UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

JUN 27 2006

Memorandum For: Michael Payne
Chief, Permits, Education and Conservation Division

From: Angela Somma
Chief, Endangered Species Division

Subject: Issuance of an incidental harassment authorization to U.S. Navy for the 2006 Rim of the Pacific Naval exercise from June to July 2006

Enclosed is the National Marine Fisheries Service's biological opinion, issued under section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA), regarding the effects of the U.S. Navy's proposed 2006 Rim of the Pacific Naval exercise and the Permits, Education and Conservation Division's proposal to issue an incidental harassment authorization for those exercises on endangered and threatened species.

The biological opinion concludes that the proposed 2006 Rim of the Pacific exercise is not likely to jeopardize the continued existence of threatened or endangered species under NMFS' jurisdiction. Critical habitat that has been designated for green, hawksbill, and leatherback sea turtles, and other listed species is outside of the area of the proposed action and would not be affected by the proposed exercise.

This biological opinion concludes the consultation for this proposed authorization. Reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of this action that may affect listed species or designated critical habitat in a manner or to an extent not previously considered in this biological opinion; (3) the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this biological opinion; or (4) a new species is listed or critical habitat designated that may be affected by the identified action.

If you have questions regarding the opinion, please contact me or Craig Johnson at (301) 713-1401

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

JUN 27 2006

Memorandum For: The Record

From: James H. Lecky
Director, Office of Protected Resources

Subject: Issuance of an incidental harassment authorization to U.S. Navy for the 2006 Rim of the Pacific Naval exercise from June to July 2006

Enclosed is the National Marine Fisheries Service's biological opinion, issued under section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA), regarding the effects of the U.S. Navy's proposed 2006 Rim of the Pacific Naval exercise and the Permits, Education and Conservation Division's proposal to issue an incidental harassment authorization for those exercises on endangered and threatened species.

The biological opinion concludes that the proposed 2006 Rim of the Pacific exercise is not likely to jeopardize the continued existence of threatened or endangered species under NMFS' jurisdiction. Critical habitat that has been designated for green, hawksbill, and leatherback sea turtles, and other listed species is outside of the area of the proposed action and would not be affected by the proposed exercise.

By regulation we are required to reinitiate formal consultation on these actions if: (1) new information reveals effects of this action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (2) the identified action is subsequently modified in a manner that causes an effect to the listed species that was not considered in the Biological Opinion; or (3) a new species is listed or critical habitat designated that may be affected by the identified action.

National Marine Fisheries Service
Endangered Species Act Section 7 Consultation

Biological Opinion

Agency: Permits, Conservation and Education Division of the Office of Protected Resources, National Marine Fisheries Service

United States Navy, Pacific Fleet

Activities Considered: 2006 Rim-of-the-Pacific Joint Training Exercises

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

Approved by: ______________________

Date: JUN 27 2006

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 the action of a federal agency "may affect" a protected species, that agency is required to consult with either the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the protected species that may be affected. For the actions described in this document, the action agency is the United States Navy, Pacific Fleet, and NMFS' Office of Protected Resources - Permits, Conservation and Education Division. The consulting agency is NMFS' Office of Protected Resources - Endangered Species Division.

This document represents NMFS' biological opinion (Opinion) on the Rim-of-the-Pacific (RIMPAC) Joint Training Exercises based on our review of the U. S. Navy's and NMFS' Office of Protected Resources - Permits, Conservation and Education Division's draft Environmental Assessment for the RIMPAC Exercises, recovery plans for humpback whales, the most current marine mammal stock assessment reports, past and current research and population dynamics modeling efforts, monitoring reports from prior research, and biological opinions on similar research. This biological opinion has been prepared in accordance with section 7 of the ESA. This biological opinion is based on information provided in the applications for the proposed permits and permit amendments, published and unpublished scientific information on the biology and ecology of threatened and endangered whales, monk seals, and sea turtles in the action area, and other sources of information.

Consultation History

On 7 December 2005, representatives of the U.S. Navy met with representatives of NMFS' Permits, Conservation and Education Division and Endangered Species Division to discuss the proposed Rim of the Pacific exercise for 2006. At that meeting, representatives of the U.S. Navy provided representatives of NMFS with copies of a December 2005 *Request for Incidental Harassment Authorization for the Incidental Harassment of Marine Mammals Resulting from Training Events Conducted During the Rim of the Pacific (RIMPAC) Exercise*.

On 3 March 2006, a representative of NMFS' Endangered Species Division met with representatives of the U.S. Navy to discuss the status of the 173 dB criterion as a threshold for harassment, the consultation process on the proposed Rim of the Pacific exercise, and the relationship between any consultation with the U.S. Navy and a consultation with NMFS' Permits, Conservation and Education Division. During that meeting, NMFS' representative explained that NMFS could start a consultation with the Navy at any time, but would schedule a consultation so it would run parallel to a consultation with any Incidental Harassment Authorization the Navy submitted to NMFS' Permits, Conservation and Education Division. At the conclusion of this meeting Navy representatives said they would send NMFS a letter to request consultation on the proposed RIMPAC exercise for 2006.

On 16 March 2006, the U.S. Navy submitted a letter to the Director of NMFS' Office of Protected Resources requesting formal consultation on the proposed RIMPAC exercise because it *may affect* threatened or endangered species under the jurisdiction of the National Marine Fisheries Service.

