclear-powered aircraft carrier). During training activities, ship speeds generally range from 10 to 14 knots; however, these vessels would also operate within the entire spectrum at lower and higher speeds during specific events, such as pursuing and overtaking hostile vessels, evasive maneuvers, and maintenance or performance checks. A variety of smaller craft such as service vessels engaged in routine operations or employed as opposition forces during training events would also be operating within the TMAA. For example, rigid hull inflatable boats (RHIBS) are 35 feet in length and can reach speeds greater than 40 knots.

5.1.3 Flights of Fixed-wing and Helicopter Aircraft

Several of the activities the Navy proposes to conduct involve the use of aircraft, including fix-wing aircraft, helicopters, 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.

5.1.4 Non-explosive Ordnance and Gunfire Disturbance

Current Navy training activities include firing a variety of weapons that employ a variety of non-explosive training rounds, including naval gun shells, cannon shells, and small caliber ammunition. As part of this training, Navy regulations require visual clearance before the training exercise of any range where ordnance (including non-explosive inert practice ordnance) is to be dropped. This risk analysis focuses on non-explosive training rounds, while potential effects of explosive munitions in the water are analyzed below in the explosions section. Missiles used in air to air training events at sea, although part of a live fire event, are designed to detonate in the air and do not constitute an at-sea explosion occurring in water as analyzed in this document. Direct ordnance strikes and disturbance associated with sound from firing are potential stressors to other listed marine mammals. Ingestion of expended ordnance is not a potential concern for marine mammals given it should sink to the ocean floor very quickly.

A gun fired from a ship on the surface of the water propagates a blast wave away from the gun muzzle. This spherical blast wave reflects off and diffracts around objects in its path. As the blast wave hits the water, it reflects back into the air, transmitting a sound pulse back into the water in proportions related to the angle at which it hits the water. Propagating energy is transmitted into the water in a finite region below the gun. A critical angle (about 13°, as measured from the vertical) can be calculated to determine the region of transmission in relation to a ship and gun (Navy 2010a).

The largest proposed shell size for these activities is a 5-inch shell. This will produce the highest pressure and all analysis will be done using this as a conservative measurement of produced and transmitted pressure, assuming that all other smaller ammunition sizes would fall under these levels.

5.1.5 Expended Materials

The proposed training exercises in the Gulf of Alaska TMAA include firing of a variety of weapons, explosive and non-explosive practice munitions such as; bombs, small arms ammunition, medium caliber cannon, missiles, targets, marine markers, flares, and chaff (see Table 2**Error! Reference source not found.**). Parachutes associated with flares and sonobuoys, as well as sonobuoys themselves, may be left in the TMAA during training exercises. The risks associated with each of these expended materials are described below.

Bombs

The majority of the bombs that would be used during training activities would be practice bombs that are not equipped with explosive warheads. Practice bombs entering the water would consist of materials like concrete, steel, and iron, and would not contain the combustion chemicals found in the warheads of explosive bombs. These components are consistent with the primary building blocks of artificial reef structures. The steel and iron, although durable, would corrode over time, with no noticeable environmental impacts. The concrete is also durable and would offer a beneficial substrate for benthic organisms. After sinking to the bottom, the physical structure of bombs would be incorporated into the marine environment by natural encrustation and/or sedimentation (Navy 2006).

Cannon and Small Arms Ammunition

Naval gun fire would use non-explosive and explosive 5-inch or 76 mm ordnance, 25 mm cannon, .50 caliber or 7.62 mm ordnance. More than 80 percent of the 5-inch and 76-mm training rounds expended would be non-explosive and contain an iron shell with sand, iron grit, or cement filler. Rapid-detonating explosive would be used in explosive rounds. Unexploded shells and non-explosive practice munitions would not be recovered and would sink to the ocean floor. Solid metal components (mainly iron) of unexploded ordnance and non-explosive practice munitions would also sink.

High-explosive, 5-inch shells are typically fused to detonate within 3 feet of the water surface. Shell fragments rapidly decelerate through contact with the surrounding water and settle to the sea floor. Unrecovered ordnance would also sink to the ocean floor. Iron shells and fragments would be corroded by seawater at slow rates, with comparably slow release rates. Over time, natural encrustation of exposed surfaces would occur, reducing the rate at which corrosion occurred. Rates of deterioration would vary, depending on the material and conditions in the immediate marine and benthic environment. However, the release of contaminants from unexploded ordnance, non-explosive practice munitions, and fragments would not result in measurable degradation of marine water quality.

The rapid-detonating explosive material of unexploded ordnance would not typically be exposed to the marine environment. Should the rapid-detonating explosive be exposed on the ocean floor, it would break down within a few hours (Navy 2006). Over time, the rapid-detonating explosive residue would be covered by ocean sediments or diluted by ocean water.

Missiles

Missiles would be fired by aircraft, ships, and naval special warfare operatives at a variety of airborne and surface targets within the TMAA. In general, the single largest hazardous constituent of missiles is solid propellant, which is primarily composed of rubber (polybutadiene) mixed with ammonium perchlorate (for example, solid double-base propellant, aluminum and ammonia propellant grain, and arcite propellant grain). Hazardous constituents are also used in igniters, explosive bolts, batteries (potassium hydroxide and lithium chloride), and warheads (for example, PBX-N high explosive components; PBXN-106 explosive; and PBX (AF)-108 explosive). Chromium or cadmium may also be found in anti-corrosion compounds coating exterior missile surfaces. In the event of an ignition failure or other launch mishap, the rocket motor or portions of the unburned propellant may cause environmental effects.

Experience with Hellfire missiles has shown that if the rocket motor generates sufficient thrust to overcome the launcher hold-back, all of the rocket propellant is consumed. In the rare cases where the rocket does not generate sufficient thrust to overcome the holdback (hang fire or miss fire), some propellant may remain unburned but the missile remains on the launcher. Jettisoning the launcher is a possibility for hang fire or miss fire situations, but in most cases the aircraft returns to base where the malfunctioning missile is handled by explosive ordnance disposal personnel.

Non-explosive practice missiles generally do not explode upon contact with the target or sea surface. The main environmental effect would be the physical structure of the missile entering the water. Practice missiles do not use rocket motors and, therefore, do not have potentially hazardous rocket fuel. Exploding warheads may be used in air-to-air missile exercises, but those missiles would explode at an offset to the target in the air, disintegrate, and fall into the ocean to avoid damaging the aerial target. High explosive missiles used in air-to-surface exercises explode near the water surface (Navy 2006).

The principal potential stressor from missiles would be unburned solid propellant residue. Solid propellant fragments would sink to the ocean floor and undergo changes in the presence of seawater. The concentration would decrease over time as the leaching rate decreased and further dilution occurred. The aluminum would remain in the propellant binder and eventually would be oxidized by seawater to aluminum oxide. The remaining binder material and aluminum oxide would pose no threat to the marine environment (Navy 2006).

Targets

At-sea targets are usually remotely operated airborne, surface, or subsurface traveling units, most of which are designed to be recovered for reuse. Small concentrations of fuel and ionic metals would be released during battery operation.

A typical aerial target drone is powered by a jet fuel engine, generates radio frequency signals for tracking purposes, and is equipped with a parachute to allow recovery. Drones also contain oils, hydraulic fluid, batteries, and explosive cartridges as part of their operating systems. There are also recoverable, remotely controlled target boats and underwater targets designed to simulate submarines. If severely damaged or displaced, targets may sink before they can be retrieved. Aerial targets employed in the TMAA would include AST/ALQ/ESM pods, Banner drones, BQM-74E drones, Cheyenne, Lear Jets, and Tactical Air-Launched Decoys, which are the only expended targets (these targets are non-powered, air-launched, aerodynamic vehicles).

Surface targets would include Integrated Maritime Portable Acoustic Scoring and Simulator Systems, Improved Surface Tow Targets, QST-35 Seaborne Powered Targets, and expendable marine markers (smoke floats). Expended surface targets commonly used in addition to marine markers include cardboard boxes, 55-gallon steel drums, and a 10-foot-diameter red balloon tethered by a sea anchor (also known as a “killer tomato”). Floating debris, such as Styrofoam, may be lost from target boats.

Most target fragments would sink quickly in the sea. Expended material that sinks to the sea floor would gradually degrade, be overgrown by marine life, and/or be incorporated into the sediments. Floating, non-hazardous expended material may be lost from target boats and would either degrade over time or wash ashore as flotsam. Non-hazardous expended materials are defined as the parts of a device made of non-reactive material. Typical non-reactive material includes metals such as steel and aluminum; polymers, including nylon, rubber, vinyl, and plastics; glass; fiber; and concrete. While these items represent persistent seabed litter, their strong resistance to degradation and their chemical composition mean they do not chemically contaminate the surrounding environment by leaching heavy metals or organic compounds.

Marine Markers and Flares

Marine markers and flares are pyrotechnic devices dropped on the water’s surface to mark a surface position. The chemicals contained within markers and flares not only burn but also produce smoke. The smoke is expected to rapidly diffuse by air movement. The marker itself would eventually sink to the bottom and become encrusted and/or incorporated into the sediments. Phosphorus contained in the marker settles to the sea floor where it reacts with the water to produce phosphoric acid, until all phosphorus is consumed by the reaction. Combustion of red phosphorus produces phosphorus oxides, which have a low toxicity to aquatic organisms (Navy 2010a).

Flares may contain magnesium or aluminum casings. Flares are designed to burn completely in air with only ash and a small plastic end cap entering the water. Flare end caps would eventually sink to the bottom and become encrusted and/or incorporated into the sediments. Solid flare and pyrotechnic residues may contain aluminum, magnesium, zinc, strontium, barium, cadmium, and nickel, as well as perchlorates. Hazardous constituents in pyrotechnic residues are typically present in small amounts or low concentrations, and are bound in relatively insoluble compounds.

Chaff

Radio frequency chaff is an electronic countermeasure designed to reflect radar waves and obscure aircraft, ships, and other equipment from radar-tracking sources. Chaff is non-hazardous and consists of aluminum-coated glass fibers (about 60 percent silica and 40 percent aluminum by weight) ranging in lengths from 0.3 to 3 inches with a diameter of about 40 micrometers. Chaff is released or dispensed from military vehicles in cartridges or projectiles that contain millions of chaff fibers. When deployed, a diffuse cloud of fibers undetectable to the human eye is formed. Chaff is a very light material that can remain suspended in air anywhere from 10 minutes to 10 hours. It can travel considerable distances from its release point, depending on prevailing atmospheric conditions (Arfsten et al. 2002).

For each chaff cartridge used, a plastic end-cap and Plexiglas piston is released into the environment in addition to the chaff fibers. The end-cap and piston are both round and are 1.3 inches in diameter and 0.13 inches thick. The fine, neutrally buoyant chaff streamers act like particulates in the water, temporarily increasing the turbidity of the ocean's surface. However, they are quickly dispersed and turbidity readings return to normal. The end-caps and pistons would sink. The expended material could also be transported long distances before becoming incorporated into the bottom sediments.

Parachutes and Sonobuoys

Aircraft-launched sonobuoys, flares, torpedoes, and expendable mobile ASW training targets (EMATTs) deploy nylon parachutes of varying sizes. When sonobuoys impact the water surface after being deployed from aircraft, their parachute assemblies are jettisoned and sink away from the sonobuoy. The parachutes are made of nylon and are about 8 feet in diameter. At maximum inflation, the canopies are between 0.15 to 0.35 square meters (1.6 to 3.8 square feet). The shroud lines range from 0.30 to 0.53 meters (12 to 21 inches) in length and are made of either cotton polyester with a 13.6 kilogram (30 pound) breaking strength or nylon with a 45.4 kilogram (100 pound) breaking strength. All parachutes are weighted with a 0.06 kilogram (2 ounce) steel material weight, which would cause the parachute to sink from the surface within about 15 minutes (although actual sinking rates would depend on ocean conditions and the shape of the parachute).

The sonobuoy system's subsurface assembly descends to a selected depth, the case falls away, and sea anchors deploy to stabilize the hydrophone (underwater microphone). The operating life of the seawater battery is about eight hours, after which the sonobuoy scuttles itself and sinks to the ocean bottom. For the sonobuoys, the Navy calculated concentrations of metals released from batteries as 0.0011 mg/L lead, 0.000015mg/L copper, and 0.0000001mg/L silver.

A sonobuoy is approximately 5 in (13 cm) in diameter, 3 ft (1 m) long, and weighs between 14 and 39 lbs (6 and 18 kg), depending on the type. Aircraft-launched sonobuoys deploy a nylon parachute of varying sizes, ranging from 1.6 to 3.8 ft^2 (0.15 to 0.35 m^2). The shroud lines range from 12 to 21 in (0.30 to 0.53 m) in length and are made of either cotton polyester with a 30-lb (13.6-kg) breaking strength or nylon with a 100-lb (45.4-kg) breaking strength. All parachutes are weighted with a 2 ounce (0.06-kg) steel material weight, which causes the parachute to sink from the surface within 15 minutes. At water impact, the parachute assembly, battery, and sonobuoy will sink to the ocean floor where they will be buried into its soft sediments or land on the hard bottom where they will eventually be colonized by marine organisms and degrade over time. These components are not expected to float at the water surface or remain suspended within the water column. Over time, the amount of materials will accumulate on the ocean floor.

However, the sonobuoys will not likely be used in the exact same location each time. Additionally, the materials will not likely settle in the same vicinity due to ocean currents.

5.1.6 Sonar Sound Fields

The Navy plans to employ mid-and high-frequency sonar systems during several of the training events it proposes to conduct in the Gulf of Alaska TMAA. Naval sonars operate on the same basic principle as fish-finders (which are also a kind of sonar): brief pulses of sound, or "pings," are projected into the ocean and an accompanying hydrophone system in the sonar device listens for echoes from targets such as ships, mines or submarines. Tactical military sonars are designed to search for, detect, localize, classify, and track submarines. The Navy typically employs two types of sonars during anti-submarine warfare exercises:

1. Passive sonars only listen to incoming sounds and, since they do not emit sound energy in the water, lack the potential to acoustically affect the environment.
2. Active sonars generate and emit acoustic energy specifically for the purpose of obtaining information concerning a distant object from the received and processed reflected sound energy.

The simplest active sonars emit omnidirectional pulses or "pings" and calculate the length of time the reflected echoes return from the target object to determine the distance between the sonar source and a target. More sophisticated active sonar emits an omnidirectional ping and then scans a steered receiving beam to calculate the direction and distance of a target. More advanced sonars transmit multiple preformed beams, listening to echoes from several directions simultaneously and providing efficient detection of both direction and range. The types of sound sources that would be used during military readiness activities in the Gulf of Alaska TMAA include:

Sonar Systems Associated With Surface Ships

A variety of surface ships participate in Navy training exercises, including guided missile cruisers, destroyers, guided missile destroyers, and frigates. Some ships (e.g., aircraft carriers) do not have any onboard active sonar systems, other than fathometers. Others, like guided missile cruisers, are equipped with active as well as passive sonars for submarine detection and tracking. The primary surface ship sonars considered are:

1. AN/SQS-53 – a computer-controlled, hull-mounted surface-ship sonar that has both active and passive operating capabilities, providing precise information for anti-submarine warfare (ASW) weapons control and guidance. The system is designed to perform direct-path ASW search, detection, localization, and tracking, from a hull-mounted transducer array. The AN/SQS-53 is characterized as a mid-frequency active (MFA) sonar, operating from 1 to 10 kilohertz (kHz); however, the exact frequency is classified. The AN/SQS-53 sonar is the major component to the AN/SQQ-89 sonar suite, and it is installed on Arleigh Burke Class guided missile destroyers, and Ticonderoga Class guided missile cruisers.

2. AN/SQS-53 Kingfisher – a modification to the AN/SQS-53 sonar system that provides the surface ship with an object detection capability. The system uses MFA sonar, although the exact frequency range is classified. This sonar system is installed on Arleigh Burke Class guided missile destroyers, and Ticonderoga Class guided missile cruisers.

3. AN/SQS-56 – a hull-mounted sonar that features digital implementation, system control by a built-in mini-computer, and an advanced display system. The sonar is an active/passive, preformed beam, digital sonar providing panoramic active echo ranging and passive digital multibeam steering (DIMUS) surveillance. The sonar system is characterized as MFA sonar, although the exact frequency range is classified. The AN/SQS-56 is the major component of the AN/SQQ-89 sonar suite and is installed on Oliver Hazard Perry Class frigates.

4. AN/SQR-19 – a tactical towed array sonar (TACTAS) that is able to passively detect adversary submarines at a very long range. The AN/SQR-19, which is a component of the AN/SQQ-89 sonar suite, is a series of passive hydrophones towed from a cable several thousand feet behind the ship. The AN/SQR-19 can be deployed by Arleigh Burke Class guided missile destroyers, Ticonderoga Class guided missile cruisers, and Oliver Hazard Perry Class frigates.

Sonar Systems Associated With Submarines

Tactical military submarines equipped with hull-mounted mid-frequency use active sonar to detect and target enemy submarines and surface ships. The predominant active sonar system mounted on submarines is AN/BQQ-10 sonar that is used to detect and target enemy submarines and surface ships. Two other systems — AN/BQQ-5 and AN/BSY-1/2 — have operational parameters that would affect marine mammals in ways that are similar to the AN/BQQ-10. In addition, Seawolf Class attack submarines, Virginia Class attack submarines, Los Angeles Class attack submarines, and Ohio Class nuclear guided missile submarines also have the AN/BQS-15 sonar system, which uses high-frequency for under-ice navigation and mine-hunting.

1. The AN/BQQ-10 is characterized as mid-frequency active sonar, although the exact frequency range is classified. The AN/BQQ-10 is installed on Seawolf Class fast attack submarines, Virginia Class fast attack submarines, Los Angeles Class fast attack submarines, and Ohio Class nuclear guided missile submarines. The BQQ-10 systems installed on Ohio Class nuclear guided missile submarines do not have an active sonar capability.

2. The AN/BQQ-5 – a bow- and hull-mounted passive and active search and attack sonar system. The system includes the TB-16 and TB-23 or TB-29 towed arrays and Combat Control System MK 2. This sonar system is characterized as mid-frequency active sonar, although the exact frequency range is classified. The AN/BQQ-5 sonar system is installed on Los Angeles Class nuclear attack submarines and Ohio Class ballistic missile nuclear submarines, although the AN/BQQ-5 systems installed on Ohio Class ballistic missile nuclear submarines do not have an active sonar capability. The AN/BQQ-5 system is being phased out on all submarines in favor of the AN/BQQ-10 sonar.

3. AN/BQS-15 – an under-ice navigation and mine-hunting sonar that uses both mid- and high-frequency (i.e., greater than 10 kHz) active sonar, although the exact frequencies are classified. Later versions of the AN/BQS-15 are also referred to as Submarine Active Detection Sonar (SADS). The Advanced Mine Detection System is being phased in on all ships and will eventually replace the AN/BQS-15 and submarine active detection sonar. These systems are installed on Seawolf Class fast attack submarines, Virginia Class fast attack submarines, Los Angeles Class fast attack submarines, and Ohio Class nuclear guided missile submarines.

4. AN/WQC-25 – an MFA sonar underwater communications system that can transmit either voice or signal data in two bands, 1.5 to 3.1 kHz or 8.3 to 11.1 kHz. The AN/WQC-2, also referred to as the “underwater telephone,” is on all submarines and most surface ships, and allows voice and tonal communications between ships and submarines.

Sonar Systems Associated With Aircraft

Aircraft sonar systems that could be deployed during active sonar events include sonobuoys (tonal [active], listening [passive], and extended echo ranging [EER] or improved extended echo ranging [IEER]) and dipping sonar (AN/AQS-13/22 or AN/AOS-22). Sonobuoys may be deployed by marine patrol aircraft or MH-60R helicopters. A sonobuoy is an expendable device used by aircraft for the detection of underwater acoustic energy and for conducting vertical water column temperature measurements. Most sonobuoys are passive, but some can generate active acoustic signals as well as listen passively. Dipping sonars are used by MH-60R helicopters. Dipping sonar is an active or passive sonar device lowered on cable by helicopters to detect or maintain contact with underwater targets. A description of various types of sonobuoys and dipping sonar is provided below.

1. AN/AQS-13 Helicopter Dipping Sonar – an active scanning sonar that detects and maintains contact with underwater targets through a transducer lowered into the water from a hovering helicopter. It operates at mid-frequency, although the exact frequency is classified. The AN/AQS-13 is operated by MH-60R helicopters.

2. AN/AQS-22 Airborne Low-Frequency Sonar (ALFS) – the Navy's dipping sonar system for the MH-60R helicopter light airborne multi-purpose system III, which is deployed from aircraft carriers, cruisers, destroyers, and frigates. It operates at mid-frequency, although the exact frequency is classified. The AN/AQS-22 employs both deep- and shallow-water capabilities.

3. AN/SSQ-62C Directional Command Activated Sonobuoy System (DICASS) – sonobuoy that operates under direct command from ASW fixed-wing aircraft or MH-60R helicopters. The system can determine the range and bearing of the target relative to the sonobuoys position and can deploy to various depths within the water column. The active sonar operates at mid-frequency, although the exact frequency range is classified. After water entry, the sonobuoy transmits sonar pulses (continuous waveform or linear frequency modulation) upon command from the aircraft. The echoes from the active sonar signal are processed in the buoy and transmitted to the receiving station onboard the launching aircraft.