On 24 April 2006, the NMFS' Permits, Conservation and Education Division published notice of its proposal to issue an Incidental Harassment Authorization that would authorize the "take," in the form of harassment, of marine mammals during the proposed RIMPAC exercise. The comment period on that proposal closed on 24 May 2006. After reviewing comments they had received from the public, the NMFS' Permits, Conservation and Education Division asked NMFS' Endangered Species Division to consult formally on their proposed Incidental Harassment Authorization.

BIOLOGICAL OPINION

Description of the Proposed Action

The U.S. Navy proposes to conduct Rim of the Pacific exercises, which are biennial, sea control and power projection fleet exercises that have been performed since 1968. The objective of the historically month-long exercise is to enhance the interoperability and proficiency of several nations' maritime and air forces to operate in coalition arrangements centered on realistic littoral (coastal) operations. RIMPAC involves forces from various RIMPAC nations. In the past, these nations have included Australia, Canada, Chile, Japan, the Republic of Korea, and the United States.

At the same time, the National Marine Fisheries Services' Permits, Conservation and Education Division proposes to issue an Incidental Harassment Authorization to the U.S. Navy pursuant to the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1361 *et seq.*) to allow non-lethal harassment of marine mammals associated with the proposed RIMPAC exercises. The RIMPAC are proposed to occur between 26 June and 28 July 2006.

The purpose of the proposed RIMPAC exercises is to implement a selected set of exercises that is combined into a multinational, sea control and power projection fleet training exercise in a multi-threat environment. RIMPAC exercises demonstrate the ability of a multinational force to communicate and operate in simulated hostile scenarios.

The Proposed RIMPAC Exercises

The proposed RIMPAC exercise encompasses in-port operations, command and control, aircraft operations, ship maneuvers, amphibious landings, troop movements, gunfire and missile exercises, submarine and antisubmarine exercises, mining and demolition activities, hulk sinking exercise, salvage, special warfare, and humanitarian operations. The following narratives discuss only those aspects of the proposed RIMPAC exercises that are necessary to understand its potential effects on threatened and endangered species under the jurisdiction of NMFS and critical habitat that has been designated for them. For a complete description of all aspects of the proposed exercises, readers should refer to the U.S. Navy's 2002 *Rim of the Pacific (RIMPAC) Programmatic Environmental Assessment* and the 2006 *Supplement* to that environmental assessment.

The exercise is likely to consist of a scenario in which one country, "Green," is attacked by another country, "Orange." The scenario assumes that "Green" has requested and received support from allied countries among the Pacific Rim nations. The allies then use military force to eliminate military hostilities and restore peace to the region.

The military activities occurring during the exercise vary from year-to-year and are based on the participants' training needs and desires and may be based in part on anticipated operations that may be required under real world conditions. Allied forces opposing Orange are usually split into multinational and bilateral forces, depending on which Pacific Rim allies participate. The Multinational Force would be composed of units from various Rim-of-the-Pacific nations. In the past, these nations have included Australia, Canada, Chile, the Republic of Korea, and the United States. The Bilateral Force will consist of units from Japan and the United States.

The Multinational Force would have up to 9 days of briefings and preparations in Pearl Harbor (see Table 1 adapted from U.S. Navy 2002). They would then move to various onshore, nearshore, and open-ocean areas for up to 21 days of work-up training exercises including amphibious insertions, and covert reconnaissance, which includes up to 6 days of advanced weapon firings at the Pacific Missile Range Facility (PMRF) and the PMRF Warning Areas and underwater ranges (see Table 1, next page).

The Bilateral Force would initially engage in up to 5 days of briefings at Pearl Harbor, Hawaii (see Table 1). Up to 11 days of work-up exercises would then be conducted by the Bilateral Force at onshore, nearshore, and open-ocean areas. The Bilateral Force would then return to Pearl

Table 1. General schedule for the 2006 Rim-of-the-Pacific Exercises (adapted from U.S. Navy 2002)			
Activity	**Average Exercise Days and (Expanded Exercise Days**	**Total No. of Average Exercise Days**	**Total No. of Average Expanded Days**
Multinational Force arrives at Pearl Harbor	Day 1 (Days 1-2)	1	2
Multinational Force In Port Briefings	Days 1-6 (Days 1-9)	6	9
Bilateral Force Arrives at Pearl Harbor	Day 1 (Days 1-2)	1	2
Bilateral Force in-port briefings	Days 1-3 and 11-14 (Days 1-5 and 16-21)	7	11
Multinational Force Workup Exercises	Days 7-20 (Days 15-36)	14	21
Bilateral Force Workup exercises	Days 3–10 and 15–20 (Days 5-15 and 22-36)	14	28
Tactical Scenario Exercises	Days 20-29 (Days 36-49)	10	14
Amphibious Landing Exercises	Days 23 and 29 (Days 34-35 and 45-49)	2	4
Amphibious back-load	Days 24 and 30 (Days 35-36 and 49-50)	2	4
Bilateral Force returns to Pearl Harbor	Days 29-30 (Days 49-52)	2	4
Multinational Force returns to Pearl Harbor	Days 29-30 (Days 49-52)	2	4
Post Exercise Activities	Days 30-32 (Days 52-56)	3	5
Dispersal	Day 33 (Days 56-57)	1	2

Table 2. Overview of the locations and training events associated with the proposed 2006 Rim of the Pacific training exercises

			Training Events																							
					AAW				ASUW/ ASW		MIW				ASUW											
												MCM														
Service	Location	Island	In Port	C & C	AIROPS	SAMEX	AAMEX	ASMEX	SSMEX	ASWEX	MINEX	SMWEX	AMWEX	UMWEX	STWEX, CASEX	GUNNEX	SINKEX	LFX	HAO/NEO	HA/DR	SPECWAROPS	DEMO	SALVAGE OPS	AMPHIBEX	SUBOPS	OTHERS
U.S. Navy	Pacific Missile Range Facility	Kauai																								
	Ni'ihau	Ni'ihau																								
	Kaula	Kaula																								
	Pearl Harbor	Oahu																								
	Iroquois Land and Underwater Range	Oahu																								
	Puuloa Underwater Range - Pearl Harbor	Oahu																								
	Barbers Point Underwater Range	Oahu																								
	Cost Guard AS Barbers Point/Kalaeloa Airport	Oahu																								
	PMRF Warning Areas	Ocean Areas																								
	Oahu Warning Areas	Ocean Areas																								
	Open Ocean Areas	Ocean Areas																								
	U.S. Command Ship	Ocean Areas																								
U.S. Marines	Marine Corps Base Hawaii	Oahu																								
	Marine Corps Training Area Bellows	Oahu																								
U.S. Air Force	Hickham Air Force Base	Oahu																								
U.S. Army	Kahuku Training Area	Oahu																								
	Makua Military Reservation	Oahu																								
	Dilingham Military Reservation	Oahu																								
	Wheeler Army Airfield	Oahu																								
	K-Pier, Kawaihae	Hawaii																								
	Bradshaw Army Airfield	Hawaii																								
	Pohakuloa Training Area	Hawaii																								
State of Hawaii	Keehi Lagoon	Hawaii																								

Table 3. Typical loadings for a Rim-of-the-Pacific Exercise (adapted from U.S. Navy 2002)

Forces	Ships	Submarines	Aircraft	Personnel
Bilateral Force	11	1	65	6,500
Multi-Naitonal Force	20	2	85	12,000
Commander Combined Task Force	6	0	23	1,400
Opposing Force	9	4	27	2,100
Totals: Typical	**46**	**7**	**200**	**22,000**
Minimum	**20**	**1**	**24**	**8,000**
Maximum	**60**	**10**	**260**	**30,000**

Harbor for up to an additional 6 days of briefings, and then conduct up to an additional 15 days of work-up exercises. The work-up exercises include up to 6 days of advanced weapon firings at PMRF and the PMRF Warning Areas and underwater ranges for an average total of 14 days, or a maximum of 26 days. The next phase of RIMPAC would consist of up to 14 days of complex scenario-driven tactical exercises intended to represent real-life conflict situations. An amphibious landing assault of PMRF by allied forces would be the culmination of the scripted phase of exercises.

RIMPAC consists of various phases of activity during the exercise period. Table 2 identifies training exercises that might be included in the proposed RIMPAC exercises as well as their location (adapted from U.S. Navy 2005). The timing, phases, and scope of the different exercises might be modified or rearranged depending on the final objectives of the overall RIMPAC exercises in 2006. Table 3 identifies the number of ships, submarines, aircraft, and personnel that might be associated with the proposed exercises (adapted from U.S. Navy 2002).

Antisubmarine Warfare

The types of anti-submarine warfare training conducted during the proposed RIMPAC include the use of ships, submarines, aircraft, non-explosive exercise weapons, and other training related devices. Nearly all RIMPAC anti-submarine warfare training would occur in the six areas delineated in Figure 1. Anti-submarine warfare events typically rotate between these six anti-submarine warfare areas and may continue while forces move between them. While anti-submarine warfare events could occur throughout the Hawaiian Islands Operating Area, most events would occur within these six areas that were used for analysis as being representative of the marine mammal habitats and the bathymetric, seabed, wind speed, and sound velocity profile conditions within the entire Hawaiian Islands Operating Area. For purposes of this analysis, all likely RIMPAC anti-submarine warfare events were modeled as occurring in these areas.

Anti-Submarine Warfare Training Operations During RIMPAC

RIMPAC 2006 is proposed to take place from about 26 June 2006 through 28 July 2006. Anti-submarine exercises are scheduled to occur on 21 days during this period. As a combined force, submarines, surface ships and aircraft will conduct anti-submarine warfare against opposition submarine targets. Submarine targets will include real submarines, target drones that simulate the operations of an actual submarine, and virtual surface action group — consisting of between one and five surface ships equipped with sonar — with one or more helicopters, and P-3 aircraft searching for submarines. RIMPAC 2006 will involve surface action groups with each surface action group event treated as an anti-submarine warfare operation.

RIMPAC 2006 would include about 44 anti-submarine warfare operations with each operation having an average event length of about 12 hours. One or more anti-submarine warfare events may occur simultaneously within the Hawaiian Islands Operating Area.