4. AN/SSQ-110A Explosive Source Sonobuoy – a commandable, air-dropped, high source level explosive sonobuoy. The AN/SSQ-110A explosive source sonobuoy is composed of two sections, an active (explosive) section and a passive section. The upper section is called the "control buoy" and is similar to the upper electronics package of the AN/SSQ-62 DICASS sonobuoy. The lower section consists of two signal underwater sound explosive payloads of Class A explosive weighing 1.9 kg (4.2 lbs) each. The arming and firing mechanism is hydrostatically armed and detonated. Once in the water, the signal underwater sound charges explode, creating a loud acoustic signal. The echoes from the explosive charge are then analyzed on the aircraft to determine a submarine's position. The AN/SSQ-110A explosive source sonobuoy is deployed by marine patrol aircraft.

5. AN/SSQ-53D/E Directional Frequency Analysis and Recording (DIFAR) – a passive sonobuoy deployed by MPA aircraft and MH-60R helicopters. The DIFAR sonobuoy provides acoustic signature data and bearing of the target of interest to the monitoring unit(s) and can be used for search, detection, and classification. The buoy uses a hydrophone with directional detection capabilities in the very low frequency, low

frequency, and mid-frequency ranges, as well as an omnidirectional hydrophone for general listening purposes.

Torpedoes

Torpedoes (primarily MK-46 and MK-48) are the primary anti-submarine warfare weapon used by surface ships, aircraft, and submarines. Torpedoes will not be used in the Gulf of Alaska as part of the proposed action.

Targets

Anti-submarine warfare training targets are used to simulate target submarines. They are equipped with one or a combination of the following devices:

(1) Acoustic projectors emanating sounds to simulate submarine acoustic signatures;

(2) Echo repeaters to simulate the characteristics of the echo of a particular sonar signal reflected from a specific type of submarine; and

(3) Magnetic sources to trigger magnetic detectors.

Training targets include MK-30 anti-submarine warfare training targets, and MK-39 expendable mobile anti-submarine warfare training targets. Targets may be non-evading while operating on specified tracks or they may be fully evasive, depending on the training requirements of the training operation.

Tracking Pingers, Transponders, and Acoustical Communications (ACOMs)

Tracking pingers are installed on training platforms to track the position of underwater vehicles. The pingers generate a precise, preset, acoustic signal for each target to be tracked. ACOMs and transponders provide the communication link between sensor packages and base platform allowing information to be exchanged.

1. MK 84 Pinger signal underwater sound – an air or surface dropped noisemaking device that emits one of five mid-frequency tonal patterns using two MFA sonars with frequencies at 3.1 and 3.5 kHz; it is used to provide prearranged signal communications to submerged submarines.

Portable Undersea Training Range (PUTR)

The Portable Undersea Training Range (PUTR) is a self-contained, portable, undersea tracking capability that employs modern technologies to support coordinated USW training for Forward Deployed Naval Forces. The PUTR will be available in two variants to support both shallow and deep water remote operations in keeping with Navy requirements to exercise and evaluate weapons systems and crews in the environments that replicate the potential combat area.

The PUTR-D consists of a set of transponders which will be deployed by a ship of opportunity and anchored to the ocean bottom. Once deployed a survey is conducted by a range vessel to determine the transponder locations and to test tracking accuracy. The transponder is activated by utilizing an acoustic command signal during operations and commanded into sleep mode when not in use. Operational lifetime, due to transponder battery life, will meet the key performance parameters, including the operating objective of actual tracking time. The transponders can remain deployed for up to 12 months in a dormant state. Transponders will be recovered for battery/buoy maintenance or for range recovery by transmitting an acoustic command which releases the transponder electronics/floatation buoy package from the anchor. The ship of opportunity will then retrieve the transponders leaving the anchor *in-situ*.

Advanced Extended Echo Ranging (AEER)

The Advance Extended Echo Ranging program examines improvements in both long-range shallow and deep water ASW search using active sources (Air Deployable Low Frequency Projector (ADLFP), Advance Ranging Source (ARS) and passive sonobuoy receivers (Air Deployable Active Radar Receiver (ADAR)). The signal processing is provided by research conducted under Advanced Multi-static Processing Program (AMSP).

The AEER system is similar to the IEER system in that it uses the AN/SSQ-101 Air Deployed Active Receiver (ADAR) sonobuoy. Instead of the SSQ-110A Extended Echo Range Sonobuoy, however, it is coupled with the SSQ-125 Air Deployable Coherent Source Sonobuoy. The SSQ-125 system is in the research and development stage with two types of sensor technology being considered (the ADLFP and ARS). The buoy is intended to provide the user with a sonobuoy with an improved bi-static acoustic source and better signal processing for harsh water environments. Table 10 below is a comparison of the echo ranging systems.

Table 10. Sonar echo ranging systems that may be used during Navy training exercises in the Gulf of Alaska temporary maritime training area.

	Current System	Current System	Future System
Aircraft System =	EER	IEER	AEER
Buoys = (Source)	SSQ-110 (EER)	SSQ-110 (EER)	SSQ-125 (ADLFP)
Buoys = (Receiver)	SSQ-77 (VLAD)	SSQ-101 (ADAR)	SSQ-101 (ADAR)
Area of use =	Deep Water Only	Littoral & Deep Water	Enhanced Littoral & Deep Water
Used by	P-3C	P-3C (IOC)	P-3C/MH-60R

5.1.7 Sound Fields and Pressure Waves from Underwater Detonations

Activities that involve at-sea explosives may affect ESA-listed species via the sound field produced during the explosion. Explosive sources having detonations in the water include: SSQ-110 EER sonobuoys and MK-82, MK-83, MK-84, BDU-45 bombs, 5” rounds and 76 mm gunnery rounds, , and Maverick missile. Explosives detonated underwater introduce loud, impulsive, broadband sounds into the marine environment. At its source, the acoustic energy of an explosive is, generally, much greater than that of sonar, so careful treatment of them is important, since they have the potential to injure. Three source parameters influence the effect of an explosive: the net effective weight of the explosive, the type of explosive material, and the detonation depth. The net explosive weight accounts for the first two parameters. The net explosive weight of an explosive is the weight of only the explosive material in a given round, referenced to the explosive power of TNT.

The detonation depth of an explosive is particularly important due to a propagation effect known as surface-image interference. For sources located near the sea surface, a distinct interference pattern arises from the coherent sum of the two paths that differ only by a single reflection from the pressure-release surface. As the source depth and/or the source frequency decreases, these two paths increasingly, destructively interfere with each other, reaching total cancellation at the surface (barring surface-reflection scattering loss).

The shock wave and blast noise from explosions are of most 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.

Explosive Source Associated With The Improved Extended Echo Ranging (IEER) System. One of the systems the Navy proposes to use as part of the proposed active sonar training is the AN/SSQ-110A explosive source sonobuoy that is composed of two sections, an active (explosive) section and a passive section. The lower, explosive section consists of two signal underwater sound explosive payloads of Class A explosive weighing 1.9 kg (4.2 lbs) each. The arming and firing mechanism is hydrostatically armed and detonated. Once in the water, the signal underwater sound charges explode, creating a loud acoustic signal.

Table 11. Potential stressors associated with the activities the Navy proposes to conduct in the Gulf of Alaska Temporary Maritime Training Area.

Range Operation	Disturbance from Vessel Movements	Vessel Collision	Disturbance from Aircraft Flights	Nonexplosive Ordnance Gunfire	Expended Material	Sonar Sound Fields	Sound Fields and Pressure Waves from Underwater Detonations
Aircraft Combat Maneuvers			✓				
Air Defense Exercise			✓				
Surface-to-Air (S-A) Missile Exercise	✓	✓	✓	✓	✓		
S-A Gunnery Exercise	✓	✓	✓	✓	✓		
Air-to-Air (A-A) Missile Exercise			✓	✓	✓		✓
Visit Board Search and Seizure	✓	✓					
Air-to-Surface (A-S) Missile Exercise			✓				
A-S Bombing Exercise			✓	✓	✓		✓
A-S Gunnery Exercise			✓	✓	✓		
Surface-to-Surface (SS) Gunnery Exercise	✓	✓		✓	✓		✓
Maritime Interdiction	✓	✓					
Sea Surface Control			✓				✓
ASW Tracking Exercise - Helicopter			✓		✓	✓	✓
ASW Tracking Exercise - MPA			✓		✓	✓	✓
ASW Tracking Exercise – Extended Echo Ranging (EER) (includes IEER and MAC)			✓		✓	✓	✓
ASW Tracking Exercise – Surface Ship	✓	✓				✓	
ASW Tracking Exercise – Submarine	✓	✓				✓	
EC Exercises			✓			✓	

Range Operation	**Disturbance from Vessel Movements**	**Vessel Collision**	**Disturbance from Aircraft Flights**	**Nonexplosive Ordnance Gunfire**	**Expended Material**	**Sonar Sound Fields**	**Sound Fields and Pressure Waves from Underwater Detonations**
Chaff Exercises			✓		✓		
Counter Targeting Exercises				✓		✓	
New Instrument Technology	✓	✓			✓	✓	
Special Warfare Operations			✓				
Air-to-Ground Bombing Exercise			✓				
Personnel Recovery			✓				
Deck Landing Qualifications	✓	✓	✓				

5.2 Exposure Analysis

The 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. The analyses is designed to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to one or more of the stressors described in the previous section.

The Navy, NMFS, and most other entities (for example, oil and gas industries for drilling platforms, geophysics organizations that conduct seismic surveys, etc.) rely on computer models, simulations, or some kind of mathematical algorithm to estimate the number of animals that might be exposed to stressors. Like all models, these approaches are based on assumptions and are sensitive to those assumptions. In reviewing the assumptions the Navy incorporates in its models, NMFS believes those models would tend to over-estimate the number of marine mammals that might be exposed to military training activities in the Gulf of Alaska TMAA because (1) those models assume that marine mammals would not try to avoid being exposed to the stressor; (2) those models assume that mean densities of marine mammals within any square kilometer area of the TMAA would be constant over time (that is, the models assume that the probability of marine mammals occurring in any square kilometer area over any time interval is 1.0, when, in fact, the probability would be much smaller than 1.0; this difference would tend to overestimate the number of animals in the action area during shorter time intervals).

The narratives that follow present the approach the Navy and NMFS Permits Division used to estimate the number of marine mammals that might be "taken" (as that term is defined pursuant to the MMPA) during training activities the Navy proposes to conduct (which is described in the *Approach to the Assessment* section of this opinion).

Marine Mammal Abundance and Density Estimates

Understanding the distribution and abundance of a particular marine mammal species or stock is necessary to analyze the potential impacts of an action on that species or stock. Furthermore, it is necessary to know the density of the animals in the affected area in order to quantitatively assess the likely impacts of a potential action on individuals and estimate take.

Density is nearly always reported for an area (e.g., animals per km^2). Analyses of survey results using distance sampling techniques include correction factors for animals at the surface but not seen as well as animals below the surface and not seen. Therefore, although the area (e.g., km^2) appears to represent only the surface of the water (two-dimensional), density actually implicitly includes animals anywhere within the water column under that surface area. In addition, density assumes that animals are uniformly distributed within the prescribed area, even though this is likely a rare occurrence. Marine mammals are usually concentrated in areas of greater importance, such as areas of high productivity, low predation, safe calving, etc. Density can occasionally be calculated for smaller areas that are regularly used by marine mammals, but more often than not, there are insufficient data to calculate density for small areas. Therefore, assuming an even distribution within the prescribed area remains the norm.

Recent survey data for marine mammals in the Gulf of Alaska is limited and most survey efforts were localized and extremely nearshore. In addition to the visual surveys, there is evidence of several species based on acoustic studies, but these do not provide measurements of abundance.

In April 2009, the Navy funded and NMFS conducted the Gulf of Alaska Line-Transect Survey (GOALS) to address the data needs for this analysis (Rone et al. 2010). Line-transect survey visual data to support distance sampling statistics and acoustic data were collected over a 10-day period both within and outside the TMAA. This survey resulted in sightings of several species and allowed for the derivation of densities for fin and humpback whale (Rone et al. 2010). In addition to this latest survey, two previous vessel surveys conducted in the nearshore region of the TMAA were also used to derive the majority of the density data used in acoustic modeling for this analysis. The methods used to derive density estimates for all remaining species in the TMAA are detailed in Appendix B of the LOA application and summarized below.

Zerbini et al. (2007) conducted dedicated vessel surveys for large whales in summer 2001-2003 from Resurrection Bay on the Kenai Peninsula to Amchitka Island in the Aleutian Islands. Survey effort near the TMAA was nearshore (within approximately 46 nm (85 km) of shore), and is delineated as “Block 1” in the original paper. Densities for this region were published for fin and humpback whales.

Waite (2003) conducted vessel surveys for cetaceans near Kenai Peninsula, within Prince William Sound and around Kodiak Island, during acoustic-trawl surveys for pollock in summer 2003. Surveys extended offshore to the 1,000 m isobaths and therefore overlapped with some of the TMAA. Waite (2003) did not calculate densities, but did provide some of the elements necessary for calculating density (please see Appendix B of the LOA application for more information). Mysticetes occurring in the Gulf of Alaska include blue, fin, gray, humpback, minke, North Pacific right, and sei whales (Angliss and Allen 2009; Rone et al. 2010). Odontocetes occurring regularly in the Gulf of Alaska include the ESA-listed sperm whale (Angliss and Allen 2009; Rone et al. 2010).

The only ESA-listed pinniped occurring regularly in the Gulf of Alaska is the Steller sea lion. Pinniped at-sea density is not available because pinniped abundance is obtained via shore counts of animals at known rookeries and haulouts. Lacking any other available means of quantification, densities of pinnipeds were derived using shore counts. Several parameters were identified for pinnipeds from the literature, including area of stock occurrence, number of animals (which may vary seasonally) and season, and those parameters were then used to calculate density. Once density per “pinniped season” was determined, those values were prorated to fit the warm water (June through October) and cold water (November through May) seasons. Determining density in this manner relies on parameters that usually contain error (e.g., geographic range is not exactly known and needs to be estimated and abundance estimates usually have large variances). As is true of all density estimates, they assume that the animals are always distributed evenly within an area which is likely never true.

Table 12. Abundance and seasonal occurrence of ESA-listed marine mammals in the Gulf of Alaska Temporary Maritime Activities Area.

Species	Abundance (CV)[1]	Stock	Occurrence (Apr – Dec)
Blue whale *(Balaenoptera musculus)*	1,368 (0.22)	Eastern North Pacific	Very rare
Fin whale *(Balaenoptera physalus)*	2,636 (0.15)	California, Oregon, and Washington	Common
Humpback whale *(Megaptera novaeangliae)*	4,005 (0.95)	Central and Western North Pacific	Common
North Pacific right whale *(Eubalaena japonica)*	Unknown (may be < 100)	Eastern North Pacific	Very rare
Sei whale *(Balaenoptera borealis)*	43 (0.61)	Eastern North Pacific	Very rare
Sperm whale *(Physeter macrocephalus)*	Unknown	North Pacific	Rare
Steller sea lion (*Eumetopias jubatus*)	38,988	Western U. S.	Common
Steller sea lion (*Eumetopias jubatus*)	45,095 - 55,832	Eastern U. S.	Common

[1] CV = Coefficient of Variance from Carretta et al. 2007a, 2007b, 2008; Angliss and Allen 2008; Calambokidis 2008

Turtle and Fish Densities

Information on leatherback sea turtles in the Gulf of Alaska TMAA suggests that its occurrence in the Gulf of Alaska is uncommon or rare (NMFS and USFWS 1998; Wing and Hodge 2002). McAlpine et al. (2004) suggest that leatherback occurrences off British Columbia are most frequent from July to September and that the species is an uncommon seasonal resident of those waters. It is likely that the same can be said for leatherbacks in Alaskan waters. Since 1960, there have been 19 documented occurrences in Alaska, ranging from Southeast Alaska to the Alaska Peninsula (Wing, B.L., NMFS-AFSC, pers. comm., 25 January 2006 as cited in Navy 2006). The majority of these occurrences were reported in August during the 1970s and 1980s. Two summer occurrences have been recorded in the waters near Cordova, located north of the OPAREA and slightly east of Prince William Sound (Stinson 1984).

Although Chinook, coho, chum, and sockeye salmon and steelhead trout, are known to occur in the Gulf of Alaska, abundance or density estimate for these species in the TMAA are not available due to the lack of data to calculate such estimates.

The oceanic distribution of eulachon is not well known but it is well-represented in Alaska Fisheries Science Center bottom trawl surveys and is caught incidentally in large numbers, primarily in the pollock fisheries (Ormseth and Vollenweider 2007). There are directed fisheries in Alaska state waters for eulachon in Upper Cook Inlet, the Copper River area, and in southeast Alaska (Ormseth and Vollenweider 2007).

5.2.1 Measures to Minimize Exposure of Protected Resources

Measures the Navy proposes to implement (see Section 2.3) or that the Permits Division (see Section 2.4) proposes to include in its MMPA authorization are intended to avoid or minimize the number of endangered or threatened species that might otherwise be exposed to the training activities in the Gulf of Alaska TMAA.

The Navy proposes to implement general maritime measures to reduce the likelihood of encounters with marine mammals and sea turtles. These include the use of watchstanders and lookouts whenever a vessel is underway (traveling to or from the TMAA or engaging in training exercises) to look for and report the presence of marine mammals and sea turtles. When an animal (or floating kelp, algal mats, clusters of seabirds, or jellyfish that sea turtles or marine mammals may be associated with) is observed and reported, staff will increase vigilance and take reasonable and practicable actions to avoid collisions and activities that might result in close interactions of naval assets and marine mammals or sea turtles. Actions would include changing speed or direction of the vessel(s), implementing safety zones during active sonar (both mid and low frequency) operations, lowering sonar transmission level or powering down sonar if animals are within the safety zone, and altering the targeted area to avoid close interactions of naval assets and protected species.

To the degree that the Navy detects marine mammals visually and takes appropriate action to avoid the animals such as maintaining safety zones when using active sonar, the number of marine mammals that are exposed to mid-frequency active sonar or the intensity of their exposure might be reduced. The effectiveness of visual monitoring is limited to daylight hours, and its effectiveness declines during poor weather conditions (JNCC 2004). In line transect surveys, the range of effective visual sighting (the distance from the ship's track or the effective strip width) varies with an animal's size, group size, reliability of conspicuous behaviors (blows), pattern of surfacing behavior, and positions of the observers (which includes the observer's height above the water surface).

The number of daylight hours estimated at Seward Alaska ranges from 13 hours 19 minutes per day in April, peaks at 18 hours 45 minutes per day in July, to 11 hours 28 minutes per day in October (ABS Alaskan www.absak.com/library/average-annual-insolation-alaska; accessed March 18, 2011).

During surveys to investigate relationships between cetacean density, krill density and oceanographic conditions, the acceptable survey conditions were defined using guidelines from the International Whaling Commission that included wind speed is less than 20 knots and Beaufort sea state is less than 6 such that the distance at which a minke whale blow might be visible is at least 1.5 nm (Hedley et al. 2001). Using those parameters for comparison with historical data (1972 through 2008), we find that during the months of April to October the average wind speed measured in the Gulf of Alaska is below 20 knots greater than 85 percent of the time (97 percent in July and 73 percent in October at buoy #46001) (NBDC 2011). Cumulative frequency of significant wave height measurements during the same historical period in the Gulf of Alaska ranged from 95 percent of significant waves below 3 meters (less than Beaufort 6) in July to 44 percent below 3 meters in October (NBDC 2011).

Given the combination of long days and relatively calm ocean conditions that would be expected from April to October, we would expect that most large marine mammals would be visible when at the surface within 1.5 nm of a vessel. However, the ESA-listed whale species of concern in this opinion spend very little time at the surface (see Section 4.2). However, under calm ocean and wind conditions, fog may reduce visual sighting distances.

During marine mammals surveys conducted in the Gulf of Alaska TMMA in 2009 in conditions of Beaufort sea state 5 or less and survey speed of 10 knots no sperm whales were observed, yet they were the most common species acoustically detected during the survey (Rone et al. 2010). The majority of acoustic detections occurred when visual monitoring was not being conducted, presumably due the sea state, fog, or night-time conditions (Rone et al. 2010). The percentage of marine animals Navy personnel would not detect, either because they will pass unseen below the surface or because they will not be seen at or near the ocean surface, is difficult to determine. However, for minke whales, Schweder et al. (1992) estimated that visual survey crews did not detect about half of the animals in a strip width. Palka (1996) and Barlow (1988) estimated that visual survey teams did not detect about 25 percent of the harbor porpoises in a strip width. Barlow et al. (2006) found that experience was a significant factor in explaining differences in sighting rates among observers. Mean sighting rates were 0.54 per 1,000km for first-time observers, 0.67 per 1,000 km for observers with 4-11 months prior experience and 0.93 per 1,000 km for observers with at least 12 months prior experience. The analysis only considered the ability of an observer to detect a beaked whale and not necessarily his/her ability to identify one (Barlow et al. 2006).

The information available leads us to conclude that the combinations of safety zones, altered vessel movement, and altered targeting of bombs, missiles, and other ordnance, triggered by visual observations would still allow some marine mammals and sea turtles to be at risk from vessel disturbance, vessel collision, disturbance from aircraft flights, nonexplosive ordnance and gunfire, expended materials, and sound fields from mid- and high-frequency active sonar transmissions, and sound fields and pressure waves from underwater explosions because some marine animals will not be detected at the ocean’s surface.

5.2.2 Mitigation Measures Proposed by NMFS Permits Division

NMFS Permits Division included compulsory mitigation measures in their MMPA regulations and proposed to include those measures in the proposed 2013-16 letter of authorization related to the Navy’s training in the Gulf of Alaska TMAA. These measures apply when the Navy is conducting training and utilizing sound sources or explosives identified in the MMPA rule (see

Section 2.4). Measures include the use of shipboard and aircraft lookouts specifically trained to detect and report marine species, and the use of safety zones for specific activities that range from 200 yards up to 2 miles depending on the sonar source or activity being conducted. Limits to sonar transmission intensity are defined for several activities and are lowered if marine mammals or sea turtles are detected within the established safety zone. If protected animals are detected within the safety zone after active sonar transmission has started, transmission levels may not exceed specified levels; in some circumstances sonar transmissions would have to cease until animals have left the safety zone area.

The Navy would be required to comply with the *Stranding Response Plan for Major Navy Training Exercises in the Gulf of Alaska TMAA* (NMFS 2011a).

5.2.3 Disturbance from Movement of Surface Vessels and Submarines

Most of the activities the Navy proposes to conduct involve some level of activity from surface vessels, submarines, or both. The probability of vessel and marine mammal interactions occurring in the TMAA is dependent upon several factors including numbers, types, and speeds of vessels; the regularity, duration, and spatial extent of activities; the presence/absence and density of marine mammals; and protective measures implemented by the Navy. During training activities, speeds vary and depend on the specific training activity. In general, Navy vessels will move in a coordinated manner but separated by many miles in distance. These activities are widely dispersed throughout the TMAA, which is a vast area encompassing 42,146 nm^2 (145,458 km^2). Consequently, the density of Navy vessels within the TMAA at any given time is extremely low.

We assume that some individuals of the endangered or threatened marine mammals (blue, fin, humpback, North Pacific right, sei, and sperm whales; and Steller sea lion) that occur in the Action Area during training exercises could be exposed to visual and acoustic stimuli associated with vessel traffic and related activities.

The risk of sea turtles being exposed is low because there are very few leatherback sea turtles likely to be in the Gulf of Alaska TMAA. Because of the low risk of encountering a leatherback sea turtle, and the mitigation measures the Navy will use to further lower the risk, NMFS concludes that the risk of disturbance to leatherback sea turtles from surface vessels and submarines is small enough to be discountable and will not be discussed further in this opinion.

Listed fish (Chinook, coho, chum, and sockeye salmon, steelhead trout, and Pacific eulachon) may also be exposed to disturbance from the movement of vessels and submarines. However, we have little information regarding the density of fish in the TMAA combined with the expectation that fish, if exposed, would move away from the vessel as it would a predator, and not experience any substantive adverse effect from such movement. Therefore, NMFS concludes that the risk of disturbance from surface vessels and submarines to ESA-listed fish (Chinook, coho, chum, and sockeye salmon, steelhead trout, and Pacific eulachon) is so small as to be discountable. Therefore, this risk will not be evaluated further in this opinion.

5.2.4 Collision with Surface Vessels and Submarines

Similar to the potential for disturbance from vessel and submarine movement, there is a potential for collision between surface vessels and submarines and whales as collisions are an acknowledged source of mortality and injury to all large whales. The ESA-listed whales (blue, fin, humpback, North Pacific right, sei, and sperm whales) that occur in the TMAA could be exposed to moving vessels and the potential for collision with such vessels.

The rarity of ship strikes involving pinnipeds and sea turtles, the vast size of the TMAA, and the relatively narrow transit line of surface vessels and submarines results in an exposure risk that is small enough to be discountable. NMFS could not find any reports regarding collisions with surface vessels or submarines and any species of fish of similar size or characteristics of the ESA-listed species being considered here. Therefore we conclude that the risk of collision between surface vessels and submarines and leatherback sea turtles, Steller sea lions, and ESA-listed fish (Chinook, coho, chum, and sockeye salmon, steelhead trout, and Pacific eulachon) is so small as to be discountable. Therefore, the risk of collision with surface vessels and submarines with these species will not be discussed further in this opinion.

5.2.5 Flights of Fixed-wing and Helicopter Aircraft

Approximately 600 fixed-wing sorties would occur in the TMAA annually under the Proposed Action. Many of these sorties would take place above 30,000 ft (9,144 m). All aircraft flights between the shore and 12 nm (22 km) from land would occur at altitudes at or above 15,000 ft above sea level (915 m) and also have no effect on marine mammals. While fixed-wing aircraft activities can occur in special use airspace throughout the Alaska training areas, a majority of the sorties are associated with Navy air combat maneuver training and will take place in the TMAA.

Under the Proposed Action, and included in the 600 fixed-wing sorties would be approximately 300 air combat maneuver sorties (average of 21 sorties per day). Altitudes range from approximately 6,000 ft (1,920 m) to 30,000 ft (9,144 m) and typical airspeeds range from very low (less than 100 knots [kts] 185.2 kilometers per hour [km/hr]) to high subsonic (less than 600 kts [1,111.2 km/hr]). Air combat maneuver training in the TMAA will also involve supersonic flight which produces sonic booms, but this would not occur below 15,000 ft (4,572 m) above mean sea level.

The maximum overpressures calculated for FA-18 aircraft supersonic over-flights range from 5.2 pounds per square foot (psf) (25.4 kg/m^2) at 10,000 ft (3,048 m) to 28.8 psf (140.6 kg/m^2) at 1,000 ft (305 m) (Navy 2006 citing Ogden 1997). Considering an extreme case of a sonic boom that generates maximum overpressure of 50 psf (244.1 kg/m^2) in air, it would become an impulsive wave in water with a maximum peak pressure of 100 psf (488.2 kg/m^2) or about 0.7 pounds per square inch (psi) (0.05 kg/cm^2).

The Navy or NMFS Permits Division did not provide an estimate of 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). The ESA-listed marine mammal species (blue, fin, humpback, North Pacific right, sei, and sperm whales) that occur in the TMAA could be exposed to these aircraft flights in the TMAA.

Exposure to fixed-wing aircraft noise would be brief (seconds) as an aircraft quickly passes overhead. Exposures would be infrequent based on the transitory and dispersed nature of the flights; repeated exposure to individual animals over a short period of time (hours or days) is unlikely. Furthermore, the sound exposure levels would be relatively low to marine mammals that spend the majority of their time underwater.

Fixed wing flights can occur throughout the TMAA, but will not be in close proximity to land and therefore far from known haul out areas and established rookeries of Steller sea lions. In addition, the Navy complies with restrictions prohibiting fixed wing aircraft or helicopter flights or surface training activities within 3,000 ft (914 m) of Steller sea lion critical habitat, rookeries or pinniped haulout areas (Navy 2010a). These mitigation measures minimize potential exposure of Steller sea lions to these training activities.

Based on the rare occurrence of leatherback sea turtles in the TMAA, they would not be expected to be exposed to the aircraft flights. Fish below the water surface (Chinook, coho, chum, and sockeye salmon, steelhead trout, or Pacific eulachon) would not be expected to be exposed to aircraft flights. Therefore, the risk to these species from aircraft flights will not be discussed further in this opinion.

Approximately 118 training events could involve helicopters in the TMAA annually under the Proposed Action. Helicopter over-flights can occur throughout the TMAA. Unlike fixed-wing aircraft, helicopter training activities can occur at low altitudes (75 ft [23 m] to 100 ft [30 m]), which increases the likelihood that marine mammals would be exposed to helicopter flights. However, the only places that helicopters are below 500 ft [152 m] above ground level (AGL) over water is during training when personnel jump from the helicopter into water from 75 ft [23 m] to 100 ft [30 m] above the surface, when doing Deck Landing Qualifications (12 events), or when using dipping sonar (192 hours). Otherwise, helicopters are 500 ft [152 m] AGL or higher while in transit.

The ESA-listed marine mammal species (blue, fin, humpback, North Pacific right, sei, and sperm whales; and Steller sea lions) that occur in the TMAA could be exposed to these helicopter flights in the TMAA. NMFS did not estimate the number of endangered or threatened species that are likely to be exposed to helicopter flights — during activities 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).

Based on the rare occurrence of leatherback sea turtles in the TMAA, they would not be expected to be exposed to helicopter flights. Fish below the water surface (Chinook, coho, chum, and sockeye salmon, steelhead trout, or Pacific eulachon) would not be expected to be exposed to helicopter flights. Therefore, the risk of helicopter flights to these species will not be discussed further in this opinion.

5.2.6 Non-explosive Ordnance and Gunfire Disturbance

The proposed Navy training activities include firing a variety of weapons that employ a variety of nonexplosive training rounds, including naval gun shells, cannon shells, and small caliber ammunition. The Navy proposed mitigation measures require visual clearance before the training exercise of any range where ordnance (including nonexplosive inert practice ordnance) is to be dropped or fired.

The largest proposed shell size for these activities is a 5-inch shell. This will produce the highest pressure and all analysis was done using this as a conservative measurement of produced and transmitted pressure, assuming that all other smaller ammunition sizes would fall under these levels. Aboard the USS Cole in June 2000, a series of pressure measurements were taken during the firing of a five-inch gun. Average pressure measured approximately 200 decibels (dB) with reference pressure of one micro Pascal (dB re 1 μPa) at the point of the air and water interface. Based on the USS Cole data, down-range peak pressure levels were calculated to be less than 186 dB re 1 μPa at 328 ft (100 m) (Navy 2010a). Based on the USS Cole data, down-range peak pressure levels were calculated to be less than 186 dB re 1 μPa at 328 ft (100 m) (DoN 2000) and as the distance increases, the pressure would decrease.

In reference to the energy flux density (EFD) harassment criteria, the EFD levels (greatest in any 1/3 octave band above 0.01 kHz) of a 5-inch gun muzzle blast were calculated to be 190 dB with reference pressure of one micropascal squared in one second (dB re 1 μPa2-sec) directly below the gun muzzle decreasing to 170 dB re 1 μPa2-sec at 328 ft (100 m) into the water (Navy 2010a). The rapid dissipation of the sound pressure wave coupled with the mitigation measures implemented by the Navy to detect marine mammals in the area prior to conducting activities, would likely result in a blast from a gun muzzle having no effect, however, the sound from gunfire may affect marine mammal species listed under the ESA.

The potential for marine mammals to be struck by fired ordnance is very low given the density of marine mammals in the TMAA and the rapid loss of velocity once entering the water. The probability of a direct ordnance strike is further reduced by Navy mitigation measures, which require the area be clear of marine mammals before ordnance is used.

The potential for leatherback sea turtles, salmonids or Pacific eulachon to be disturbed by the sound of gunfire or struck by fired ordnance is sufficiently low that it can be considered discountable. Therefore, further analysis of this potential risk for leatherback sea turtles, salmonids and Pacific eulachon is not evaluated further in this opinion.

5.2.7 Expended Materials

Expendable materials include bombs, small arms ammunition, missiles, targets, marine markers, flares, chaff, parachutes and sonobuoys, and expendable training targets.

Bombs and Missiles

The U.S. Navy proposes to deploy bombs and missiles during anti-surface warfare exercises. Non-explosive practice bombs are not equipped with explosive warheads. Practice bombs entering the water would consist of materials like concrete, steel, and iron, and would not contain the combustion chemicals found in the warheads of explosive bombs. These components are consistent with the primary building blocks of artificial reef structures. The steel and iron, although durable, would corrode over time, with no noticeable environmental impacts. The concrete is also durable and would offer a beneficial substrate for benthic organisms. After sinking to the bottom, the bombs would be incorporated into the marine environment by natural encrustation and/or sedimentation (Navy 2010a). After sinking to the bottom, the bombs would be incorporated into the marine environment by natural encrustation and/or sedimentation (Navy 2010a).

High explosive bombs would be fused to detonate on contact with the water. It is estimated that 99 percent of these bombs would explode within 5 feet of the ocean surface (Navy 2010a). Anti-swimmer grenades detonate at a depth of no more than 3 m from the water's surface. Upon detonation anti-swimmer grenades will explode into small metallic pieces. Bomb bodies are steel and the bomb fins are either steel or aluminum. The steel may contain small percentages (typically less than 1 percent) of any of the following: carbon, manganese, phosphorus, sulfur, copper, nickel, chromium, molybdenum, vanadium, columbium, or titanium. The aluminum fins, in addition to the aluminum, may also contain: zinc, magnesium, copper, chromium, manganese, silicon, or titanium. Small and mostly metallic pieces of the bombs and grenades will quickly come to rest on the seafloor with each detonation. All these materials will slowly corrode over time.

Chemical products of underwater explosions are initially confined to a thin, circular area called "the surface pool". It is estimated that 100 percent of the solid explosion products and 10 percent of the gases remain in the pool (Navy 2010a). After the turbulence of the explosion has dispersed, the pool stabilizes and the chemical products are diluted and become undetectable. Initial concentrations of the chemical by-products of ordnance detonations are not hazardous to marine life and are rapidly dispersed in the ocean and because of continued dispersion and mixing, no buildup of explosion products in the water column would occur. Chemical effects to the marine environment and water quality are considered to be negligible from a BOMBEX (Navy 2010a). Initial concentrations of the chemical by-products of ordnance detonations are not hazardous to marine life and are rapidly dispersed in the ocean.

The concentrations of chemicals associated with bomb bodies and the explosive materials that are contained within high explosives are not hazardous to marine mammals, sea turtles, or fishes, their prey, competitors, or predators. At the concentrations associated with explosive ordnance the U.S. Navy proposes to use in its training exercises, bombs and the chemicals associated with these bombs are not likely to adversely affect the endangered or threatened species that are likely to occur in the Gulf of Alaska TMAA, either through direct action on the organisms themselves, through their food, or as a result of their action on competitors, predators, or pathogens. As a result, we do not consider this category of potential stressors further in our analyses.

Small Arms Ammunition

Naval gunfire within the Gulf of Alaska TMAA would include non-explosive 5 in, 76-mm, 25 mm cannon, .50 cal or 7.62 mm rounds.

Shell fragments from gunfire would rapidly decelerate through contact with the surrounding water and settle to the sea floor. Un-recovered ordnance would sink to the ocean bottom. Metal shells and fragments would be corroded by seawater at slow rates, with comparable slow release rates. Over time, natural encrustation of exposed surfaces would occur, reducing the rate at which subsequent corrosion occurs. The rates of deterioration would vary, depending on the material and conditions in the immediate marine and benthic environment (Navy 2010a), but explosive residues are expected to become covered by ocean sediments or diluted by ocean water; therefore the release of contaminant from unexploded ordnance, non-explosive ordnance, and fragments is not expected to result in degradation of marine water quality. As such, the degradation of expended ordnance the Navy proposes to use in its training exercises is not likely to adversely affect the endangered or threatened species that are likely to occur within the Gulf of Alaska TMAA, either through direct action on the organisms themselves, through their food, or as a result of their action on competitors, predators, or pathogens. As a result, we do not consider this category of potential stressors further in our analyses.

Targets

The number of at-sea targets used by the Navy will likely vary over the 3-year duration of the proposed action. At-sea targets are usually remotely operated surface, traveling units, most of which are designed to be recovered for reuse. Aerial and surface targets would be deployed annually within the Gulf of Alaska TMAA. Surface targets would include EMATTs, an inflatable orange vinyl target called a killer tomato, and the towed spar. Each can serve as a training tool. The killer tomatoes are recovered at the end of their use during a training event and thus have no effect on marine mammals or their habitat. Floating debris, such as Styrofoam, may be lost from target boats.

Most target fragments would sink quickly in the sea. Expended material that sinks to the sea floor would gradually degrade, be overgrown by marine life, and/or be incorporated into the sediments. Floating non-hazardous expended material may be lost from target boats and would either degrade over time or wash ashore as flotsam. Non-hazardous expended materials are defined as the parts of a device made of non-reactive material. Typical non-reactive material includes metals such as steel and aluminum; polymers, including nylon, rubber, vinyl, and plastics; glass; fiber; and concrete. While these items represent persistent seabed litter, their strong resistance to degradation and their chemical composition mean they do not chemically contaminate the surrounding environment by leaching heavy metals or organic compounds. As a result, we do not consider this category of potential stressors further in our analyses.

Marine Markers and Flares

Marine markers and flares are pyrotechnic devices dropped on the water's surface to mark a surface position. The chemicals contained within markers and flares not only burn but also produce smoke. The smoke is expected to rapidly diffuse by air movement. The marker itself would eventually sink to the bottom and become encrusted and/or incorporated into the sediments. Phosphorus contained in the marker settles to the sea floor where it reacts with the water to produce phosphoric acid, until all phosphorus is consumed by the reaction. Combustion of red phosphorus produces phosphorus oxides, which have a low toxicity to aquatic organisms (Navy 2010a). Combustion of red phosphorus produces phosphorus oxides, which have a low toxicity to aquatic organisms (Navy 2010a).

Flares may contain magnesium or aluminum casings. Flares are designed to burn completely in air with only ash and a small plastic end cap entering the water. Flare end caps would eventually sink to the bottom and become encrusted and/or incorporated into the sediments. Solid flare and pyrotechnic residues may contain aluminum, magnesium, zinc, strontium, barium, cadmium, and nickel, as well as perchlorates. Hazardous constituents in pyrotechnic residues are typically present in small amounts or low concentrations, and are bound in relatively insoluble compounds. The chemicals associated with marine markers and flares are not likely to adversely affect the endangered or threatened species that are likely to occur within the TMAA, either through direct action on the organisms themselves, through their food, or as a result of their action on competitors, predators, or pathogens. As a result, we do not consider this category of potential stressors further in our analyses.

Chaff

Radio frequency chaff (chaff) is an electronic countermeasure designed to reflect radar waves and obscure aircraft, ships, and other equipment from radar-tracking sources. Chaff is non-hazardous and consists of aluminum coated glass fibers (about 60 percent silica and 40 percent aluminum by weight) ranging in lengths from 0.3 to 3 inches with a diameter of about 40 micrometers. Chaff is released or dispensed from military vehicles in cartridges or projectiles that contain millions of chaff fibers. When deployed, a diffuse cloud of fibers undetectable to the human eye is formed. Chaff is a very light material that can remain suspended in air anywhere from 10 minutes to 10 hours. It can travel considerable distances from its release point, depending on prevailing atmospheric conditions (Arfsten et al. 2002).

For each chaff cartridge used, a plastic end-cap and Plexiglas piston is released into the environment in addition to the chaff fibers. The end-cap and piston are both round and are 1.3 inches in diameter and 0.13 inches thick. The fine, neutrally buoyant chaff streamers act like particulates in the water, temporarily increasing the turbidity of the ocean‘s surface. However, they are quickly dispersed and turbidity readings return to normal.

Based on the dispersion characteristics of chaff, large areas of open water in the Gulf of Alaska TMAA would be exposed to chaff, but the chaff concentrations would be low. For example, Hullar et al. (1999) calculated that a 4.97-mile by 7.46-mile area (37.1 square miles or 28 square nautical miles) would be affected by deployment of a single cartridge containing 150 grams of chaff. The resulting chaff concentration would be about 5.4 grams per square nautical mile. This corresponds to fewer than 179,000 fibers per square nautical mile or fewer than 0.005 fibers per square foot, assuming that each canister contains five million fibers. The probability of individual animals being struck by this ordnance or encountering chaff particles is sufficiently small to be treated as discountable, even after considering the amount of ordnance the Navy would expend during the training activities it plans to conduct in the TMAA, As a result, we do not consider this category of potential stressors further in our analyses.

Parachutes and Sonobuoys

Aircraft-launched sonobuoys, flares, torpedoes, and EMATTs deploy nylon parachutes of varying sizes. As described above, at water impact, the parachute assembly is expended and sinks, as all of the material is negatively buoyant. Some components are metallic and will sink rapidly. Entanglement and the eventual drowning of a marine mammal in a parachute assembly would be unlikely, since such an event would require the parachute to land directly on an animal, or the animal would have to swim into it before it sinks. The expended material will accumulate on the ocean floor and will be covered by sediments over time, remaining on the ocean floor and reducing the potential for entanglement. If bottom currents are present, the canopy may billow (bulge) and pose an entanglement threat to marine animals with bottom feeding habits; however, the probability of a marine mammal encountering a submerged parachute assembly and the potential for accidental entanglement in the canopy or suspension lines is considered to be unlikely.

The potential for marine mammals to encounter expended material is low given the density of marine mammals in the TMAA. The probability is further reduced by Navy mitigation measures, which require the area be clear of marine mammals before most of the equipment would be deployed. The potential for leatherback sea turtles, salmonids or Pacific eulachon to encounter expected material is sufficiently low that it can be considered discountable.

Based on the above information, NMFS does not consider this category of potential stressors further in the analyses.

5.2.8 Sonar Sound Fields

Annual sonar exposures to listed marine mammal species are based on the number of ASW events estimated to occur under the Proposed Action. The sonar hours, number of dipping sonar events, and number of sonobuoys proposed for use under the Proposed Action are presented in Table 13.