Active Acoustic Devices
Tactical military sonars are designed to search for, detect, localize, classify, and track submarines. The Navy plans to employ two types of sonars with the proposed RIMPAC exercises: passive and active:

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 in the RIMPAC exercises include:

Sonar Systems Associated with Surface Ships. A variety of surface ships participate in RIMPAC, including guided missile cruisers, destroyers, guided missile destroyers, and frigates. Some ships (e.g., aircraft carriers) do not have any onboard active sonar systems, other than fathometers. Others, like guided missile cruisers, are equipped with active as well as passive sonars for submarine detection and tracking. For purposes of the analysis, all surface ship sonars were modeled as equivalent to AN/SQS-53C having a nominal source level of 235 decibels (dB_{rms}) re 1 μPa-s at 1 m[1].

Sonar Systems Associated with Submarines. Submarines are equipped with a variety of active and passive sonar systems that they use to detect and target enemy submarines and surface ships. However, submarines rarely use active sonars and, when they do, sonar pulses are very short.

Sonar Systems Associated with Aircraft. Aircraft sonar systems that would operate during RIMPAC include sonobuoys and dipping sonar. P-3 aircraft may deploy sonobuoys while helicopters may deploy sonobuoys or dipping sonars (the latter are used by carrier-based helicopters). Sonobuoys are expendable devices used by aircraft for the detection of underwater acoustic energy and for conducting vertical water column temperature measurements. Most sonobuoys are passive, but some can generate active acoustic signals, as well as listen passively. Dipping sonar is an active or passive sonar device lowered on cable by helicopters to detect or maintain contact with underwater targets. During RIMPAC, these systems active modes are only used briefly for localization of contacts and are not used in primary search capacity. Because active mode dipping sonar use is very brief (2-5 pulses of 3.5-700 msec), it is extremely unlikely its use would have any effect on marine mammals.

Torpedoes. Torpedoes are the primary anti-submarine warfare weapon used by surface ships, aircraft, and submarines. The guidance systems of these weapons can be autonomous or electronically controlled from the launching platform through an attached wire. The autonomous guidance systems are acoustically based. They operate either passively, exploiting the emitted sound energy by the target, or actively ensonifying the target and using the received echoes for guidance. All torpedoes used for anti-submarine warfare during RIMPAC would be located in the range area managed by PMRF and would be non-explosive and recovered after use.

Acoustic Device Countermeasures. These countermeasures act as decoys by making sounds that simulate submarines to avert localization or torpedo attacks.

Training Targets. Anti-submarine warfare training targets are used to simulate target submarines. They are equipped with one or a combination of the following devices: (1) acoustic projectors emanating sounds to simulate submarine acoustic signatures; (2) echo repeaters to simulate the characteristics of the echo of a particular sonar signal reflected from a specific type of submarine; and (3) magnetic sources to trigger magnetic detectors. Based on the operational characteristics (source output level and/or frequency) of these acoustic sources, they are not likely to affect threatened or endangered marine mammals; therefore they were not modeled for RIMPAC 2006.

Range Sources. Range pingers are active acoustic devices that allow each of the in-water platforms on the range (e.g., ships, submarines, target simulators, and exercise torpedoes) to be tracked by hydrophones in the range transducer nodes. In addition to passively tracking the pinger signal from each range participant, the range transducer nodes also are capable of

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

transmitting acoustic signals for a limited set of functions. These functions include submarine warning signals, acoustic commands to submarine target simulators (acoustic command link), and occasional voice or data communications (received by participating ships and submarines on range).

In addition to the anti-submarine warfare exercises, the proposed RIMPAC exercises include the following:

Surface-to-air missile exercise (SAMEX) which is designed to provide realistic training and evaluation of surface ships and their crews in defending against enemy aircraft and missiles. For this exercise, target drones representing enemy aircraft or missiles are flown or towed into the vicinity of the surface ship. The crew must identify the incoming object and respond with surface-to-air missiles as appropriate. Two types of missiles will be used with this exercise. One missile is equipped with an instrumentation package, while the other type is equipped with a warhead. Recoverable target drones are refurbished and reused.

The exercise consists of one or more surface ships and/or submarines, one or more (20 to 50) target drones, and a helicopter and weapons recovery boat for target recovery. The surface-to-air missiles are launched from ships and/or submarines located within PMRF Warning Area. Targets are launched from an existing ground-based target launch site at PMRF Launch Complex and/or Kauai Test Facility, PMRF; from a Mobile Aerial Target Support System located in the open ocean within the PMRF Warning Areas; or released from an aircraft. The exercise requires approximately 2 to 5 hours, but could range from 8 to 60 hours.

Air-to-air missile exercise (AAMEX), which is designed to provide aircrews with experience in using aircraft missile firing systems, and to develop new firing tactics. For this exercise jet target drones are launched from PMRF Launch Complex, Kauai Test Facility, or an aircraft controlled by PMRF. The targets are engaged by aircraft equipped with air-to-air missiles. The targets are tracked by the aircraft and then the air-to-air missiles are launched at the targets. Recoverable target drones and all recoverable elements are refurbished and reused.

The exercise includes 1 to 6 jet target drones, 2 to 20 aircraft, 2 to 20 missiles and a weapons recovery boat for target recovery (Pacific Missile Range Facility, Barking Sands, 1998). The exercise is conducted within PMRF Warning Area. Targets are launched from an existing ground-based target launch site at PMRF Launch Complex and/or Kauai Test Facility, PMRF; from a Mobile Aerial Target Support System located in the open ocean within the PMRF Warning Areas; or released from an aircraft. Each exercise typically lasts 2 to 6 hours, but could range from 2 to 30 hours.

Air-to-surface missile exercise (ASMEX), which is designed to provide a basic training situation for U.S. Air Force, U.S. Navy, U.S. Marine and multinational air groups in air-to-surface missile firing; conventional ordnance delivery including bombing (MK80 series bombs, live and inert), gunnery, and rocket and precision guided munitions firing; and close air support techniques.

The exercise consists of 1 to 16 aircraft, carrying missiles and/or bombs (live and inert), rockets, precision guided munitions, or flying without ordnance (dry runs) are used during the exercise.

At sea, Seaborne Powered Targets (occasionally a live bomb target), Improved Surface Towed Targets, excess ship hulks (live bombs), and a computer-generated island that is located within the Barking Sands Underwater Range Expansion are used as targets for inert bomb drops. The Naval Gunfire Scoring System gathers data for scoring of surface ships and aircraft conducting gunnery and bombardment exercises within the Barking Sands Tactical Underwater Range. On land, terrain features, constructed props, and/or tank hulks are used as targets. During recent RIMPACs there have been three to four environmentally cleaned ex-USS ships utilized as sinkable targets. When an exercise is scripted to utilize a combination of missiles to sink a target, the exercise is called a SINKEX.

The exercise involves helicopters and/or 1 to 16 fixed wing aircraft with air-to-surface missiles, anti-radiation missiles (electromagnetic radiation source seeking missiles), high-speed radiation missiles (electromagnetic radiation producing missiles that simulate radar and radio transmitters), and/or bombs (live and inert), rockets, or precision-guided munitions. The exercise is typically conducted within PMRF Warning Area and last about 4 hours. However, a SINKEX exercise
typically lasts 10 to 12 hours per target, but may include a separate day per hulk (4 to 6) extending the duration out as far as 40 to 72 hours.

Surface-to-surface missile exercise (SSMEX), which is designed to provide basic training for fleet units in firing surface-to-surface missiles. The exercise involves one or more surface ships, submarines, and SEPTARs. The surface ships and/or submarines can operate as a single unit or as multiple fire units against the SEPTARs.

These exercises include 4 to 20 surface-to-surface missiles, a weapons recovery boat, and a helicopter for environmental and photo evaluation. When a Harpoon anti-ship missile is used, the exercise is called a HARPOONEX. At sea, SEPTARs, ISTTs, excess ship hulks, and a computer-generated island that is located within the BSURE are used as targets for aircraft bomb drops. The Naval Gunfire Scoring System gathers data for scoring of surface ships and aircraft conducting gunnery and bombardment exercises within Barking Sands Tactical Underwater Range. On land, terrain features, constructed props, and/or tank hulks are used as targets. During recent RIMPACs there have been three to four environmentally cleaned ex-USS ships utilized as sinkable targets. When an exercise is scripted to utilize a combination of missiles to sink a target, the exercise is called a SINKEX. All missiles are equipped with instrumentation packages or a warhead. Surface-to-air missiles can also be used in a surface-to-surface mode. These exercises are conducted within PMRF Warning Area. Each exercise typically lasts 2 hours, but could range from 4 to 35 hours.

Anti-submarine warfare exercise (ASWEX) which is designed to provide crews of anti-submarine ships, aircraft (including airships), submarines, and helicopters experience in locating and pursuing underwater targets and dropping inert torpedo weapons. The exercise involves locating and pursuing underwater targets and dropping inert torpedoes and inert air-dropped mines from anti-submarine aircraft and helicopters. Weapon recovery boats and helicopters are used to locate and recover the targets, torpedoes, and mines.

The exercise includes ships, fixed wing aircraft, helicopters, torpedo targets, 1 to 10 submarines, and weapons recovery boats and/or helicopters. Five submarines participated in RIMPAC 2002. Weapons used encompass inert air-dropped mines, lightweight and heavyweight wire-guided inert long-range torpedoes launched from helicopters, aircraft, surface ships, and submarines. Sensors include sonars, non-acoustic sensors (sonobuoys), and airborne early warning radars. These exercises activities are conducted within PMRF Warning Area, the Oahu Warning Areas or the open ocean. Each ASWEX typically runs for 7 days but could range from 1 to 50 days.

The use of sonobuoys is generally limited to areas greater than 183 meters (100 fathoms, or 600 feet) in depth. Before dropping sonobuoys, the crew visually determines that the area is clear. Although the altitude varies at which buoys are dropped, the potential for drift during descent generally favors release at lower altitudes, where visual searches for marine mammals or sea turtles are more effective. When the sonobuoy is released, a small parachute (about 4 feet in diameter) retards its entry into the ocean. For operational reasons, the sonobuoy is designed to float on the surface and, after a controlled period of time (no longer than 8 hours), the complete package (with the parachute) will sink to the bottom.

Aerial and submarine mining exercise (MINEX) which is designed to provide practice with techniques for submarine-launched mobile mines and to provide a basis for crew qualification in aerial mining. The exercise involves one or more aircraft and both computer-simulated and inert exercise mines. Mine warfare exercises are limited to either the simulated laying of aircraft-deployed mines, where no actual mine ordnance is dropped, or the use of inert exercise mines or inert exercise submarine-deployed mines.