Table 13. Sonar hours, dipping sonar events, and number of sonobuoys the Navy would implement each year.

SQS 53 Sonar [a]	SQS-56 Sonar [a]	BQQ-10 Sonar [a]	BQS-15 Sonar [a]	SSQ-62 DICASS Sonobuoy [b]	AQS 22 Dipping Sonar[c]
578	52	48	24	266	192

[a] *Number reflects hours of operations not total transmission time, representative for all variants of system.*
[b] *Number is counted by buoy.*
[c] *Number is counted as individual use "dips" of the system.*

The Navy developed exposure models specific to active sonar activities they proposed to implement in the Gulf of Alaska TMAA. Details regarding the criterion for modeling and analysis of potential effects from sonar are provided in Appendix D of the EIS/OEIS (Navy 2011). Also provided are common active sound sources deployed in the TMAA and the estimated typical ranges or distances to regulatory thresholds established by NMFS under MMPA for cetaceans for the most often used and most powerful hull mounted surface ship sonar.

The Navy used an exposure threshold for onset-TTS of 195 dB re 1μPa2-s for all cetacea. This result is supported by the short-duration tone data of Finneran et al. (2005; 2002b) and the long-duration sound data from Nachtigall et al. (2003). These data demonstrate that TTS in small odontocetes is correlated with the received energy level and that onset-TTS exposures are fit well by an equal-energy line passing through 195 dB re 1μPa2-s. Absent any additional data for other species and being that it is likely that small odontocetes are more sensitive to the mid and high frequency active sonar, this is a conservative threshold.

The Navy used a PTS threshold of 215 dB re 1μPa2-s in their analysis for all cetacea based on a 20 dB increase in exposure energy level over that required for onset-TTS. The 20 dB value is based on estimates from terrestrial mammal data of PTS occurring at 40 dB or more of threshold shift, and on threshold shift growth occurring at a rate of 1.6 dB/dB increase in exposure energy level. Unlike cetaceans, the TTS and PTS thresholds used for pinnipeds vary with species. The Navy used thresholds of 206 dB re 1μPa2-s for TTS and 226 dB re 1μPa2-s for PTS for Steller sea lions.

The number of exposures of threatened and endangered marine mammal species to sonar associated with the proposed training activities during each year was estimated by the Navy and NMFS Permits Division at one blue whale, 11,019 fin whales, 1,394 humpback whales, one North Pacific right whale, four sei whales, 328 sperm whales, and 11,105 Steller sea lions.

Because leatherback sea turtles are rare in the Gulf of Alaska TMAA in combination with the extensive site selection procedures and mitigation measures that the Navy would use, the risk to leatherback sea turtles from sonar associated with the proposed military readiness activities is considered small enough to be discountable and will not be further evaluated in this opinion.

It is difficult to assess the exposure risk of salmon and eulachon to sonar because we do not have information on the abundance or distribution of these species in the TMAA. The most cautious approach is to assume that some unquantifiable number of salmon and eulachon would be exposed to sonar.

5.2.9 Sound Fields and Pressure Waves from Underwater Detonations

The annual exposure events of ESA-listed marine mammal species to at-sea explosions for the proposed Navy training activities are based on the number of events involving live ordnance under the Proposed Action. The typical ranges, or distances, to regulatory thresholds with effects for IEER sonobuoys (SSQ-110) and other at-sea explosions on marine mammals and sea turtles are provided in Appendix D of the EIS/OEIS. The number of events involving live ordnance use under the Proposed Action is presented in Table 14. The estimated exposure event numbers do not take into account any reduction resulting from standard mitigation measures.

Table 14. The U.S. Navy's proposed annual at-sea explosions for the Gulf of Alaska Temporary Maritime Activities Area.

MK-82	MK-83	MK-84	76-mm	5-inch	SSQ-110 (EER/IEER) Sonobuoy
128	12	4	28	84	80

Criteria and thresholds for estimating the impacts on marine mammals from a single at-sea explosion event were determined during the environmental assessments for the two Navy ship-shock trials: the Seawolf Final EIS (Navy 1998) and the Churchill Final EIS (Clarke and Norman 2005). In the analysis of the effects of detonations on marine mammals conducted by the Navy for the Churchill EIS, analysts compared the injury levels reported by the best of these experiments to the injury levels that would be predicted using the modified Goertner method, and found them to be similar (Goertner 1982; Navy 2010a). The criteria and thresholds for injury and harassment are summarized in Table 15.

There are two criteria for non-injurious harassment involving at-sea explosions. The first is TTS, which is a temporary, recoverable, loss of hearing sensitivity. The criterion for TTS is 182 decibel (dB) referenced to 1 square micropascal-second (μPa^2-s) maximum Sound Exposure Level (SEL) level in any 1/3-octave band at frequencies greater than 100 Hz for sea turtles. There is a second criterion for estimating TTS threshold: 12 psi peak pressure. Navy policy is to use the 23 psi criterion for explosive charges less than 2,000 lb (909 kg) and the 12 psi criterion for explosive charges larger than 2,000 lb (909 kg). It was introduced to provide a safety zone for TTS when the explosive or the animal approaches the sea surface (for which case the explosive energy is reduced but the peak pressure is not reduced).

Table 15. Explosive threshold levels modeled by the Navy to estimate exposures of ESA-listed species in the Gulf of Alaska Temporary Maritime Activities Area.

Threshold Type	Threshold Level
Level A – 50% Eardrum rupture	205 dB re 1μPa$_2$-s
Temporary Threshold Shift (TTS) (peak 1/3 octave energy)	182 dB re 1μPa$_2$-s
Sub-TTS Threshold for Multiple Successive Explosions (peak 1/3 octave energy)	177dB re 1μPa$_2$-s
Temporary Threshold Shift (TTS) (peak pressure)	23 psi
Level A – Slight lung injury (positive impulse)	13 psi-ms
Fatality – 1% Mortal lung injury (positive impulse)	31 psi-ms

The Navy proposes to employ a suite of measures to protect endangered and threatened marine mammals and sea turtles from being exposed to underwater detonations during the activities they plan to conduct in the Gulf of Alaska TMAA. These measures involve activity dependent procedures, safety zones, and monitoring protocols based on previous experiences, including studies conducted during the USS Winston S Churchill shock trials (Clarke and Norman 2005). Those studies concluded that the monitoring protocols effectively insured that marine mammals or sea turtles did not occur within 3.7 kilometers of the underwater detonations.

By incorporating safety zones, monitoring, and shut down procedures, the Navy should substantially reduce instances of marine mammals and sea turtles being exposed to energy from underwater detonations associated with the two proposed sinking exercises. Based on the information available, these mitigation and monitoring protocols are likely to prevent endangered or threatened marine mammals and sea turtles from being exposed to detonations associated with these exercises, which would reduce or eliminate their probability of being adversely affected by these detonations.

The threatened and endangered marine mammal species that would be exposed to sound fields from underwater detonations that are part of the proposed training activities during each year are estimated by the Navy and NMFS Permits Division at one blue whales, 18 fin whales, one humpback whale, one North Pacific right whale, four sei whales, one sperm whale, and three Steller sea lions.

5.3 Response Analyses

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.

In this consultation, NMFS considers their probable responses to the stressors described in Section 5.1 given the exposure estimated in Section 5.2.

5.3.1 Responses to Disturbance from Movement of Surface Vessels and Submarines

The proposed activities would be widely dispersed throughout the Gulf of Alaska TMAA, which is an area encompassing 42,146 nm^2 (145,458 km^2). The transit track of an individual vessel or submarine would be narrow relative to the size of the TMAA. If behavioral disruptions of whales result from the presence of aircraft or vessels, it is expected to be temporary. Animals are expected to resume their migration, feeding, or other behaviors without any threat to their survival or reproduction. Marine mammals react to vessels in a variety of ways and seem to be generally influenced by the activity the marine mammal is engaged in when a vessel approaches (Richardson et al. 1995). Some respond negatively by retreating or engaging in antagonistic responses while other animals ignore the stimulus altogether (Terhune and Verboom 1999; Watkins 1986).

The predominant reaction is likely to be neutral or avoidance behavior, rather than attraction behavior. Additional information regarding each listed species is provided below.

Blue and Sei Whales

There is little information on blue whale or sei whale response to vessel presence (NMFS 1998a; NMFS 1998b). Sei whales have been observed ignoring the presence of vessels and passing close to the vessel (Weinrich et al. 1986). In the absence of available data, the response of blue and sei whales to vessel traffic is assumed to be similar to that of the other baleen whales, ranging from avoidance maneuvers to disinterest in the presence of vessels. Any behavioral response would be short-term in nature. Blue or sei whales would be expected to return to their pre-disturbance activities once the vessel has left the area.

Fin and Humpback Whales

Fin whales have been observed altering their swimming patterns by increasing speed, changing their heading, and changing their breathing patterns in response to an approaching vessel (Jahoda et al. 2003). Observations have shown that when vessels remain 328 ft (100 m) or farther from fin and humpback whales, they were largely ignored (Watkins 1981b). Only when vessels approached more closely did the fin whales in the study alter their behavior by increasing time at the surface and engaging in evasive maneuvers. The humpback whales did not exhibit any avoidance behavior (Watkins 1981b). However, in other instances humpback whales did react to vessel presence. In a study of regional vessel traffic, Baker et al. (1983) found that when vessels were in the area, the respiration patterns of the humpback whales changed. The whales also exhibited two forms of behavioral avoidance when vessels were between 0 and 6,562 ft (2,000 m) away (Baker et al. 1983): 1) horizontal avoidance (changing direction and/or speed) when vessels were between 6,562 ft (2,000 m) and 13,123 ft (4,000 m) away, or 2) vertical avoidance (increased dive times and change in diving pattern).

Based on existing studies, it is likely that fin and humpback whales would have little reaction to vessels that maintain a reasonable distance from the animals. The distance that will provoke a response varies based on many factors including, but not limited to, vessel size, geographic location, and individual animal tolerance levels (Baker et al. 1983; Jahoda et al. 2003; Watkins 1981b). Should the vessels approach close enough to invoke a reaction, animals may engage in avoidance behaviors and/or alter their breathing patterns. Reactions exhibited by the whales would be temporary in nature. They would be expected to return to their pre-disturbance activities once the vessel has left the area.

North Pacific Right Whales

Although very little data exists examining the relationship between vessel presence and significant impact to North Pacific right whales, it is thought that any disturbance impacts would be minor and/or temporary in nature. In the North Pacific, ship strikes may pose a potential threat to North Pacific right whales. However, because of their rare occurrence and scattered distribution, it is impossible to assess the threat of ship strikes to this species at this time. For these reasons, NMFS has not identified ship collisions as a major threat because the estimated annual rate of human-caused mortality and serious injury appears minimal. Through 2002, there were no reports of ship strikes of North Pacific right whales by large ships along the U.S. West Coast and Canada (Jensen and Silber 2004). In addition, North Pacific right whales are protected through measures such as the 500-yard (1,500-m) no-approach limit, which affords them additional protection and further alleviates any effect vessel traffic might have on behavior or distribution (50 CFR §224.103).

Sperm Whales

Sperm whales generally show little to no reaction to ships, except on close approaches (within several hundred meters); however, some did show avoidance behavior such as quick diving (Wursig et al. 1998). In addition, in the presence of whale watching and research boats, changes in respiration and echolocation patterns were observed in male sperm whales (Richter et al. 2006). Disturbance from boats did not generally result in a change in behavior patterns and is short-term in nature (Magalhaes et al. 2002). As such, vessel movements in the TMAA may affect, but not likely to adversely affect, sperm whales.

5.3.2 Responses to Collision with Surface Vessels and Submarines

Collisions with surface vessels are a well-established threat to endangered and threatened marine mammals (Jensen and Silber 2002; Laist et al. 2001; Panigada et al. 2006). Individuals of all of the endangered and threatened whale species considered in this opinion have been struck, killed, or both in collisions with surface vessels; that is, as a result of being struck by the bow or hull of the ship or as a result of being struck by the ship‘s propellers. There have been no known collisions, referred to as “ship strikes,” by Navy vessels in Alaska waters over many years of operation.

The Navy's operational orders and mitigation measures 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. The proposed activities would occur annually between April and October. The average wind speed is below 20 knots approximately 88 percent of the time (NBDC 2011). The monthly average wave height is less than 3 meters for every month the proposed activities would occur except October. For October, the mean wave height is below 3 meters about 50 percent of the time (NBDC 2011). Daylight hours are extended in the Gulf of Alaska during the summer months. Thus, the likelihood of lookouts or watchstanders observing marine mammals is at its highest. The measures, which include marine observers on the bridge of ships, requirements for course and speed adjustments to maintain safe distances from whales, and having any ship that observes whales alert other ships in the area, have historically been effective measures for avoiding collisions between surface vessels and whales in the Gulf of Alaska TMAA.

In addition to lookouts, there are often other watchstanders such as ship officers and supervisory personnel, as well as lookouts responsible for safe navigation and avoidance of in-water objects (marine mammals, other vessels, flotsam, marine debris, etc.). There are numerous reports from Navy transits and exercises in other locations involving the detection of whales with vessels subsequently proactively maneuvering to avoid a collision with a whale. For the safety of the crew, stewardship of marine mammals, and to avoid damage to vessels, the Navy does what it can to avoid ship strikes.

For Alaska waters, the available whale-vessel collision data has been presented in an unpublished preliminary summary (Gabriele et al. 2007). The summary presents an opportunistically collected record containing reports of 62 whale-vessel collisions between 1978 and 2006 with most occurring in Southeast Alaska. This report is likely biased toward near shore reports and inland waters of Southeast Alaska where the authors were located and where nearshore vessels and a population of humpback whales overlap. Only one collision was recorded within the TMAA (involving a fishing vessel/sperm whale).

Neilson et al. (Neilson et al. 2012) summarized 108 reported whale-vessel collisions in Alaska from 1978–2011, of which 25 are known to have resulted in the whale's death. They found 89 definite and 19 possible/probable strikes based on standard criteria created for the study. Most strikes involved humpback whales (86%) with six other species documented. Small vessel strikes were most common (<15 m, 60%), but medium (15–79 m, 27%) and large (≥80 m, 13%) vessels also struck whales. Among the 25 mortalities, vessel length was known in seven cases (190–294 m) and vessel speed was known in three cases (12–19 kn). In 36 cases, human injury or property damage resulted from the collision, and at least 15 people were thrown into the water. In 15 cases humpback whales struck anchored or drifting vessels, suggesting the whales did not detect the vessels.

As is evident from the Alaska record, most known collisions in Alaska waters involve humpback whales, although worldwide historical records indicate fin whales were the most likely species to be struck (Laist et al. 2001). Vessel collisions and disturbances are not recognized significant threats to Steller sea lion. Most of the TMAA is above deep water and well offshore, which is not the preferred habitat for humpback whales, but is an area where fin whales or other species may certainly be present.

Mitigation measures would be used to reduce the likelihood of a collision with whales. Naval vessels will maneuver to keep at least 1,500 ft (500 yds) away from any observed whale in the vessel's path and avoid approaching whales head-on. These requirements do not apply if a vessel's safety is threatened, such as when change of course will create an imminent and serious threat to a person, vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver. Vessels will take all practicable steps to alert other vessels in the vicinity of the whale.

In summary, fin, humpback and other large whales may be present in the TMAA, but the available data on whale-vessel collisions indicates that collisions are unlikely overall. The risk of collision is further reduced by the short duration of the exercises, Navy protocols for maintaining a lookout at all times, and maneuvering to avoid whales when possible. Given these factors, it is unlikely that Navy training activities in the TMAA would result in a collision with a whale.

5.3.3 Responses to Flights of Fixed-wing and Helicopter Aircraft

Marine mammals exposed to low-altitude fixed-wing aircraft flights could exhibit a short-term behavioral response, but not to the extent where natural behavioral patterns would be abandoned or significantly altered. Fixed-wing aircraft flights are not expected to result in chronic stress because it is extremely unlikely that individual animals would be repeatedly exposed to low altitude flights. Fixed-wing aircraft flights may affect, but are not likely to adversely affect ESA-listed marine mammals.

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. 2002; Richter et al. 2006; Smultea et al. 2008; Wursig et al. 1998). Richardson et al. (1985) reported that bowhead whales (*Balaena mysticetus*) 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 flights 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. 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 (2008) reported that the sperm whales formed a semi-circular "fan" formation that was similar to defensive formations reported by other investigators.

Several sperm whales in the group were observed to turn on their sides, to apparently look up toward the aircraft. Richter et al. (2003) reported that the number of sperm whale blows per surfacing increased when recreational whale watching aircraft were present, but the changes in ventilation were small and probably of little biological consequence. The presence of whale watching aircraft also apparently caused sperm whales to turn more sharply, but did not affect blow interval, surface time, time to first click, or the frequency of aerial behavior (Richter et al. 2003). A review of behavioral observations of baleen whales indicates that whales will either demonstrate no behavioral reaction to an aircraft or, occasionally, display avoidance behavior such as diving (Koski et al. 1998). Smaller delphinids also generally display a neutral or startle response (Wursig et al. 1998).

Species, such as Kogia spp. and beaked whales, that show strong avoidance behaviors with ship traffic, also exhibit disturbance reactions to aircraft (Wursig et al. 1998). Although there is little information regarding reactions to aircraft for other cetacean species, it is expected that reactions would be similar to those described above; either no reaction or quick avoidance behavior.

Most observations of cetacean responses to aircraft are from aerial scientific surveys that involve aircraft flying at relatively low altitudes and low airspeeds. It should be noted that most of the aircraft exposures analyzed in the studies mentioned above are different than Navy aircraft flights. Survey and whale watching aircraft are expected to fly at lower altitudes than typical Navy fixed-wing flights. Exposure durations would be longer when aircraft are specifically attempting to observe or follow an animal. These factors might increase the likelihood of a response to survey or whale watching aircraft. Mullin et al. (1991) reported that sperm whale reactions to aerial survey aircraft (standard survey altitude of 750 ft [229 m]) were not consistent. Some sperm whales remained on or near the surface the entire time the aircraft was in the vicinity, while others dove immediately or a few minutes after the sighting.

Marine mammals exposed to low-altitude fixed-wing aircraft over-flights could exhibit a short-term behavioral response, but not to the extent where natural behavioral patterns would be abandoned or significantly altered. Fixed-wing aircraft flights are not expected to result in chronic stress because it is extremely unlikely that individual animals would be repeatedly exposed to low altitude over-flights. Fixed-wing aircraft flights may affect, but are not likely to adversely affect ESA-listed marine mammals.

Very little data are available regarding reactions of cetaceans to helicopters. One study observed that sperm whales showed no reaction to a helicopter until the whales encountered the downdrafts from the helicopter rotors (Clarke 1956). Other species such as bowhead whales show a range of reactions to helicopter over-flights, including diving, breaching, change in direction or behavior, and alteration of breathing patterns (Patenaude et al. 2002). These reactions were less frequent as the altitude of the helicopter increased to 492 ft (150 m) or higher. Given the amount of available data, the response of ESA-listed cetaceans to helicopter over-flights under the Proposed Action is assumed to be similar to that of other cetacean species, ranging from avoidance maneuvers to disinterest in the presence of helicopters.

Helicopters are used in studies of several species of seals hauled out and is considered an effective means of observation (Bester et al. 2002; Bowen et al. 2006; Gjertz and Borset 1992), although they have been known to elicit behavioral reactions such as fleeing (Hoover 1988). In other studies, harbor and other species of seals and sea lions showed no reaction to helicopter flights (Gjertz and Borset 1992). Hoover (1988) reported strong reactions to aircraft below 200 ft (61 m), but minimal reaction to aircraft above 250 ft (76 m). However, there are no haul outs or rookeries in the TMAA and none of these overflight activities in the TMAA would take place near a Steller sea lion haul out or rookery location.

Marine mammals exposed to a low-altitude helicopter over-flights under the Proposed Action could exhibit a short-term behavioral response, but not to the extent where natural behavioral patterns would be abandoned or considerably altered. Helicopter flights are not expected to result in chronic stress because it is extremely unlikely that individual animals would be repeatedly exposed. Helicopter flights can occur throughout the TMAA, but will not be in close proximity land and therefore far from known Steller sea lion haul out areas and established rookeries. In addition, the Navy complies with restrictions prohibiting fixed wing aircraft or helicopter overflight or surface training activities within 3,000 ft (914 m) of Steller sea lion critical habitat, rookeries or pinniped haulout areas. These measures minimize adverse reactions of Steller sea lions to training activities.

5.3.4 Responses to Non-explosive Ordnance and Gunfire Disturbance

The U.S. Navy proposes to employ a suite of measures to protect endangered and threatened marine mammals from being exposed to non-explosive ordnance and gunfire during the activities they plan to conduct in the Gulf of Alaska TMAA. These measures include buffer zones around intended targets, avoidance of floating weeds, kelp and algae mats, and the use of ordnance only after visually sighting the target.

As previously stated in the exposure analysis, the likelihood of blue, fin, humpback, North Pacific right, sei, and sperm whales; and Steller sea lions being exposed to sound from gunfire is low. Sound produced from small arms ammunition would, under most scenarios, be commingled with sounds associated with vessel movement and/or aircraft/helicopter flights as well.