Aerial mining requires one or more aircraft. Submarine mining involves one or more submarines, divers, and a weapons recovery boat to recover the mines, and one or more helicopters. Aerial mining lines are generally developed off the southwest coast of Kauai and the southeast coast of Niihau, within PMRF Warning Areas W-186 and W-188. Submarine mining exercises are conducted within PMRF Warning Area W-188 (figure 2-8) Aircraft operations are conducted within R3101 (figure 2-8). These exercises last about 1 to 3 hours. Submarine MINEX may last from 1 to 4 days.

Ship mine warfare exercise (SMWEX) which is designed to allow surface ship sonar operators to train in shallow-water environments. Mine detection helicopter sonar operators can also train in this area. Two types of exercises are included. The first type is a structured exercise where PMRF tracking systems would monitor passing ships. Tracking data combined with shipboard or helicopter acquired data would provide the basis for analysis of the exercise. In the second type of exercise, a ship would traverse seaward of the buoy field and attempt to detect the buoys without monitoring. This type of exercise would occur when ships enter or depart PMRF instrumented areas for other exercises.

The mine warfare training area is approximately 1.6 kilometer (1 mile) off shore and consists of 10 buoys in 2 columns oriented north-south. Each buoy is 94 centimeters (37 inches) in diameter and moored to the sea floor by a wire rope. The ocean depth varies between 45.7 and 107 meters (150 and 350 feet), and the buoys are at least 15 meters (50 feet) below the ocean surface. Various marine and aerial assets, capable of tracking underwater objects over a 2,590-square-kilometer (1,000-square-mile) area, would be used during the structured exercise. In the second type of exercise, only shipboard assets would be used. The mine warfare training area is located between 1.2 and 2 kilometers (0.75 and 1.25 miles) from shore and is adjacent to the PMRF Shallow Water Training Area. This exercise can take from 3 to 72 hours.

Strike warfare exercise (STWEX) *and close air support exercise* (CASEX) which is designed to provide a basic training situation for U.S. Air Force, U.S. Navy, U.S. Marine and multinational air groups in air-to-surface missile firing; conventional ordnance delivery including bombing (MK80 series bombs, live and inert), gunnery, and rocket and precision guided munitions firing; and close air support techniques.

The exercise can involve 1 to 16 aircraft, carrying missiles and/or bombs (live and inert), rockets,
precision guided munitions, or flying without ordnance (dry runs) are used during the exercise. At sea, excess ship hulks and a computer-generated island that is located within the Barking Sands Underwater Range Expansion are used as targets for aircraft missile firing and bomb drops. The Naval Gunfire Scoring System gathers data for scoring of surface ships and aircraft conducting gunnery and bombardment exercises within the Barking Sands Tactical Underwater Range. On land, terrain features, constructed props, and/or tank hulks are used as targets. Air crews conduct STWEX in conjunction with ground or airborne forward air controllers.

STWEX assets include helicopters and/or 1 to 16 fixed wing aircraft with air-to-surface missiles, anti-radiation missiles (electromagnetic radiation source seeking missiles), high-speed radiation missiles (electromagnetic radiation producing missiles that simulate radar and radio transmitters), and/or bombs (live and inert), rockets, or precision-guided munitions. Targets include excess ship hulks, and simulated electronic targets at the Barking Sands Tactical Underwater Range and Barking Sands Underwater Range Expansion Ranges operated by PMRF. The Barking Sands Tactical Underwater Range and Barking Sands Underwater Range Expansion Ranges consist of passive bottom-mounted hydrophones, which receive signals from pingers mounted internally on the exercise rounds and submarines. The underwater tracking system detects the water impacts and directs the data to the Naval Gunfire Scoring System.

STWEX, and CASEX exercises are conducted within Oahu Restricted Airspace R-3107 (at Kaula only inerts would be employed) and Warning Area W-187 (at Kaula only inerts would be employed) and PMRF Warning Area, and the Pohakuloa Training Area on Hawaii. The exercise would last about 4 hours; although strike warfare exercises could last from 4 to 35 hours.

Gunnery exercise (GUNNEX) which is designed to provide gunnery practice for surface vessel crews against both stationary and moving targets. Gunnery training operations involve the use of highly automated guns against surface (land, excess vessel hulks [see SINKEX], and simulators) or aerial targets. Crews respond to threats from air attack and surface-skimming missiles that require extremely fast reaction times and a heavy volume of fire. Ships fire inert exercise rounds, and aircraft fire inert exercise rounds and drop inert exercise bombs at stationary targets on Kaula and at the computer-generated island located within Barking Sands Underwater Range Expansion (PMRF Warning Area W-188).

The exercise involves 1 to 10 surface vessels, observation helicopters, SEPTARs, ISTTs, orange buoys, towed aerial targets, excess ship hulks, jet aerial targets, and the Barking Sands Underwater Range Expansion. Ship-deployed and air-deployed weapons systems are used, ranging from 20-millimeter to 5-inch caliber guns.

These exercises would be conducted within PMRF Warning Areas W-186 and W-188, Oahu Warning Areas W-187 (Kaula), W-194, and Restricted Airspace R-3107 (Kaula). The exercises could involve from 5 to 50 events taking from 1 to 100 hours.

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

The vessels used as targets are selected from a list of destroyers, tenders, cutters, frigates, cruisers, tugs, and transports approved by the U.S. Environmental Protection Agency. Examples of missiles that could be fired at the targets include AGM-142 from a B-52 bomber, Walleye AGM-62 from FA-18 aircraft, and a Harpoon from a P-3C aircraft. Surface ships and submarines may use either torpedoes or Harpoons, surface-to-air missiles in the surface-to-surface mode, and guns. Other weapons and ordnance could include, but are not limited to, bombs, Mavericks, Penguins, and Hellfire. SINKEX vessels can number from one to six per RIMPAC.

These exercises are conducted at an approved site (minimum depth 1,800 meters [5,905 feet], at least 93-111 kilometers [50-60 nautical miles] northwest from shore) within PMRF Warning Area. The proposed RIMPAC exercises could involve from 1 to 6 SINKEX, each lasting from 3 to 8 hours.

Live fire exercise (LFX) which is designed to provide ground troops with live-fire training and combined arms live-fire exercises training, including aerial gunnery and artillery firing. This benefits ground personnel by receiving semi-realistic training. These exercises can include platoon troop movements through numerous target objectives with various weapons. Aerial gunnery exercises and artillery and mortar exercises are also conducted as part of combined and separate exercises. Live fire and blanks are used. Blanks are used outside of defined impact areas.
Each exercise generally lasts 1 to 24 hours.

Humanitarian assistance operation/non-combatant evacuation operation (HAO/NEO) which is designed to provide training in implementing humanitarian assistance in an increasingly hostile setting, ultimately requiring evacuation of personnel and troops. These training exercises involve approximately 150 personnel and troops and specialists who initially provide assistance to civilians and then evacuate the civilians when necessary. This scenario could also be used to simulate a prisoner-of-war camp or place where people are interned. Direct action is also included in the exercise because it involves a similar number of troops. The direct action exercise is much quicker and involves about 50 personnel and 150 troops who gain access to an area by boat or helicopter, storm the location, recover the mission target, and return to their units.

Special warfare operations (SPECWAROPS) which is designed to provide covert insertion and reconnaissance training for small Special Warfare units. This exercise is performed by the U.S. Navy and the U.S. Marines. Activities include special reconnaissance, Combat Search and Rescue, and Direct Action Tactical Recovery of Aircraft and Personnel. SR (R&S) units consist of small special warfare unit and utilize helicopters, submarines, and CRRC to gain covert access to military assets, gather intelligence, stage raids, and return to their host units. Reconnaissance inserts and beach surveys are often conducted before large-scale amphibious landings and can involve several units gaining covert access using a boat.

Amphibious insertions would be conducted at PMRF, Niihau, and Kahuku Beach, Oahu and K-Pier, Hawaii. Insertions from helicopters would take place at Bradshaw Army Airfield, Makua Military Reservation, and Kahuku Military Training Area, Dillingham Military Reservation, and Wheeler Army Airfield. Port Allen, Kauai and Marine Corps Base Hawaii, Oahu are used to stage boat raids, and Makaha Ridge-PMRF, Niihau, Bradshaw Army Airfield and Dillingham Military

Reservation would also be used for helicopter raids and downed pilot training. Similar activities are conducted at Pearl Harbor including Ford Island and various underwater ranges, Coast Guard Air Station Barbers Point/Kalaeloa Airport, Oahu, Hickam Air Force Base, Marine Corps Training Area Bellows/Bellows Air Force Station, and Pohakuloa Training Area. Also activities occur within the Oahu and PMRF Warning Areas as well as in the open ocean. These exercises last from several hours to several days.

Underwater demolition exercises (DEMO) which are designed to provide training in the identification and destruction or neutralization of inert ground mines and floating/moored mines and possibly excess ship hulks. DEMO exercises are mainly training in the detection and explosive attack of inert, underwater mines. Tactics against ground or bottom mines involve the diver placing a specific amount of explosives, which when detonated underwater at a specific distance from a mine results in neutralization of the mine. Floating, or moored, mines involve the diver placing a specific amount of explosives directly on the mine. Floating mines encountered by fleet ships in open-ocean areas will be detonated at the surface. In support of an amphibious assault, divers and U.S. Navy marine mammal assets deploy in very shallow water depths (3 to 12 meters [10 to 40 feet]) to locate mines and obstructions.

Divers are transported to the mines by boat or helicopter. Inert dummy mines are used in the exercises. The total net explosive weight used against each mine ranges from less than 0.5 kilogram to 9 kilograms (less than 1 pound to 20 pounds). As part of RIMPAC, the U.S. Navy's Very Shallow Water Mine Countermeasures Detachment of Commander Mine Warfare Command will deploy trained Atlantic bottlenose dolphins (*Tursiops truncatus*) of their marine mammal mine-hunting systems in several missions. Each mission will include up to four motorized small craft, several crew members and a trained dolphin. Each trained animal is deployed under behavioral control.