Marine mammals exposed to these latter stressors would be expected to exhibit a short-term behavioral response, but not to the extent where natural behavioral patterns would be abandoned or considerably altered. Responses of marine mammals 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 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 sound sources by retreating out of the area, provided the received level is high enough to evoke a response, while other individuals do not.

5.3.5 Responses to Sonar Sound Fields

Of all of the stressors we consider in this opinion, the potential responses of marine mammals upon being exposed to low- and mid-frequency active sonar have received the greatest amount of attention and study. Nevertheless, despite decades of study, it is important to acknowledge that empirical evidence on the responses of free-ranging marine animals to active sonar is very limited. The narratives that follow this introduction summarize the best scientific and commercial data and other evidence available on the responses of other species to active sonar or other acoustic stimuli. Potential responses are categorized for discussion as; physical damage, acoustic resonance, noise-induced loss of hearing sensitivity, behavioral responses (broken down further into behavioral avoidance of initial exposures or continued exposure, vigilance, continued pre-disturbance behavior, habituation, or no response), impaired communication, fitness consequences of vocal adjustments, allostasis, stranding events (broken down further into global stranding patterns and taxonomic patterns). Based on this body of information, we identify the probable responses of endangered and threatened marine animals by species to active sonar transmissions that would be associated with the training activities in the Gulf of Alaska TMAA.

Potential Responses

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

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

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

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

Based on the information available, the endangered or threatened marine mammals and sea turtles that we are considering in this opinion are not likely to experience acoustic resonance. All of the evidence available suggests that this phenomenon poses potential risks to smaller cetaceans like beaked whales rather than the larger cetaceans that have been listed as endangered. Thus far, this phenomenon has not been reported for or associated with sea turtles, perhaps because they do not engage in dive patterns that are similar to those of beaked whales.

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

Acoustic exposures can result in three main forms of noise-induced losses in hearing sensitivity: permanent threshold shift, temporary threshold shift, and compound threshold shift (Ward et al.

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

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

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

Despite the extensive amount of attention given to threshold shifts by researchers, environmental assessments conducted by the Navy and seismic survey operators, and its use in permits issued by NMFS Permits Division, it is not certain that threshold shifts are common. Several variables affect the amount of loss in hearing sensitivity: the level, duration, spectral content, and temporal pattern of exposure to an acoustic stimulus as well as differences in the sensitivity of individuals and species. All of these factors combine to determine whether an individual organism is likely to experience a loss in hearing sensitivity as a result of acoustic exposure (Ward et al. 1998; Yost 2007). In free-ranging marine mammals, an animal's behavioral responses to a single acoustic exposure or a series of acoustic exposure events would also determine whether the animal is likely to experience losses in hearing sensitivity as a result of acoustic exposure. Unlike humans whose occupations or living conditions expose them to sources of potentially-harmful noise, in most circumstances, free-ranging animals are not likely to remain in a sound field that contains potentially harmful levels of noise unless they have a compelling reason to do so (for example, if they must feed or reproduce in a specific location). Any behavioral responses that would take an animal out of a sound field or reduce the intensity of its exposure to the sound field would also reduce the animal's probability of experiencing noise-induced losses in hearing sensitivity.

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

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

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

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

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

Marine animals might experience one of these behavioral responses, they might experience a sequence of several of these behaviors (for example, an animal might continue its pre-disturbance behavior for a period of time, then abandon an area after it experiences the consequences of physiological stress) or one of these behaviors might accompany responses such as permanent or temporary loss in hearing sensitivity. The narratives that follow summarize the information available on these behavioral responses.

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

However, Kvadsheim et al. (2007) conducted a controlled exposure experiment in which killer whales (*Orcinus orca*) that had been fitted with D-tags were exposed to mid-frequency active sonar (Source A: was a 1.0 s upsweep 209 dB at 1 - 2 kHz every 10 seconds for 10 minutes; Source B: was a 1.0 s upsweep 197 dB at 6 - 7 kHz every 10 s for 10 min). When exposed to Source A, a tagged killer whale and the group it was traveling with did not appear to avoid the source. When exposed to Source B, the tagged whales along with other whales that had been carousel feeding, ceased feeding during the approach of the sonar and moved rapidly away from the source (the received level associated with this response 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.

In the Caribbean, sperm whales avoided exposure to mid-frequency submarine sonar pulses, in the range 1000 Hz to 10,000 Hz (IWC 2005). Blue and fin whales have occasionally been reported in areas ensonified by airgun pulses; however, there have been no systematic analyses of their behavioral reactions to airguns. Sightings by observers on seismic vessels off the United Kingdom suggest that, at times of good sightability, the number of blue, fin, sei, and humpback whales seen when airguns are shooting are similar to the numbers seen when the airguns are not shooting (Stone 1997; Stone 1998; Stone 2000; Stone 2001a; 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).

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

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

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

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

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

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

As stated above, Tyack et al. (2011) investigated the behavioral responses of beaked whales to multi-day naval exercises involving mid-frequency active sonar, playbacks of simulated sonar, and recorded killer whale calls with a device that records sound, movement, and orientation at the Atlantic Undersea Test and Evaluation Center (AUTEC), in the Tongue of the Ocean near Andros Island in the Bahamas. Tyack et al. (Tyack et al. 2011) found that beaked whales stopped echolocating during deep foraging dives and moved away from both simulated active sonar and killer whale sounds. During actual sonar exercises, beaked whales were primarily detected near the periphery of the range, on average 16 km away from the sonar transmissions. Once the exercise stopped, beaked whales gradually filled in the center of the range over 2–3 days. A satellite tagged whale moved outside the range during an exercise, returning over 2–3 days post-exercise. The beaked whales reacted to these three sound playbacks at sound pressure levels below 142 dB re 1 µPa by stopping echolocation followed by unusually long and slow ascents from their foraging dives.

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

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

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

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

Nowacek et al. (2004) conducted controlled exposure experiments on North Atlantic right whales using ship noise, social sounds of con-specifics, and an alerting stimulus (frequency modulated tonal signals between 500 Hz and 4.5 kHz). Animals were tagged with acoustic sensors (D-tags) that simultaneously measured movement in three dimensions. Whales reacted strongly to alert signals at received levels of 133-148 dB SPL, mildly to conspecific signals, and not at all to ship sounds or actual vessels. The alert stimulus caused whales to immediately cease foraging behavior and swim rapidly to the surface. Several studies have demonstrated that cetaceans will avoid human activities such as vessel traffic, introduced sounds in the marine environment, or both. Lusseau (2003) reported that bottlenose dolphins in Doubtful Sound, New Zealand, avoided approaching tour boats by increasing their mean diving interval. Male dolphins began to avoid tour boats before the boats were in visible range, while female dolphins only began to avoid the boats when the boats became intrusive (he attributed the differential responses to differences in energetics: the larger body size of male dolphins would allow them to compensate for the energy costs of the avoidance behavior more than female dolphins). Bejder et al. (2006) studied the effects of vessel traffic on bottlenose dolphins in Shark Bay, Australia, over three consecutive 4.5-year periods. They reported that the dolphins avoided the bay when two tour operators began to operate in the bay.

Marine mammals may avoid or abandon an area temporarily during periods of high traffic or noise, returning when the source of the disturbance declines below some threshold (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.

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

Based on a review of observations of the behavioral responses of 122 minke whales, 2,259 fin whales, 833 right whales, and 603 humpback whales to various sources of human disturbance, Watkins (1986) reported that fin, humpback, minke, and North Atlantic right whales ignored sounds that occurred at relatively low received levels, that had the most energy at frequencies below or above their hearing capacities, or that were from distant human activities, even when those sounds had considerable energies at frequencies well within the whale's range of hearing. Most of the negative reactions that had been observed occurred within 100 m of a sound source or when sudden increases in received sound levels were judged to be in excess of 12 dB, relative to previous ambient sounds From these observations, we would have to conclude that the distance between marine mammals and a source of sound, as well as the received level of the sound itself, will help determine whether individual animals are likely to respond to the sound and engage in avoidance behavior.

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

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

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

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

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

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

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

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

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

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

Continued Pre-Disturbance Behavior, Habituation, or No Response: Under some circumstances, some individual animals that would be exposed to active sonar transmissions and other sounds associated with military readiness activities will continue the behavioral activities they were engaged in before they were exposed (Richardson et al. 1995). For example, Watkins (1986) reviewed data on the behavioral reactions of fin, humpback, right and minke whales that were exposed to continuous, broadband low-frequency shipping and industrial noise in Cape Cod Bay. He concluded that underwater sound was the primary cause of behavioral reactions in these species of whales and that the whales responded behaviorally to acoustic stimuli within their respective hearing ranges. Watkins also noted that whales showed the strongest behavioral reactions to sounds in the 15 Hz to 28 kHz range, although negative reactions (avoidance, interruptions in vocalizations, etc.) were generally associated with sounds that were either unexpected, too loud, suddenly louder or different, or perceived as being associated with a potential threat (such as an approaching ship on a collision course). In particular, whales seemed to react negatively when they were within 100 m of the source or when received levels increased suddenly in excess of 12 dB relative to ambient sounds. At other times, the whales ignored the source of the signal and all four species habituated to these sounds. Nevertheless, Watkins concluded that whales ignored most sounds in the background of ambient noise, including the sounds from distant human activities even though these sounds may have had considerable energies at frequencies well within the whale‘s range of hearing. Further, he noted that fin whales were initially the most sensitive of the four species of whales, followed by humpback whales; right whales were the least likely to be disturbed and generally did not react to low-amplitude engine noise. By the end of his period of study, Watkins (1986) concluded that fin and humpback whales had generally habituated to the continuous, broad-band, noise of Cape Cod Bay while right whales did not appear to change their response.

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

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

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

This does not mean, however, that there are no costs involved with continuing pre-disturbance behavior in the face of predation or disturbance. We assume that individual animals that are exposed to sounds associated with military readiness activities will apply the economic model we discussed earlier (Ydenberg and Dills 1986). By extension, we assume that animals that choose to continue their pre-disturbance behavior would have to cope with the costs of doing so, which will usually involve physiological stress responses and the energetic costs of stress physiology (Frid and Dill 2002).

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

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

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

The results reported by Watkins (1986) and Aicken et al. (2005) could be explained either by concluding that the marine mammals had habituated to the sounds or they could be explained by concluding that the animals had made a decision to continue their pre-disturbance behavior despite the potential risks represented by the sounds (that is, the animals tolerated the disturbance). The results reported by Watkins (1986) are better explained using risk allocation than habituation because he associated the strongest, negative reactions (avoidance, interruptions in vocalizations, etc.) with sounds that were either unexpected, too loud, suddenly louder or different, were perceived as being associated with a potential threat (such as an approaching ship on a collision course), or were from distant human activities despite having considerable energy at frequencies well within the whale's range of hearing (whales would be less likely to respond to cues they would associate with a predator if their distance from the predator preserved their ability to escape a potential attack).

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

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

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

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

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

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

Although this type of response also has not been studied extensively in marine animals, Holt et al. (2007) reported that endangered southern resident killer whales (*Orcinus orca*) in Haro Strait off the San Juan Islands in Puget Sound, Washington, increased the amplitude of their social calls in the face of increased sounds levels of background noise.

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

Slabbekorn and Ripmeister (2008), Slabbekorn and den Boer-Visser (2006), and Slabbekorn and Peet (2003a) studied patterns of song variation among individual great tits (*Parus major*) in an urban population in Leiden, The Netherlands, and among 20 different urban and forest populations across Europe and the United Kingdom. Adult males of this species that occupied territories with more background noise (primarily traffic noise) sang with higher minimum frequencies than males occupying non-urban or quieter sites. Peak or maximum frequencies of these songs did not shift in the face of high background noise.

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

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

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

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

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

Foote et al. (2004) compared recordings of endangered southern resident killer whales that were made in the presence or absence of boat noise in Puget Sound during three time periods between 1977 and 2003. They concluded that the duration of primary calls in the presence of boats increased by about 15 percent during the last of the three time periods (2001 to 2003). They suggested that the amount of boat noise may have reached a threshold above which the killer whales needed to increase the duration of their vocalization to avoid masking by the boat noise.

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

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

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

Although this form of vocal adjustment has not been studied extensively in marine animals, Dahlheim (1987) studied the effects of man-made noise, including ship, outboard engine and oil-drilling sounds, on gray whale calling and surface behaviors in the San Ignacio Lagoon, Baja, California. She reported statistically significant increases in the calling rates of gray whales and changes in calling structure (as well as swimming direction and surface behaviors) after exposure to increased noise levels during playback experiments. Although whale responses varied with the type and presentation of the noise source, she reported that gray whales generally increased their calling rates, the level of calls received, the number of frequency-modulated calls, the number of pulses produced per pulsed-call series and call repetition rate as noise levels increased.

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

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

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

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

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

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

Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses produced by echosounders and submarine sonar (Watkins 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995).

Because they spend large amounts of time at depth and use low frequency sound sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999b). Furthermore, because of their apparent role as important predators of mesopelagic squid and fish, changes in their abundance could affect the distribution and abundance of other marine species.

The echolocation calls of toothed whales are subject to masking by high frequency sound. Human data indicate low frequency sound can mask high frequency sounds (i.e., upward masking). Studies on captive odontocetes by Au et al. (Au 1993; Au et al. 1985; Au et al. 1974) indicate that some species may use various processes to reduce masking effects (e.g., adjustments in echolocation call intensity or frequency as a function of background noise conditions). There is also evidence that the directional hearing abilities of odontocetes are useful in reducing masking at the high frequencies these cetaceans use to echolocate, but not at the low-to-moderate frequencies they use to communication (Zaitseva et al. 1980).

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

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

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

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

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

Hearing is one of the primary senses cetaceans use to gather information about their environment and to communicate with other members of their species. Although empirical information on the relationship between sensory impairment (TTS, PTS, and acoustic masking) on cetaceans remains limited, it seems reasonable to assume that reducing an animal's ability to gather information about its environment and to communicate with other members of its species would be stressful for animals that use hearing as their primary sensory mechanism. Therefore, we assume that acoustic exposures sufficient to trigger onset PTS or TTS would be accompanied by physiological stress responses because terrestrial animals exhibit those responses under similar conditions (NRC 2003). More importantly, marine mammals might experience stress responses at received levels lower than those necessary to trigger onset TTS. Based on empirical studies of the time required to recover from stress responses (Moberg 2000), we also assume that stress responses are likely to persist beyond the time interval required for animals to recover from TTS and might result in pathological and pre-pathological states that would be as significant as behavioral responses to TTS.

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

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

On 9 June 2008, the United Kingdom's largest mass stranding event (MSE) of short-beaked common dolphins (*Delphinus delphis*) occurred in Falmouth Bay, Cornwall. At least 26 dolphins died, and a similar number was refloated/herded back to sea (Jepson et al. 2013). International naval exercises occurred in close proximity to the stranding event with the most intense part of the exercises (including mid-frequency sonars) occurring four days before the stranding event and resuming with helicopter exercises on the morning of the stranding event. Researchers concluded that the stranding event was likely a “two-stage process” where a group of normally pelagic dolphins entered Falmouth Bay and, after 3–4 days in/around the Bay, a second acoustic/disturbance event occurred causing them to strand (Jepson et al. 2013).

It should be noted that none of these stranding events involved endangered or threatened species. For these analyses, we defined a stranded marine mammal as any dead marine mammal on a beach or floating nearshore; any live cetacean on a beach or in water so shallow that it is unable to free itself and resume normal activity; or any live pinniped which is unable or unwilling to leave the shore because of injury or poor health (Gulland et al. 2001; Wilkinson 1991).

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

Those studies suggest that, in many animal species, disease, reproductive state, age, experience, stress loading, energy reserves, and genetics combine with other stressors like body burdens of toxic chemicals to create fitness consequences in individual animals that would not occur without these risk factors. The contribution of these potential risk factors to stranding events (or causal relationships between these risk factors and stranding events) is still unknown, but the extensive number of published reports in the literature suggests that an experimental investigation into a causal relationship is warranted. Over the past three decades, several mass stranding events — stranding events that involve two or more individuals of the same species (excluding a single cow-calf pair) — that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduce sound into the marine environment.

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

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

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

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

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

Stranding events involving baleen whales (blue, bowhead, Bryde's, fin, gray, humpback, minke, right, and sei whales) and stranding events involving sperm whales have very different patterns than those of beaked whales and other smaller cetaceans. First, mass stranding events of baleen whales are very rare. Fourteen humpback whales stranded on the beaches of Cape Cod, Massachusetts between November 1987 and January 1988 (Geraci 1989); however, that stranding event has been accepted as being caused by neurotoxins in the food of the whales. In 1993, three humpback whales stranded on the east coast of Sao Vincente Island in the Cape Verde Archipelago, but they were in an advanced state of decay when they stranded so their cause of death remains unknown (Reiner et al. 1996). Finally, two minke whales (*Balaenoptera acutirostra*) stranded during the mass stranding event in the Bahamas in 2000 (see further discussion of this stranding event below). This is noteworthy because it is the only mass stranding of baleen whales that has coincided with the Navy's use of mid-frequency active sonar and because there are so few mass stranding events involving baleen whales.

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

Likely Response of Blue Whales

The Navy estimated that one blue whale would be exposed to sonar levels that would be considered harassment under the MMPA and no blue whales would be exposed to sonar levels likely to cause harm each year that the LOA would be in place. These exposure estimates did not consider the mitigation measures that will be used to reduce the exposure risk.

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

Melcón et al. (2012) tested whether mid-frequency active sonar and other anthropogenic noises in the mid-frequency band affected the production of d-calls in blue whales in the Southern California Bight (the same area that Southall et al. conducted their study). Despite being classified as “low-frequency hearing specialists,” Melcón et al. (2012) reported that blue whales heard, responded to and changed their behavior in response to sounds in the mid-frequency range. For this outcome to have occurred, it was necessary for the blue whales to hear and devote attentional resources to the sonar, despite its high frequency (relative to their putative hearing sensitivity) and its low received level.

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

Based on all of the information summarized above, including new research and stranding events, if blue whales are exposed to sonar, they might change their behavioral state if they are migrating, but they are not likely to change their behavioral state if they are actively foraging at the surface. However, as we discussed previously, we do not assume that these blue whales would respond to the active sonar rather than all of the environmental cues produced by a vessel moving through the ocean‘s surface while transmitting active sonar in the Gulf of Alaska TMAA.

Likely Response of Fin Whales

The Navy modeling analysis estimates that 11,016 fin whales could be exposed to sonar levels that NMFS would classify as behavioral harassment under the MMPA each year. The analysis also indicates there would be 21 exposure events each year to accumulated acoustic energy above 195 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS. No fin whales would be exposed to sound levels that could cause PTS.

The Navy states that given the large size of individual fin whales, pronounced vertical blow, and mean aggregation of three animals in a group (probability of trackline detection = 0.90 in Beaufort Sea States of 6 or less)(Barlow 2003) it is likely that lookouts would detect a group of fin whales at the surface. The implementation of mitigation measures to reduce exposure to high levels of sonar sound; and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to mid-frequency active (MFA)/ high-frequency active (HFA) sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS or PTS.

Fin whales continued to vocalize in the presence of boat sound (Edds and Macfarlane 1987). Similar to blue whales, the anatomical information available on fin whales suggests that they are not likely to hear mid-frequency sounds and have acute infrasonic hearing (Ketten 1997). Yet new research indicates that blue whales do hear and respond to some sonar transmissions. Based on this information, fin whales may change their behavioral state if they are migrating, but they are not likely to change their behavioral state if they are actively foraging at the surface.

Even though any undetected fin whales transiting the TMAA may exhibit a reaction when initially exposed to active acoustic energy, field observations indicate the effects would not cause disruption of natural behavioral patterns to a point where such behavioral patterns would be abandoned or significantly altered.

Likely Response of North Pacific Right Whales

The Navy did not use a model to estimate the number of North Pacific right whales that may be impacted by sonar activities because density data were not available for this species. Individuals of this species are rare in the Gulf of Alaska. Assuming that North Pacific right whales may rarely occur in the TMAA based on the estimated average group size of one derived from Angliss and Allen (2009), the Navy estimated that one North Pacific right whale could be exposed to sonar levels that NMFS would classify as behavioral harassment under the MMPA each year. The Navy assumes that there would be zero exposure events to accumulated acoustic energy above 195 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS. No North Pacific right whales would be exposed to sound levels that could cause PTS.

Because there are so few North Pacific right whales and because they are extremely unlikely to be present in the TMAA, impact modeling was not attempted (given an approximate zero density, modeling would also not be productive). Although North Pacific right whales could occur in the action area, it is an extremely unlikely probability based on habitat preferences and the summer season when training is likely to take place. If a right whale did happen to be present during ASW training activities, it is not likely to hear (1 kHz–10 kHz) sounds and therefore is not likely to respond physiologically or behaviorally.

Likely Response of Sei Whales

The Navy did not model impacts to sei whales because density data were not available for this species. Accounting for the potential that rare species may be present and based on the estimated average group size of four derived from Leatherwood et al. (1982), the analysis estimates that four sei whales could be exposed annually to sonar levels that NMFS would classify as behavioral harassment under the MMPA from activities using acoustic sources (e.g., sonar, pingers, etc.). The analysis also indicates there would be zero exposure events to accumulated acoustic energy above 195 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS. No sei whales would be exposed to sound levels that could cause PTS.

This estimate does not take into account the mitigation measures the Navy would use to reduce the number of marine mammals exposed to sonar. The Navy states that given the large size of individual sei whales, pronounced vertical blow, aggregation of approximately three animals (probability of trackline detection = 0.90 in Beaufort Sea States of 6 or less; (Barlow 2003), the distance within which they would have to approach the active sonar source (approximately 153 yd [140 m] for the most powerful source), and the assumption that many animals would likely avoid active sonar sources to some degree (NMFS 2008a), it is likely that lookouts would detect a group of sei whales at the surface. This reduces the likelihood of sei whales potentially being exposed to sonar.

There is little information on the acoustic abilities of sei whales or their response to human activities. The only recorded sounds of sei whales are frequency modulated sweeps in the range of 1.5 to 3.5 kHz (Thompson et al. 1979) but it is likely that they also vocalize at frequencies below 1 kHz as do fin whales. There are no audiograms of baleen whales but they tend to react to anthropogenic sound below 1kHz suggesting that they are more sensitive to low frequency sounds (Richardson et al. 1995). Therefore, sei whales are not likely to respond to any sonar proposed for use in the Gulf of Alaska TMAA.

Likely Response of Humpback Whales

The Navy estimates that humpback whales could be exposed a maximum of 1,388 times to sonar levels that NMFS would classify as behavioral harassment under the MMPA annually. The analysis also indicates there would be six exposure events to accumulated acoustic energy above 195 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS each year. No humpback whales would be exposed to sound levels that could cause PTS.

The Navy states that given the large size of individual humpback whales (Leatherwood et al. 1982), and pronounced vertical blow, it is likely that lookouts would detect humpback whales at the surface. In addition, although humpback whales typically travel over deep, oceanic waters during migration (which does not occur during the same period as Navy activities in the TMAA), their feeding and breeding habitats are mostly in shallow, coastal waters over continental shelves (Clapham and Mead 1999), which increases the likeliness of detection. The implementation of mitigation measures to reduce exposure to high levels of sonar sound, and the short duration and intermittent exposure to sonar, reduces the likelihood that exposure to sonar sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

There are no audiograms of baleen whales, but they tend to react to anthropogenic sound below 1 kHz, suggesting that they are more sensitive to low-frequency sounds (Richardson et al. 1995). Based on this information, if they do not hear these sounds, they are not likely to respond physiologically or behaviorally to those received levels, such that effects would be insignificant. A single study suggested that humpback whales responded to mid-frequency sonar (3.1-3.6 kHz re 1 μPa_2-s) sound (Maybaum 1989). The hand held sonar system had a sound artifact below 1,000 Hz which caused a response to the control playback (a blank tape) and may have affected the response to sonar (i.e., the humpback whale responded to the low-frequency artifact rather than the MFA sonar sound) which was either an increase in distance from the source, or an increase of swimming speed.

Humpback whales responded to small vessels (often whale watching boats) by changing swim speed, respiratory rates and social interactions depending on proximity to the vessel and vessel speed, with responses varying by social status and gender (Bauer and Herman 1986; Bauer 1986). Animals may even move out of the area in response to vessel noise (Salden 1988). Frankel and Clark (Frankel and Clark 2000; Frankel and Clark 2002) reported that there was only a minor response by humpback whales to the Acoustic Thermometry of Ocean Climate sound source and that response was variable with some animals being found closer to the sound source during use.

Likely Response of Sperm Whales

The risk function and Navy post-modeling analysis estimates sperm whales could be exposed a maximum of 327 times to sonar levels that NMFS would classify as behavioral harassment under the MMPA annually. The analysis also indicates there would be one exposure event annually to accumulated acoustic energy above 195 dB re 1 μPa2-s, which is the threshold established indicative of onset TTS. No sperm whales would be exposed to sound levels that could cause PTS.

It is unlikely that any of the potentially affected sperm whales would incur harm because of the distance within which they would have to approach the active sonar source (approximately 153 yd [140 m] for the most powerful source), the fact that many animals would likely avoid active sonar sources to some degree, and the likelihood that Navy monitors would detect some of these animals prior to an approach within this distance and implement active sonar power down or shutdown.

The Navy states that given the large size of individual sperm whales, pronounced blow (large and angled), and average group size of approximately seven animals (probability of trackline detection = 0.87 in Beaufort Sea States of 6 or less (Barlow 2003), it is likely that lookouts would detect a group of sperm whales at the surface. Sperm whales generally show little to no reaction to ships, except on close approaches (within several hundred meters), which would increase the detectability of the whales. While dives usually last 30 to 45 min, sperm whales can make prolonged dives of well over an hour (Whitehead 2003). This makes detection more difficult but passive acoustic monitoring can detect and localize sperm whales from their calls (Moore et al. 2006; White et al. 2006).

Sperm whales that are exposed to mid-frequency (1 kHz to 10 kHz) sounds may react in several ways (Richardson et al. 1995). While Watkins et al. (1985) observed that sperm whales exposed to 3.25 kHz to 8.4 kHz pulses interrupted their activities and left the area, other studies indicate that, after an initial disturbance, the animals return to their previous activity. During playback experiments off the Canary Islands, André et al. (Andre and Jurado 1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not exhibit any general avoidance reactions. When resting at the surface in a compact group, sperm whales initially reacted strongly but then ignored the signal completely (Andre and Jurado 1997).

Sperm whales have been reported to have reacted to military sonar, apparently produced by a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent and becoming difficult to approach (Watkins et al. 1985b). Captive bottlenose dolphins and a white whale exhibited changes in behavior when exposed to 1 sec pulsed sounds at frequencies similar to those emitted by multi-beam sonar that is used in geophysical surveys (Ridgway and Carder 1997; Schlundt et al. 2000), and to shorter broadband pulsed signals (Finneran et al. 2000; Finneran et al. 2002b). Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al. 2002b; Schlundt et al. 2000). Dolphins exposed to 1-sec intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa rms and belugas did so at received levels of 180 to 196 dB and above. Received levels necessary to elicit such reactions to shorter pulses were higher (Finneran et al. 2000; Finneran et al. 2002b). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran et al. 2002b). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway and Carder 1997; Schlundt et al. 2000). The relevance of these data to free-ranging odontocetes is uncertain. In the wild, cetaceans sometimes avoid sound sources well before they are exposed to the levels listed above, and reactions in the wild may be more subtle than those described by Ridgway et al. (1997) and Schlundt et al. (Schlundt et al. 2000). Based on the frequencies of their vocalizations, sonar transmissions might temporarily reduce the active space of sperm whale vocalizations. Most of the energy of sperm whales clicks is concentrated at 2 to 4 kHz and 10 to 16 kHz, which overlaps with the mid-frequency sonar. 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.

There is some evidence of disruptions of clicking and behavior from sonars (Goold 1999; Watkins 1985; Watkins and Schevill 1975), pingers (Watkins 1985), the Heard Island Feasibility Test (Bowles et al. 1994), and the Acoustic Thermometry of Ocean Climate (Costa et al. 1998). Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders (Watkins 1985). Goold (Goold 1999) reported six sperm whales that were driven through a narrow channel using ship noise, echosounder, and fishfinder emissions from a flotilla of 10 vessels. Watkins and 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).

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. (2000b) noted that sighting frequency did not differ significantly among the different acoustic levels examined in the northern Gulf of Mexico, contrary to what Mate et al. (1994) reported. Sperm whales may also have responded to seismic airgun sounds by ceasing to call during some (but not all) times when seismic pulses were received from an airgun array >300 km away (Bowles et al. 1994).

A recent study offshore of northern Norway indicated that sperm whales continued to call when exposed to pulses from a distant seismic vessel. Received levels of the seismic pulses were up to 146 dB re 1 μPa peak-to-peak (Madsen et al. 2002). Similarly, a study conducted off Nova Scotia that analyzed recordings of sperm whale sounds at various distances from an active seismic program did not detect any obvious changes in the distribution or behavior of sperm whales (McCall-Howard 1999). Recent data from vessel-based monitoring programs in United Kingdom waters suggest that sperm whales in that area may have exhibited some changes in behavior in the presence of operating seismic vessels (Stone 1997; Stone 1998; Stone 2000; Stone 2001a; 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 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).

Other studies identify instances in which sperm whales did not respond to anthropogenic sounds. Sperm whales did not alter their vocal activity when exposed to levels of 173 dB re 1 μPa from impulsive sounds produced by 1 g TNT detonators (Madsen and Møhl 2000). When Andre et al. (Andre and Jurado 1997) exposed sperm whales to a variety of sounds to determine what sounds may be used to scare whales out of the path of vessels, sperm whales were observed to have startle reactions to 10 kHz pulses (180 dB re 1 μPa at the source), but not to the other sources played to them.

Likely Response of Steller Sea Lions

The risk function and Navy post-modeling analysis estimated Steller sea lions could be exposed a maximum of 11,105 times to sonar levels that would classify as behavioral harassment under the MMPA annually. The Navy analysis also indicates there could be one exposure event annually to accumulated acoustic energy above 206 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS. No Steller sea lions would be exposed to sound levels that could cause PTS.

These estimates represent the total number of takes and not necessarily the number of individuals taken, as a single individual may be taken multiple times over the course of the year. The short duration and intermittent transmission of the sonar signals, combined with relatively rapid vessel speed, reduces the likelihood that exposure to sonar sound would cause a behavioral response that may affect vital functions, or cause TTS or PTS. The set-up procedures and checks required for safety of event participants make it unlikely that Steller sea lions would remain in an area undetected before explosive detonation occurred.

The minimum abundance estimate for the western DPS of Steller sea lions is 38,988 individuals and for the Eastern DPS is 45,095 to 55,832 (Angliss and Allen 2009). Given the wide dispersal of individuals, both the Western and Eastern DPSs may occur in the Gulf of Alaska (Angliss and Outlaw 2008; Navy 2006), with about 70 percent of the population living in Alaskan waters. Relative to the population size, the Navy's activities are anticipated to result only in a limited number of Level B harassment takes. For the Gulf of Alaska, foraging habitat is primarily shallow, nearshore, and continental shelf waters 4.3 to 13 nm (8 to 24 km) offshore with a secondary occurrence inshore of the 3,289 ft (1,000 m) isobaths, and a rare occurrence seaward of the 3,280 ft (1,000 m) isobaths. Steller sea lions have been sighted foraging in the middle of the Gulf of Alaska (Navy 2006). The April 2009 survey in the TMAA encountered two groups of Steller sea lions (Rone et al. 2010). No aquatic foraging critical habitat exists within the TMAA. Steller sea lions form large rookeries during late spring and most births occur from mid-May through mid-July outside the boundaries of the TMAA. There are no known areas used by Steller sea lions for reproduction or calving within the TMAA.

Likely Response of ESA-listed Fishes

Chinook, coho, chum, and sockeye salmon, steelhead trout, and eulachon are known to occur in the Gulf of Alaska, however, abundance or density estimate for these species in the TMAA are not available due to the lack of data to calculate such estimates. As such, the effects of sonar were qualitatively analyzed.

Of the fish species with distributions overlapping the TMAA for which hearing sensitivities are known, most are hearing generalists, including salmonid species. The hearing capability of Atlantic salmon (*Samo salar*), a hearing generalist, indicates a rather low sensitivity to sound (Hawkins and Johnstone 1978). Laboratory experiments yielded responses only to 0.58 kHz and only at high sound levels. The salmon's poor hearing is likely due to the lack of a link between the swim bladder and inner ear (Jørgensen et al. 2005). It is expected that other salmonid species have comparable hearing capabilities due to morphological similarities. Most marine fish, including the ESA-listed salmonids, are hearing generalists and have their best hearing sensitivity below mid-frequency sonar. If they occur, behavioral responses would be brief, reversible, and not biologically significant. Sustained auditory damage is not expected. Sensitive life stages (larvae and eggs) very close to the sonar source may experience injury or mortality, but are not expected as these life stages in ESA-listed species are in freshwater locales. The use of Navy mid-frequency sonar and high-frequency sonar, would not compromise the productivity of fish or adversely affect their habitat.

While the impact of anthropogenic sound on marine mammals has been extensively studied, the effects of sound on fish are largely unknown (Popper 2003; Popper 2008; Popper and Hastings 2009a). There is a lack of empirical information on the effects of exposure to sound, let alone sonar, for the vast majority of fish. The few studies on sonar effects have focused on behavior of individuals of a few species and it is unlikely their responses are representative of the wide diversity of other marine fish species (Jørgensen et al. 2005). The literature on vulnerability to injury from exposure to loud sounds is similarly limited, relevant to particular species, and, because of the great diversity of fish, not easily extrapolated.

A recent study found that exposure of caged rainbow trout, channel catfish, and hybrid sunfish to high-intensity sonar did not induce acute pathology. In the study, fishes were exposed to low-frequency sounds for 324 or 628 seconds with a received peak signal level of 193 dB re 1 μPa rms or to mid-frequency sounds for 15 seconds with a received peak signal level of 210 dB re 1 μPa rms. Although a variety of clinical observations from various tissues and organ systems were described, no exposure-related pathologies were observed. This study represents the first investigation of the effects of high-intensity sonar on fish tissues in vivo. Data from this study indicate that exposure to low and mid-frequency sonars, as described in this report, might not have acute effects on fish tissues (Kane et al. 2010). More studies are needed on the hearing thresholds for fish species and on temporary and permanent hearing loss associated with exposure to sounds.

The effects of sound may not only be species specific, but also depend on the mass of the fish (especially where any injuries are being considered) and life history phase (eggs and larvae may be more or less vulnerable to exposure than adult fish). The use of sounds during spawning by some fish, and their potential vulnerability to masking by anthropogenic sound sources, also requires further investigation. No studies have established effects of cumulative exposure to any type of sound or have determined whether subtle and long-term effects on behavior or physiology could have an impact upon survival of fish populations.

The limited information currently available suggests that listed salmonid species are unlikely to be affected by the projected rates and areas of use of military sonar. They may be able to detect mid-frequency sonar at the lower end of its range, which may result in short-term behavioral responses such as startle and avoidance. However, sonar use in the military readiness training activities in the Gulf of Alaska TMAA is not likely to result in direct impacts to listed salmon or eulachon species.

5.3.6 Responses to Sound Fields and Pressure Waves from Underwater Detonations

For marine mammal species, pressure waves from an explosion can impact air cavities, such as lungs and intestines causing instantaneous or proximate mortality. Extensive hemorrhaging of the lungs due to underwater shock waves may cause death to a marine mammal through suffocation (Hill 1978). Other common injuries which may result in mortality include circulatory failure, broncho-pneumonia in damaged lungs, or peritonitis resulting from perforations of an animal‘s intestinal wall (Hill 1978). The degree of injury associated with impulse is believed to be directly proportional to mammal mass (Yelverton et al. 1973), therefore, conservative criteria for the impulse effect are based on the lowest possible affected mammalian weight (e.g. dolphin calves, (Navy 1998).

Non-lethal injuries include slight lung hemorrhage and tympanic membrane rupture from which the mammal is expected to recover (Richmond et al. 1973; Yelverton et al. 1973). Eardrum damage criteria are based upon a limited number of small charge tests (Richmond et al. 1973; Yelverton et al. 1973). Ranges for the percentage by which tympanic membranes rupture in response to underwater explosions can be calculated by a conservative tympanic membrane damage model (U.S. Navy 1996). General criteria for damage to marine mammal tympanic membranes have been reported to occur at impulse levels down to 20 psi-msec (Yelverton et al. 1973).

Most impact analyses have focused on large shipshock explosions in nearshore waters (for example, the USS Seawolf) or deep offshore waters (for example, USS Winston S Churchill or the Mesa Verde (LPD 19)). Based upon information provided in the final environmental impact statement for the USS Seawolf shock trial (Navy 1998), the Navy developed two criteria to determine if signals generated by detonations would acoustically harass marine mammals: (1) an energy-based temporary threshold shift injury criterion of 182 dB re 1 uPa^2-sec derived from bottlenose dolphins (Ridgway and Carder 1997); and (2) a 12 - lbs/in^2 (psi) peak pressure cited by Ketten (1995) as associated with the safe outer limit (for the 10,000 lb charge for the minimal, recoverable auditory trauma (i.e., temporary threshold shifts).

The Navy's exposure model did not consider the mitigation actions proposed by the Navy or those required by NMFS Permits Division. Therefore, it is likely the model results over estimated the number of animals that would be exposed to sound or pressure waves from explosions.

Possible short-term reactions of mysticetes disturbed by human-made noise include interruption of feeding, resting, or social activities, and abrupt diving or swimming away (Richardson 1995). Various studies and reported observations for a number of different mysticete species indicate variability in the responses to sounds of relatively high intensity (Bowles et al. 1994; Malme et al. 1984; Maybaum 1989; Mobley et al. 1988; Richardson 1995; Richardson et al. 1991). In most instances, responses are affected by species, age and sex class, social context, habitat, habituation, and sound-source characteristics. Observed effects are generally fewer and less pronounced with respect to constant and predictable acoustic characteristics.

Data from the limited studies on bottlenose dolphins (Ridgway and Carder 1997) suggest that the auditory effects of underwater noise on cetaceans differ from the more studied terrestrial mammals. Although marine mammals possess auditory mechanics similar to terrestrial mammals (air filled middle ear), the cetacean ear is adapted to accommodate rapid pressure changes. The extent and result of that accommodation, however, is unknown. At least one researcher concluded that cetaceans are more vulnerable to blast injuries because of their marine adaptations (Richardson 1995).

In 1996, Todd et al. described the effects of construction site underwater explosions on humpback whales (Todd et al. 1996). The explosions took place in a narrow, shallow fjord-like area and ranged from charges of 2,200 lb to 12,125 lb. The same 1 nmi detonation unsafe zone was instituted for all explosions. Detonations occurred repeatedly over a period of months. Humpback whales did not display overt behavioral responses, but did, over a period of time, experience an increased entrapment rate in fishing gear. Damage to the eardrums was discovered in the entrapped whales. Ketten et al. (1993) concluded that the increased entrapment could have been due to cumulative effects of repeated exposure to explosions, the effects of which were increased in intensity due to the shape and constitution of the blast area.

Other non-lethal, auditory effects might be sustained by cetaceans. Both sensorineural loss (insult, loss of ear hairs) and permanent damage to middle ear mechanics (rupture of ossicles, eardrums) might be sustained. Marine mammals have morphological adaptations to the marine environment whereby energy is conducted through head tissues to the inner ear rather than through the drum and ossicles. Damage to the auditory complex at any pathway may result in either a permanent (non-recoverable) threshold shift or a temporary threshold shift. Threshold shifts affect an animal's ability to hear and, in odontocetes, echolocate. Effects to the auditory systems of marine mammals such as permanent threshold shift or permanent loss of all hearing, may also eventually lead to mortality if sufficiently severe. The loss of ability to hear environmental cues, communicate with conspecifics, or forage could result in compromised body condition, increased susceptibility to entanglement or entrapment, collision with ships, or reduced reproductive success.

Likely Response of Blue Whales

The exposure analysis indicates there would be one exposure event to blue whales from impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of sub-TTS behavioral disturbance annually. The analysis also indicates there would be zero exposure events to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and zero exposure events to impulsive sound or pressures from explosive sources that would cause slight physical injury.

We have little direct information on the hearing of blue whales or their sensitivity to sounds in their environment. Based on their anatomical and physiological similarities to both sei and fin whales, we assume that the hearing thresholds of blue 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 short-term reactions of blue whales are possible that include minor interruption of feeding, resting, or social activities, and possibly diving or swimming away (Richardson 1995); none of these short term reactions would cause disruption of natural behavioral patterns to a point where long-term behavioral patterns would be abandoned or significantly altered.

Likely Response of Fin Whales

Analysis indicates there would be 13 exposure events to fin whales from impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of sub-TTS behavioral disturbance annually. The analysis also indicates there would be 5 exposure events to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and zero exposure events to impulsive sound or pressures from explosive sources that would cause slight physical injury annually.

Fin whales continued to vocalize in the presence of boat sound (Edds and Macfarlane 1987). Similar to blue whales, the anatomical information available on fin whales suggests that they are not likely to hear mid-frequency sounds and have acute infrasonic hearing (Ketten 1997). Based on this information, if they do not hear these sounds, they are not likely to respond physiologically or behaviorally to those received levels.

Even though any undetected fin whales transiting the TMAA may exhibit a reaction when initially exposed to active acoustic energy, field observations indicate the effects would not cause disruption of natural behavioral patterns to a point where such behavioral patterns would result in long-term abandonment of areas.

Likely Response of Humpback Whales

Analysis indicates there would be one exposure event to humpback whales from impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of sub-TTS behavioral disturbance annually. The analysis also indicates there would be zero exposure events to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and zero exposure events to impulsive sound or pressures from explosive sources that would cause slight physical injury.

A study of behavioral effects of exposure to underwater explosions of humpback whales conducted in 1991-1992 off the coast of Newfoundland found that humpback whales showed little behavioral reaction to the detonations in terms of decreased residency, overall movements, or general behavior (Todd et al. 1996). However, this study found an increase in the rate of entrapment of humpback whales which they suggest may have been influenced by the long-term effects of exposure to deleterious levels of sound.

Richardson et al. (1991; 1995) review a number of studies documenting "disturbance reactions" of humpbacks to a variety of man-made sources, including seismic exploration devices. They conclude that humpbacks and other mysticetes "seem quite tolerant of low- and moderate-level noise pulses . . . as high as 150 dB re 1 pPa" (Richardson et al. 1991), although they based this on limited behavioral measures and also note that there has been little documentation of their reaction to explosions.

Likely Response of North Pacific Right Whales

Assuming that this species may be present and based on the estimated average group size of one derived from Calambokidis et al. (2009), the analysis indicates there would be one exposure event to North Pacific right whales from impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of sub-TTS behavioral disturbance annually. The analysis also indicates there would be zero exposure events to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and zero exposure events to impulsive sound or pressures from explosive sources that would cause slight physical injury.

Activities involving at-sea explosions should occur well outside the preferred habitat for feeding North Pacific right whales. Given that they are few in number and with standard operating procedures requiring area clearance, there should be no exposure events to right whales from impulsive sound or pressures from explosive sources that would result in behavioral reactions or cause slight physical injury.

Likely Response of Sei Whales

Assuming that rare species may be present and based on the estimated average group size of four, the analysis indicates there would be four exposure events to sei whales from impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of sub-TTS behavioral disturbance annually. The analysis also indicates there would be zero exposure events to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and zero exposure events to impulsive sound or pressures from explosive sources that would cause slight physical injury.

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 exposure to underwater explosions would not cause long-term disruption of natural behavioral patterns to a point where such behavioral patterns would be abandoned or significantly altered.

Likely Response of Sperm Whales

Accounting for the potential that rare species may be present and based on the estimated average group size of one derived from Rone et al. (2010), the analysis indicates there would be one exposure event to sperm whales from impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of sub-TTS behavioral disturbance annually. The analysis also indicates there would be zero exposure events to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and zero exposure events to impulsive sound or pressures from explosive sources that would cause slight physical injury.

When Andre et al. (1997) exposed sperm whales to a variety of sounds to determine what sounds may be used to scare whales out of the path of vessels, sperm whales were observed to have startle reactions to 10 kHz pulses (180 db re 1 µPa at the source), but not to the other sources played to them. Published reports identify instances in which sperm whales may have responded to an acoustic source and other instances in which they did not appear to respond behaviorally when exposed to seismic surveys. Mate et al. (1994) reported an opportunistic observation of the number of sperm whales to have decreased in an area after the start of airgun seismic testing. However, Davis et al. (2000a) 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

A recent study offshore of northern Norway indicated that sperm whales continued to call when exposed to pulses from a distant seismic vessel. Received levels of the seismic pulses were up to 146 dB re 1 µPa peak-to-peak (Madsen et al. 2002). Similarly, a study conducted off Nova Scotia that analyzed recordings of sperm whale sounds at various distances from an active seismic program did not detect any obvious changes in the distribution or behavior of sperm whales (McCall-Howard 1999). Recent data from vessel-based monitoring programs in United Kingdom waters suggest that sperm whales in that area may have exhibited some changes in behavior in the presence of operating seismic vessels (Stone 1997; Stone 1998; Stone 2000; Stone 2001a; Stone 2001b; 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.

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.

Likely Response of Steller Sea Lions

The Navy estimated that two Steller sea lions would be exposed to impulsive sound or pressures from explosive sources of 177 dB, which is the threshold indicative of sub-TTS behavioral disturbance annually. The analysis also indicates that there would be one exposure event to impulsive sound or pressures from explosive sources of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and zero exposure events to impulsive sound or pressures from explosive sources that would cause slight physical injury annually.

Target area clearance procedures, which are part of the Navy's standard mitigation measures, reduce the likelihood that Steller sea lions will be exposed to at sea explosions associated with Navy training events.

If Steller sea lions are exposed to underwater explosions, they are likely to startle and swim away from the area. However, any reaction would be short-term and not cause disruption of natural behavioral patterns to a point where such behavioral patterns would be abandoned or significantly altered

Likely Response of ESA-listed Fishes

At-sea explosions that occur in the TMAA are associated with training exercises that use explosive ordnance, including bombs (BOMBEX), and naval gun shells (GUNEX, 5-inch high explosive rounds), and SSQ-110 sonobuoys. Tests conducted for training activities in Puget Sound, Washington provided distances at which physical injury to chum and Chinook salmon could occur for detonation of 20-lb. and 5-lb. charges, as shown in Table 16.

Table 16. Approximate Distances from Detonation Resulting in No Injury or 1 Percent Mortality to Fish.

Species	No Effect (no injury) Distance (feet [meters])	
	20-lb (9-kg)	**5-lb (2-kg)**
Juvenile chum salmon	2,789 (850)	1,903 (580)
Juvenile Chinook salmon	2,560 (780)	1,729 (527)
Adult chum salmon	1,149 (350)	771 (235)
Adult Chinook salmon	1,050 (320)	709 (216)

Source: Department of the Navy, 2000b (Final BA EOD Puget Sound)

While the physical conditions differ between the test location and the Gulf of Alaska, this data provides a rough approximation for distances at which salmon may be injured based on activities such as a GUNEX employing a 5-in high explosive round containing approximately 10-lb. NEW. As shown above, the distances over which adult Chinook or chum salmon could be injured or killed are considerably smaller than the injury distances for juveniles.

Regarding the potential for physical injury, Table 17 shows "safe distances," based on no injury and 90 percent survival for adult and juvenile bull trout, using the method of Young (1991). Although bull trout are not present in the Gulf of Alaska, this data is presented here to serve as an approximation for assessment.

Table 17. Approximate Distances from Detonation Resulting in No Injury or 90 Percent Mortality to bull trout.

Species	No Effect (no injury) Distance (m)		90 Percent Survival Distance (m)	
	5-lb (2-kg)	20-lb (9-kg)	5-lb (2-kg)	20-lb (9-kg)
Juvenile bull trout	480	710	161	237
Adult bull trout	250	375	85	125

Note: Based on method of Young (1991). Assumes charge is at a depth of 50 ft (15.2 m) and fish are in "shallow" water. No injury distances are estimated from 90 percent survival distances.

The evidence of short- and long-term behavioral effects, as defined by changes in fish movement, etc., is non-existent (Popper 2008; Popper and Hastings 2009b). It is unknown if the presence of an explosion or impulsive source at some distance, while not physically harming a fish, would alter its behavior in any significant way (Popper 2008).

Impacts to fish from detonations would be possible, but have a low potential for occurrence because although maturing salmon destined for North American streams are widely distributed throughout the Gulf of Alaska during the spring and summer (Salo 1991), disturbances to water column from at-sea explosions would be short-term and localized. The proposed activities in GOA involving at-sea explosions will be limited in number. While serious injury and/or mortality to individual ESA-listed fish could occur if they were present in the vicinity of at-sea explosions, this would not result in impacts to fish populations based on the low number of fish that would be affected.

5.4 Integration and Synthesis

The Integration and Synthesis section is the final step of NMFS' assessment of the risk posed to species and critical habitat as a result of implementation of the proposed action. In this section, we add the effects of the action (Chapter 2.4) to the environmental baseline (Chapter 2.3) and the cumulative effects (Chapter 2.5) to assess whether it is reasonable to expect that the proposed action is not likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Chapter 2.2).

Thus far, we have described the endangered or threatened species that are likely to be exposed to the activities the Navy proposes to conduct and the probable responses of those endangered or threatened species given that exposure. In this section of the opinion, we describe the probable consequences of those responses for endangered or threatened individuals, the population(s) those individuals represent, and the species those populations comprise to determine whether the proposed military readiness activities are likely to jeopardize the continued existence of those species by appreciably reducing the reproduction, numbers, or distribution of those species in the wild.

As we discussed in the *Approach to the Assessment* section of this opinion, we begin our risk analyses by asking whether the probable physical, physiological, behavioral, or social responses of endangered or threatened species are likely to reduce the fitness of endangered or threatened individuals or the growth, annual survival or reproductive success, or lifetime reproductive success of those individuals. If we would not expect listed species exposed to an action's effects to experience reductions in the current or expected future reproductive success (that is, their fitness), we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (Anderson 2000; Brandon 1978; Mills and Beatty 1979; Stearns 1977; Stearns 1992). Therefore, if we conclude that listed species are not likely to experience reductions in their fitness, we would conclude our assessment because we would not expect the effects of the action to affect the performance of the populations those individuals represent or the species those population comprise. If, however, we conclude that listed species are likely to experience reductions in their fitness as a result of their exposure to an action, we then determine whether those reductions would reduce the viability of the population or populations the individuals represent and the "species" those populations comprise (in section 7 consultations, the "species" represent the listed entities, which might represent species, subspecies, or distinct populations segments of vertebrate taxa).

As part of our risk analyses, we consider the consequences of exposing endangered or threatened species to the stressors associated with the proposed actions, individually and cumulatively, given that the individuals in the action areas for this consultation are also exposed to other stressors in the action area and elsewhere in their geographic range. These stressors or the response of individual animals to those stressors can produce consequences — or "cumulative impacts"— that would not occur if animals were only exposed to a single stressor.

As we discuss in the narratives that follow, our analyses led us to conclude that endangered or threatened individuals that are likely to be exposed to the military readiness activities the Navy proposes to conduct in the Gulf of Alaska are likely to experience disruptions in their normal behavioral patterns, but they are not likely to be killed, injured, or experience measurable reductions in their current or expected future reproductive success as a result of that exposure.

5.4.1 Blue Whale

Based on the results of the exposure analyses we would expect blue whales to be exposed to vessel traffic associated with Navy training exercises (posing risk of disturbance and collision), aircraft flight and non-explosive ordnance and gunfire (with low exposure risk), low- and mid-frequency active sonar, and pressure waves and sound fields associated with underwater detonations in the Gulf of Alaska TMAA.

Based on the response analysis, blue whales are likely to have minimal, if any, behavior disruption from vessel traffic. Assuming that whales that occur within 560 meters (1,968 feet) of Navy vessels moving at speeds greater than 14 knots would have some risk of being struck by the vessel; one blue whale might occur close enough to a Navy vessel that is underway to have some risk of being struck. Nevertheless, the low frequency of collisions between ships and large whales in the Gulf of Alaska suggests that a collision is not likely. As a result, the evidence available does not lead us to expect a blue whale to be struck by a Navy vessel in the Gulf of Alaska TMAA during the next three years.

Blue whales exposed to aircraft or non-explosive ordnance and gunfire would be expected to exhibit a short-term behavioral response, but not to the extent where natural behavioral patterns would be abandoned or considerably altered.

Blue whale vocalizations include a variety of sounds described as low frequency moans or long pulses in the 10-100 Hz band (Clark and Fristrup 1997; Cummings and Thompson 1971; Edds and Macfarlane 1987; McDonald et al. 1995; Rivers 1997; Thompson and Friedl 1982). The most typical signals are very long, patterned sequences of tonal infrasonic sounds in the 15-40 Hz range. Ketten (1998) reports the frequencies of maximum energy between 12 and 18 Hz. Shorter transient higher-frequency calls (30-200Hz) are associated with feeding and most likely social behaviors, but their function remains largely unknown (Di Lorio 2005) . The context for the 30-90 Hz calls suggests that blue whales use these calls to communicate but they do not appear to be related to the reproductive ecology of blue whales. Blue whale moans within the frequency range of 12.5-200 Hz, with pulse duration up to 36 seconds, have been recorded off Chile (Cummings and Thompson 1971). The whale produced a short, 390 Hz pulse during the moan.

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. As a result, we assume that blue whale vocalizations are partially representative of their hearing sensitivities. This assumption and the evidence available lead us to conclude that blue whales are not likely to respond to high-frequency sound sources associated with the proposed training activities because of their hearing sensitivities.

Based on our review of the relative frequency of physical, physiological, and behavioral responses of cetaceans that have been exposed to mid-frequency active sonar, we would expect blue whales to either ignore the stimulus, change their location to avoid continued exposure to the sound, make vocal adjustments to calls or other vocalizations (for example, increasing the amplitude or repetition rates of their vocalizations or the timing of their vocalization), or engage in minor changes in their behavior. This evasive behavior or changes in behavioral state would represent disruptions of the normal behavioral patterns that are essential to the life history of the individual blue whales exhibiting these responses.

Because of the mitigation measures the Navy plans to employ before engaging in training activities, the number of blue whales exposed to any stressors associated with the Navy's training activities would be minimized.

The blue whales that are exposed to the training activities in the Gulf of Alaska TMAA might not respond to the acoustic cues generated by Navy vessels, while in other circumstances, they are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, and social interactions (Amaral and Carlson 2005; Au and Green 2000; Corkeron 1995; Erbe 2002b; Felix 2001; Magalhaes et al. 2002; Melcon et al. 2012; Richter et al. 2006; Scheidat et al. 2004; Simmonds 2005; Southall et al. 2011; Watkins 1986; Williams et al. 2002). The blue whales that are likely to be exposed would have had prior experience with similar stressors resulting from their exposure in waters off Japan and Hawai′i; that experience will make some blue whales more likely to avoid activities associated with the training while others would be less likely to engage in avoidance behavior. Some blue whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship as they engage in avoidance behavior. However, we do not expect these physiological stress responses to reduce the fitness of the blue whales that occur in the Gulf of Alaska TMAA.

In conclusion, we expect two instances each year in which individual blue whales might experience short-term disruptions of their normal behavioral patterns as a result of their exposure to mid- or low-frequency active sonar and sound fields or pressure waves from explosives associated with the training exercises, as well as other activities the Navy plans to conduct in the Gulf of Alaska TMAA annually. The small number and short duration of these exposure events, however, are not likely to disrupt its behavior patterns to a degree that is likely to reduce the current or expected future reproductive success of the blue whale involved. Therefore, we would not expect the military readiness activities the Navy proposes to conduct in the Gulf of Alaska TMAA to affect the performance of the populations those blue whales represent or the species those population comprise. By extension, we would not expect those military readiness activities to appreciably reduce the blue whales' likelihood of surviving and recovering in the wild.

5.4.2 Fin Whale

Based on the results of the exposure analyses we would expect some fin whales to be exposed to vessel traffic associated with Navy training exercises (posing risk of disturbance and collision), aircraft flight and non-explosive ordnance and gunfire (with low exposure risk), low- and mid-frequency active sonar, and pressure waves and sound fields associated with underwater detonations on the Gulf of Alaska TMAA.

Based on the response analysis, fin whales are likely to have minimal, if any, behavior disruption from vessel traffic. We assume that whales that occur within 560 meters (1,968 feet) of Navy vessels moving at speeds greater than 14 knots would have some risk of being struck by the vessel. Nevertheless, the low frequency of collisions between ships and large whales in the Gulf of Alaska TMAA suggests that a collision is not likely. As a result, the evidence available does not lead us to expect a fin whale to be struck by a Navy vessel in the Gulf of Alaska TMAA in either year between April 2011 and April 2013.

Fin whales exposed to aircraft flights or non-explosive ordnance and gunfire would be expected to exhibit a short-term behavioral response, but not to the extent where natural behavioral patterns would be abandoned or considerably altered.

Based on the results of the exposure analyses, each year NMFS would expect about 11,037 exposure events involving fin whales to result from the 578 hours of training the Navy plans to conduct with AN/SQS-53, the 52 hours of training with AN/SQS-56, the 48 hours of training with AN/BQQ-10, the 24 hours of training with BQS-15, the 266 dips of training with SSQ-62 DICASS, the 192 dips with an AQS-22, and the 40 hours of ANSSQ-110A/125 (MAC) and the use of explosives in the Gulf of Alaska TMAA.

Fin whales produce a variety of low-frequency sounds in the 10-200 Hz band (Edds 1988; Thompson and Friedl 1982; Watkins 1981a). The most typical signals are long, patterned sequences of short duration (0.5-2s) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton 1964). Estimated source levels are as high as 190 dB (McDonald et al. 1995; Patterson and Hamilton 1964; Thompson et al. 1992; Watkins et al. 1987). In temperate waters intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clarke and Charif 1998). Short sequences of rapid pulses in the 20-70 Hz band are associated with animals in social groups (McDonald et al. 1995). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

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. As a result, we assume that fin whale vocalizations are partially representative of their hearing sensitivities. This assumption and the evidence available lead us to conclude that fin whales are not likely to respond to high-frequency sound sources associated with the proposed training activities because of their hearing sensitivities.

As we discussed, we assume that the fin whales that might be exposed to stressors associated with Navy readiness activities in the Gulf of Alaska TMAA are members of the population of fin whales that inhabits the northwest Pacific Ocean. These fin whales would not only be exposed to readiness activities on the TMAA considered in this opinion, they would also be exposed to readiness activities the Navy conducts off the Japanese archipelago. As a result, the same individuals would be exposed to low- and mid-frequency active sonar associated with anti-submarine warfare and strike warfare exercises associated with those training exercises.

The fin whales that are likely to be exposed to the training activities in the Gulf of Alaska TMAA might not respond to the acoustic cues generated by Navy vessels, while in other circumstances, they are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, and social interactions (Amaral and Carlson 2005; Au and Green 2000; Corkeron 1995; Erbe 2002b; Felix 2001; Magalhaes et al. 2002; Richter et al. 2006; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams et al. 2002). The fin whales that are likely to be exposed in the Gulf of Alaska TMAA would have had prior experience with similar stressors during the winters in waters off Japan and California; that experience will make some fin whales more likely to avoid activities associated with the training while others would be less likely to engage in avoidance behavior. Some fin whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship as they engage in avoidance behavior. However, these responses are not likely to reduce the fitness of the fin whales that occur in the Gulf of Alaska TMAA.

In conclusion, approximately 11,037 instances each year in which individual fin whales might be exposed to mid- or low-frequency active sonar or underwater explosives associated with the training exercises and other activities the Navy plans to conduct in the Gulf of Alaska TMAA. As such, they may experience disruptions of their normal behavioral patterns as a result of their exposure. These exposure events relative to the time interval over which fin whales occur in the Gulf of Alaska, however, are not likely to disrupt their behavior patterns to a degree that is likely to reduce the current or expected future reproductive success of the fin whales involved. Therefore, we would not expect the military readiness activities the Navy proposes to conduct in the Gulf of Alaska TMAA to affect the performance of the populations those fin whales represent or the species those population comprise. By extension, we would not expect those military readiness activities to appreciably reduce the fin whales' likelihood of surviving and recovering in the wild.

5.4.3 Humpback Whale

Based on the results of our exposure analyses we would expect humpback whales to be exposed to vessel traffic (posing risk of disturbance and collision), aircraft flight and non-explosive ordnance and gunfire (with low exposure risk), active sonar, and pressure waves and sound fields from underwater detonations associated with Navy training exercises in the Gulf of Alaska TMAA.

Based on the response analysis, humpback whales are likely to have minimal, if any, behavior disruption from vessel traffic. We assume that whales that occur within 560 meters (1,968 feet) of Navy vessels moving at speeds greater than 14 knots would have some risk of being struck by the vessel. Nevertheless, the low frequency of collisions between ships and large whales in the Gulf of Alaska TMAA suggests that a collision is not likely. As a result, the evidence available does not lead us to expect a humpback whale to be struck by a Navy vessel in the Gulf of Alaska TMAA in any given year.

Humpback whales exposed to aircraft flights or non-explosive ordnance and gunfire would be expected to exhibit a short-term behavioral response, but not to the extent where natural behavioral patterns would be abandoned or considerably altered.

Based on the results of the exposure analyses, each year we would expect about 1,395 exposure events involving humpback whales to result from the 578 hours of training the Navy plans to conduct with AN/SQS-53, the 52 hours of training with AN/SQS-56, the 48 hours of training with AN/BQQ-10, the 24 hours of training with BQS-15, the 266 dips of training with SSQ-62 DICASS, the 192 dips with an AQS-22, and the 40 hours of ANSSQ-110A/125 (MAC) in the Gulf of Alaska TMAA.

Because of the mitigation measures the Navy plans to employ before engaging in military readiness activities, we would not expect humpback whales to be exposed to underwater detonations at received levels that would be expected to cause them to experience 50 percent tympanic membrane rupture or at received levels that would be expected to produce slight lung injury as a result of their exposure (these two received levels are considered thresholds for Level A "take" or injury by NMFS' Permits Division). However, we would expect one humpback whale to be exposed to underwater detonations in the Gulf of Alaska TMAA at received levels greater than or equal to 182 dB SEL or 23 psi-ms, which NMFS' Permits Division considers as a threshold for Level B "take" or behavioral harassment.

In some circumstances humpback whales might not respond to the acoustic cues generated by Navy vessels, while in other circumstances, they are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, and social interactions (Amaral and Carlson 2005; Au and Green 2000; Corkeron 1995; Erbe 2002b; Felix 2001; Magalhaes et al. 2002; Richter et al. 2006; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams et al. 2002). The humpback whales that are likely to be exposed in the Gulf of Alaska TMAA would have had prior experience with similar stressors resulting from their exposure in waters off Japan and California where they winter; that experience will make some humpback whales more likely to avoid activities associated with the training while others would be less likely to engage in avoidance behavior. Some humpback whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship as they engage in avoidance behavior. However, these responses are not likely to reduce the fitness of the humpback whales that occur in the Gulf of Alaska TMAA.

In conclusion, we expect 1,395 instances in which individual humpback whales might experience some minor disruptions of their normal behavioral patterns each year as a result of their exposure to sonar associated with the training exercises and other activities the Navy plans to conduct in the Gulf of Alaska TMAA. The short duration of these exposure events and the likely response of the whales to exposure, however, are not likely to disrupt its behavior patterns to a degree that is likely to reduce the current or expected future reproductive success of the humpback whales involved. Therefore, we would not expect the military readiness activities the Navy proposes to conduct on the Gulf of Alaska TMAA to affect the performance of the populations those humpback whales represent or the species those populations comprise. By extension, we would not expect those military readiness activities to appreciably reduce the humpback whales' likelihood of surviving and recovering in the wild.

5.4.4 North Pacific Right Whale

Based on the results of the exposure analyses each year we would expect two North Pacific right whales to be exposed to vessel traffic associated (posing risk of disturbance and collision), aircraft flight and non-explosive ordnance and gunfire (with low exposure risk), low- and mid-frequency active sonar, and pressure waves and sound fields associated with underwater detonations in the Gulf of Alaska TMAA.

Considering the measures the Navy will use to minimize exposing North Pacific right whales to these stressors and the scarcity of these whales in the Gulf of Alaska TMAA, the response analysis suggests that the activities are not likely to disrupt the behavior patterns of the individual North Pacific right whales to a degree that is likely to reduce the current or expected future reproductive success of the whales involved. NMFS would not expect the military readiness activities the Navy proposes to conduct on the Gulf of Alaska TMAA to affect the performance of the populations those North Pacific right whales represent or the species those populations comprise. By extension, we would not expect those military readiness activities to appreciably reduce the North Pacific right whales' likelihood of surviving and recovering in the wild.

5.4.5 Sei Whale

Based on the results of our exposure analyses we would expect sei whales to be exposed to vessel traffic (posing risk of disturbance and collision), aircraft flight and non-explosive ordnance and gunfire (with low exposure risk), active sonar, and pressure waves and sound fields from underwater detonations associated with military readiness activities in the Gulf of Alaska TMAA.

Considering that the measures the Navy will use to minimize exposing sei whales to these stressors and that these whales are relatively rare in the Gulf of Alaska, the likelihood of sei whales being disturbed by or in a collision with a vessel is very low. Similarly, aircraft flights or non-explosive ordnance and gunfire would result in only minor, if any, behavioral responses that would not reduce the current or expected future reproductive success of the whales involved

As discussed in the *Status of the Species* section of this opinion, we have almost no information on vocalizations produced by 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. That is, we assume 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 (1 kHz–10 kHz) sounds. Furthermore, we assume that sei whale vocalizations are partially representative of their hearing sensitivities so we assume that sei whales are not likely to respond to high-frequency sound sources associated with the proposed training activities because of their hearing sensitivities.

Because of the mitigation measures the Navy plans to employ before engaging in sinking exercises or underwater detonations, we would not expect sei whales to be exposed to underwater detonations on the Gulf of Alaska TMAA at received levels that would be expected to cause them to experience 50 percent tympanic membrane rupture or that would be expected to produce slight lung injury as a result of their exposure.

In conclusion, we expect eight instances each year in which individual sei whales might experience disruptions of their normal behavioral patterns as a result of their exposure to active sonar associated with the training exercises and other activities the Navy plans to conduct in the Gulf of Alaska TMAA annually. Because of the small number of exposure events relative to the number of sei whales that occur in the Gulf of Alaska TMAA and the short duration of the exposure relative to the time interval over which sei whales occur in those waters, however, they are not likely to disrupt the behavior patterns of the individual sei whales to a degree that is likely to reduce the current or expected future reproductive success of the whales involved. Therefore, we would not expect the military readiness activities the Navy proposes to conduct on the Gulf of Alaska TMAA to affect the performance of the populations those sei whales represent or the species those populations comprise. By extension, we would not expect those military readiness activities to appreciably reduce the sei whales’ likelihood of surviving and recovering in the wild.

5.4.6 Sperm Whale

Based on the results of the exposure analyses we would expect sperm whales to be exposed to vessel traffic associated with Navy training exercises (posing risk of disturbance and collision), aircraft flight and non-explosive ordnance and gunfire (with low exposure risk), low- and mid-frequency active sonar, and pressure waves and sound fields associated with underwater detonations in the Gulf of Alaska TMAA.

Sperm whales are likely to have minimal, if any, behavior disruption from vessel traffic. Sperm whales generally show little to no reaction to ships, except on close approaches (within several hundred meters). Assuming that whales that occur within 560 meters (1,968 feet) of Navy vessels moving at speeds greater than 14 knots would have some risk of being struck by the vessel; sperm whales might occur close enough to a Navy vessel that is underway to have some risk of being struck. Nevertheless, the low frequency of collisions between ships and large whales on the Gulf of Alaska TMAA suggests that a collision is not likely. As a result, the evidence available does not lead us to expect a sperm whale to be struck by a Navy vessel on the Gulf of Alaska TMAA in any given year.

Sperm whales exposed to aircraft flights or non-explosive ordnance and gunfire would be expected to exhibit a short-term behavioral response, but not to the extent where natural behavioral patterns would be abandoned or considerably altered.

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 et al. 1993). These clicks were estimated to have source levels at 171 dB re 1 μPa (Levenson 1974). Current evidence suggests that the disproportionately large heads of sperm whales are adaptations that allow them to produce these vocalizations (Cranford 1992; Norris and Harvey. 1972); but see (Clarke 1979)). This suggests that the production of these loud low-frequency clicks is extremely important to the survival of individual sperm whales. The function of these vocalizations is relatively well-studied (Goold and Jones 1995; Weilgart et al. 1993): long series of monotonous regularly spaced clicks are associated with feeding and are thought to help sperm whales echolocate while the distinctive, short, patterned series of clicks, called codas, are associated with social behavior and interactions within social groups (Weilgart and Whitehead 1993).

Because the Navy will not be engaging in sinking exercises and the use of mitigation measures prior to underwater detonations, we would not expect sperm whales to be exposed to underwater detonations at received levels that would be expected to cause them to experience 50 percent tympanic membrane rupture or at received levels that would be expected to produce slight lung injury as a result of their exposure (these two received levels are considered thresholds for Level A “take” or injury by NMFS’ Permits Division). However, we would expect one sperm whale to be exposed to underwater detonations on the Gulf of Alaska TMAA at received levels greater than or equal to 182 dB SEL or 23 psi-ms annually, which NMFS’ Permits Division considers as a threshold for Level B “take” or behavioral harassment.

As we discussed, we assume that the sperm whales that might be exposed to stressors associated with Navy readiness activities on the Gulf of Alaska TMAA are members of the population of sperm whales that inhabits the northwest Pacific Ocean. These sperm whales would not only be exposed to readiness activities on the TMAA considered in this opinion, they would also be exposed to activities off the Japanese archipelago. As a result, the same individuals would be exposed to low- and mid-frequency active sonar associated with anti-submarine warfare and strike warfare exercises associated with those training exercises. We expect 329 instances each year in which sperm whales might be exposed to active sonar at received levels that might change their behavioral state.

The sperm whales that are exposed to the training activities in the Gulf of Alaska TMAA might not respond to the acoustic cues generated by Navy vessels, while in other circumstances, they are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, and social interactions (Amaral and Carlson 2005; Au and Green 2000; Corkeron 1995; Erbe 2002b; Felix 2001; Magalhaes et al. 2002; Richter et al. 2006) (Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams et al. 2002). The sperm whales that are likely to be exposed on the Gulf of Alaska TMAA would have had prior experience with similar stressors resulting from their exposure in waters off Japan earlier in the year; that experience will make some sperm whales more likely to avoid activities associated with the training while others would be less likely to engage in avoidance behavior. Some sperm whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship as they engage in avoidance behavior. However, these responses are not likely to reduce the fitness of the sperm whales that occur in the Gulf of Alaska TMAA.

In conclusion, we expect 329 instances in which individual sperm whales might experience disruptions of their normal behavioral patterns each year as a result of their exposure to mid- or low-frequency active sonar associated with the training exercises and other activities the Navy plans to conduct in the Gulf of Alaska TMAA each year. Because of the small number of exposure events relative to the number of sperm whales that occur in the Gulf of Alaska TMAA and the short duration of the exposure relative to the time interval over which sperm whales occur in those waters, however, they are not likely to disrupt the behavior patterns of the individual sperm whales to a degree that is likely to reduce the current or expected future reproductive success of the whales involved. Therefore, we would not expect the military readiness activities the Navy proposes to conduct on the Gulf of Alaska TMAA to affect the performance of the populations those sperm whales represent or the species those populations comprise. By extension, we would not expect those military readiness activities to appreciably reduce the sperm whales' likelihood of surviving and recovering in the wild.

5.4.7 Steller Sea Lion

Based on the results of the exposure analyses each year we would expect 11,108 Steller sea lions to be exposed to vessel traffic associated with Navy training exercises (posing risk of disturbance), aircraft flight and non-explosive ordnance and gunfire (with low exposure risk), low- and mid-frequency active sonar, and pressure waves and sound fields associated with underwater detonations in the Gulf of Alaska TMAA.

Steller sea lions are likely to avoid vessel traffic if encountered. Helicopter flights can occur throughout the TMAA, but will not be in close proximity land and therefore separated from known Steller sea lion haul out areas and established rookeries. The Navy complies with restrictions prohibiting fixed wing aircraft or helicopter overflight or surface training activities within 3,000 ft (914 m) of Steller sea lion critical habitat, rookeries or pinniped haulout areas. These mitigation measures minimize adverse reactions of Steller sea lions to training activities.

Steller sea lions exposed to non-explosive ordnance and gunfire would be expected to exhibit a short-term behavioral response, but not to the extent where natural behavioral patterns would be abandoned or considerably altered. Because the exposures of Steller sea lions are not likely to disrupt the behavior patterns of the individual animals to a degree that is likely to reduce the current or expected future reproductive success of the sea lions involved, we would not expect the military readiness activities the Navy proposes to conduct on the Gulf of Alaska TMAA to affect the performance of the populations those Steller sea lions represent or the species those populations comprise. By extension, we would not expect those military readiness activities to appreciably reduce the Steller sea lions' likelihood of surviving and recovering in the wild.

5.4.8 Leatherback Sea Turtles

The Gulf of Alaska TMAA is near the northern edge of the known extent of the Pacific range for leatherback sea turtles. Their distribution patterns based on water temperature elsewhere suggests that the number of leatherback sea turtles in the Gulf of Alaska is likely very low. The results of the exposure analyses, including the low number of leatherback sea turtles, and the Navy's measures to minimize exposure of leatherback sea turtles, the led NMFS to conclude that the risks to leatherback sea turtles were sufficiently small as to be discountable and not warrant further analysis. Therefore, the proposed activities are not likely to disrupt the behavior patterns of the individual animals to a degree that is likely to reduce the current or expected future reproductive success of the leatherback sea turtles involved, and we would not expect the military readiness activities the Navy proposes to conduct on the Gulf of Alaska TMAA to affect the performance of the populations those leatherback sea turtles represent or the species those populations comprise. By extension, we would not expect those military readiness activities to appreciably reduce the leatherback sea turtles' likelihood of surviving and recovering in the wild.

5.4.9 Chinook, Coho, Chum, and Sockeye Salmon and Steelhead Trout

Based on the results of the exposure analyses we would expect Chinook, coho, chum, and sockeye salmon and steelhead trout to be exposed to low- and mid-frequency active sonar, and pressure waves and sound fields associated with underwater detonations in the Gulf of Alaska TMAA. Because the exposures of Chinook, coho, chum, and sockeye salmon and steelhead trout are not likely to disrupt the behavior patterns of the individual animals to a degree that is likely to reduce the current or expected future reproductive success of the fishes involved, we would not expect the military readiness activities the Navy proposes to conduct on the Gulf of Alaska TMAA to affect the performance of the populations those Chinook, coho, chum, and sockeye salmon and steelhead trout represent or the species those populations comprise. By extension, we would not expect those military readiness activities to appreciably reduce the Chinook, coho, chum, and sockeye salmon and steelhead trout likelihood of surviving and recovering in the wild.

5.4.10 Pacific Eulachon

Based on the results of the exposure analyses we would expect Pacific eulachon to be exposed to, low- and mid-frequency active sonar, and pressure waves and sound fields associated with underwater detonations in the Gulf of Alaska TMAA. Because the exposures of Pacific eulachon are not likely to disrupt the behavior patterns of the individual animals to a degree that is likely to reduce the current or expected future reproductive success of the Pacific eulachon involved, we would not expect the military readiness activities the Navy proposes to conduct on the Gulf of Alaska TMAA to affect the performance of the populations those Pacific eulachon represent or the species those populations comprise. By extension, we would not expect those military readiness activities to appreciably reduce the Pacific eulachon likelihood of surviving and recovering in the wild.

6 CONCLUSION

After reviewing the current status of blue whales, fin whales, humpback whales, North Pacific right whales, sei whales, sperm whales, Steller sea lions, leatherback sea turtles, Chinook salmon, coho salmon, chum salmon, sockeye salmon, steelhead trout, and Pacific eulachon, the environmental baseline for the action area, the effects of the military readiness activities the Navy proposes to conduct in the Gulf of Alaska TMAA annually during May 2013 through May 2016 for which the NMFS Permits Division proposes to issue a Letter of Authorization pursuant to MMPA regulations, and the cumulative effects, it is NMFS' biological opinion that the Navy's proposed activities are not likely to jeopardize the continued existence of these threatened and endangered species under NMFS jurisdiction.

Because critical habitat that has been designated for endangered or threatened species does not occur in the action area, it is not likely to be adversely affected by the military readiness activities the Navy proposes to conduct in the Gulf of Alaska TMAA.

7 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibits the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2) of the ESA, taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of an Incidental Take Statement.

The instances of take by harassment identified below would generally represent changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures and, therefore, would represent significant disruptions of the normal behavioral patterns of the animals that have been exposed. The "take" estimates that follow are grouped responses to active sonar, vessel traffic, explosive detonations, and other environmental cues associated with the surface vessels involved in major training exercises. We assume animals would respond to the suite of environmental cues that include sound fields produced by active sonar, sounds produced by the engines of surface vessels, sounds produced by displacement hulls, and other sounds associated with training exercises. That is, we assume endangered marine mammals will perceive and respond to all of the environmental cues associated with an exercise rather than the single stimulus represented by active sonar.

7.1 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" if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (51 FR 19953). The amount of take resulting from the Navy's activities was difficult to estimate because we have no empirical information on (a) the actual number of listed species that are likely to occur in the different sites, (b) the actual number of individuals of those species that are likely to be exposed, (c) the circumstances associated with any exposure, and (d) the range of responses we would expect different individuals of the different species to exhibit upon exposure.

The instances of annual harassment identified in Table 18 would generally represent changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures. Therefore, they would represent significant disruptions of the normal behavioral patterns of the animals that are expected to be exposed to the U.S. Navy's military readiness activities in the Gulf of Alaska TMAA.

Table 18. Expected number of instances in which individual members of endangered or threatened species are likely to be "taken" as a result of their exposure to military readiness activities in the Gulf of Alaska Temporary Maritime Activities Area.

Species	Annually	Total 2013-2016	Form of the "Take"
Blue whale	2	6	Harassment
Fin whale	11,037	33,111	Harassment
Humpback whale	1,395	4,185	Harassment
North Pacific right whale	2	6	Harassment
Sei whale	8	24	Harassment
Sperm whale	329	987	Harassment
Steller sea lion	11,108	33,324	Harassment

No whales would die or be wounded as a result of their exposure to U.S. Navy military readiness activities in the Gulf of Alaska TMAA. Because of their hearing sensitivities, we generally expect blue, fin, and sei 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 this list 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.

We do not have a means to quantitatively assess take of salmon, steelhead, or Pacific eulachon. However, as analyzed in this opinion we would expect only minor temporary disturbances to these fish species from the Navy's military readiness activities in the Gulf of Alaska TMAA.

7.2 Effect of the Take

In the accompanying opinion, NMFS determined that the number of individuals that might be exposed to potential stressors from military readiness activities in the Gulf of Alaska TMAA are likely to respond to that exposure in ways that NMFS would classify as "take" as that term is defined pursuant to section 3 of the Endangered Species Act. 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 or explosive detonations and any associated disruptions are expected to be temporary and would not affect the reproduction, survival, or recovery of these species.

7.3 Reasonable and Prudent Measures

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

1. The U.S. Navy shall submit reports that identify the general location, timing, number of sonar hours, and other aspects of the active sonar training activities the U.S. Navy plans to conduct in the Gulf of Alaska TMAA over the next three years.

2. The Permits Division shall submit reports that summarize how and to what extent the U.S. Navy complied with the MMPA Letter of Authorization.

7.4 Terms and Conditions

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

The U.S. Navy shall submit a report to the Chief of the Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, 1315 East-West Highway, Silver Spring, MD 20910 by December 15th summarizing the activities that occurred through October of the same year. With regard to species listed under the ESA, the report shall include:

1) Exercise Information (for each exercise or training event):
   a) Exercise designator;
   b) Date that exercise began and ended;
   c) Location;
   d) Number and types of active sonar sources used;
   e) Number and types of passive sonar acoustic sources used;
   f) Number and types of vessels, aircraft, etc., participating in exercise;
   g) Total hours of observation by watchstanders before, during and after excercise;
   h) Total hours of all active sonar source operation;
   i) Total hours of each active sonar source (along with explanation of how hours are calculated for sources typically quantified in alternate way (buoys, torpedoes, etc.));
   j) Total hours of passive acoustic search time;
   k) Wave height (high, low, and average during exercise);
   l) General visibility conditions during exercise;
   m) Total number and types of rounds expended/explosives detonated;

2) Individual ESA-listed animal sighting information:
   a) Location of sighting;

b) Species (if not possible – indication of whale/dolphin/pinniped);
c) Number of individuals;
d) Any observations of calves;
e) Initial detection sensor;
f) Type of platform observation made from (including, for example, what type of surface vessel; i.e., FFG, DDG, or CG);
g) Length of time observers maintained visual contact with the animal(s);
h) Wave height (ft);
i) Visibility;
j) Sonar source in use (y/n);
k) Indication of whether animal is <200 yd, 200-500 yd, 500-1,000 yd, 1,000-2,000 yd, or >2,000 yd from sonar source;
l) Mitigation Implementation – Whether operation of sonar sensor was delayed, or sonar was powered or shut down, and how long the delay was;
m) If source in use is hull-mounted, true bearing of animal from ship, true direction of ship's travel, and estimation of animal's motion relative to ship (opening, closing, parallel);
n) Distance of marine mammal from actual detonations (or target spot if not yet detonated) – use four categories to define distance:
    i) the modeled injury threshold radius for the largest explosive used in that exercise;
    ii) the required exclusion zone;
    iii) the required observation distance; or
    iv) greater than the required observed distance.
o) Observed behavior of animal – reported in plain language and without trying to categorize.
p) Whether sighting was before, during, or after detonations/exercise, and how many minutes before or after.

3) An evaluation of the effectiveness of mitigation measures designed to avoid exposing marine mammals to sonar. This evaluation shall identify the specific observations that support any conclusions the Navy reaches about the effectiveness of the mitigation.
4) A table indicating the number of ESA-listed species taken.
5) If the level of take exceeds or is likely to exceed the number identified in this ITS, then the U.S. Navy must submit a written report detailing why the take level was exceeded or is likely to be exceeded.

The Permits Division shall submit a report to the Chief of the Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, 1315 East-West Highway, Silver Spring, MD 20910 by January 15th summarizing the activities that occurred through

October of the previous year. With regard to species listed under the ESA, the report shall include:

1) A summary of how the U.S. Navy complied with the MMPA LOA including:
    a) Reporting of annual exercise activities;
    b) Compliance with mitigation measures;
    c) Mitigation actions taken to reduce takes of ESA-listed species;
    d) A table indicating the number of ESA-listed marine mammals taken.
    e) The Permits Division evaluation of the effectiveness of mitigation measures designed to avoid exposing ESA-listed marine mammals active sonar. This evaluation shall identify the specific observations that support any conclusions the Permits Division reaches about the effectiveness of the mitigation.

8 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 (50 CFR §402.02).

The following conservation recommendations would provide information for future consultations involving the issuance of marine mammal permits that may affect endangered whales as well as reduce harassment related to research activities:

1. *Cumulative Impact Analysis.* The Navy and NMFS Permits Division should work with NMFS Endangered Species Division and other relevant stakeholders (the Marine Mammal Commission, International Whaling Commission, and the marine mammal research community) to develop a method for assessing the cumulative impacts of anthropogenic noise on cetaceans, pinnipeds, sea turtles, and other marine animals. This includes the cumulative impacts on the distribution, abundance, and the physiological, behavioral and social ecology of these species.

In order to keep NMFS' Endangered Species Division informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Permits Division should notify the Endangered Species Act Interagency Cooperation Division of any conservation recommendations they implement in their final action.

9 REINITIATION OF CONSULTATION

This concludes formal consultation on military readiness activities the Navy's plans to conduct training in the Gulf of Alaska TMAA and the NMFS' Permits Division's proposal to issue a Letter of Authorization for three years from May 2013 through May 2016 that would allow them to authorize the Navy to "take" marine mammals incidental to this training. As provided in 50 CFR §402.16, reinitiation of formal consultation is normally required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, Action Agencies are normally required to reinitiate section 7 consultation immediately.

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