These activities take place offshore in the Pu'uloa Underwater Range, Pearl Harbor; Iroquois Land/Underwater Range within Pearl Harbor; Barbers Point Underwater Range off-shore of Coast Guard Air Station Barbers Point/Kalaeloa Airport; and PMRF, Kauai (Majors Bay area); PMRF and Oahu Training Areas; and in open-ocean areas. RIMPAC may involve from 1 to 30 demo events, which each even lasting 1 to 4 hours.

Salvage operations, which are designed to provide a realistic training environment for fire at sea, de-beaching of ships, and harbor clearance operations training by U.S. Navy diving and salvage units. As part of these exercises, the U.S. Navy's Mobile Diving and Salvage Unit One and divers from other countries would practice swift and mobile ship and barge salvage, towing, battle damage repair, deep ocean recovery, harbor clearance, removal of objects from navigable waters, and underwater ship repair capabilities.

Amphibious exercise (AMPHIBEX), which are designed to provide a realistic environment for amphibious assault training, reconnaissance training, hydrographic surveying, surf condition observance, and communication. Training forces are normally a mix of three to five amphibious ships equipped with aircraft landing platforms for helicopter and fixed wing operations and well decks for carrying landing craft and assault amphibian vehicles (AAVs). The training force typically launches its aircraft, and landing craft up to 40 kilometers (25 miles) from a training beachhead. Amphibious vehicles are typically launched approximately 1,829 meters (2,000 yards) from the beach. The aircraft provide support while the landing craft approach and move onto the beach. The troops disperse from the landing craft and would utilize existing vegetation for cover and concealment while attacking enemy positions. Naval Surface Fire Support and CASEX are integrated into an amphibious assault. There will be simulated gunnery as part of the PMRF AMPHIBEX, using small arms with blanks. The landing craft and troops proceed to a designated area where they stay 1 to 4 days. The backload operation takes place when actions on the objective are completed. The backload will normally be accomplished over a 2- to 3-day period.

The primary location for the amphibious landings is Majors Bay, PMRF, Kauai. Amphibious landings could also occur at the K-Pier boat ramp, Kawaihae, Hawaii, Marine Corps Base Hawaii (three beaches), Marine Corps Training Area Bellows portion of Bellows Air Force Station, Oahu, and at the K-Pier boat ramp, Kawaihae, Hawaii. These exercises typically occur over a 2- to 3-day period, with three separate exercises per RIMPAC, but could range from a 2 to 14 days, with one to four separate exercises.

Amphibious landings are restricted to specific areas of designated beaches. As described by the Navy, these exercises would be conducted in compliance with Executive Order 13089, Coral Reef Protection. Before each major amphibious landing exercise is conducted, a hydrographic survey will be performed to map out the precise transit routes through sandy bottom areas. Within 1 hour of initiating landing activities, the landing routes and beach areas would be determined to be clear of marine mammals and sea turtles. If any are seen, the exercise would be delayed until the animals leave the area. During the landing the crews follow established procedures, such as having a designated lookout watching for other vessels, obstructions to navigation, marine mammals (whales or monk seals), or sea turtles. Other measures include publication of training overlays that identify the landing routes and any restricted areas. Sensitive cultural resource areas are identified and bounded by a keep-out buffer. Where necessary, pre-exercise surveys for turtles are conducted so their feeding and nesting areas would be avoided. Vehicles are restricted to existing roads, trails, and other disturbed areas and would not traverse undisturbed, off-road areas where they might harm vegetation or stimulate erosion. (U.S. Pacific Command, 1995a)

Submarine operations (SUBOPS) which are designed to train Navy personnel in using active and passive sonar systems to find surface ships and submarines, responding to simulated attacks using evasive maneuvering and countermeasures in deep and shallow waters, and avoiding detection by submarine warfare weapon systems. Exercises include underway operations, Submarine Warfare Exercises (submarine versus submarine and submarine versus ship tracking), Range exercises (torpedo firing exercises), and a Torpedo Training and Certification program conducted at the PMRF ranges.

SUBOPS will occur throughout much of the Hawaii Operating Area. Weapon firing would mainly occur in the PMRF Shallow Water Training Range, Barking Sands Tactical Underwater Range and Barking Sands Underwater Range Expansion Ranges, and the training areas within the 100-fathom isobath contour between the islands of Maui, Lanai, and Molokai, including Penguin Bank. Submarine operations would occur continuously throughout RIMPAC although individual exercises typically last several hours to 7 days.

The Incidental Harassment Authorization

The proposed Incidental Harassment Authorization would be valid from 5 July 2006, through 29 July 2006 and, as proposed, would be valid only for the operation of mid-frequency tactical sonar during designated RIMPAC ASW exercises within the Hawaiian Islands Operations Area. As proposed, the incidental "take" of marine mammals would be limited to the following species:

Mysticete whales: fin whale (*Balaenoptera physalus*), Bryde`s whale (*Balaenoptera edeni*), sei whale (*Balaenoptera borealis*)

Odontocete whales: sperm whale (*Physeter macrocephalus*), dwarf and pygmy sperm whales (*Kogia simus* and *K. breviceps*), short-finned pilot whale (*Globicephala macrorhynchus*), Risso's dolphin (*Grampus griseus*), rough-toothed dolphin (*Steno bredanensis*), Fraser's dolphin (*Lagenodelphis hosei*), bottlenose dolphin (*Tursiops truncatus*), spinner dolphin (*Stenella longirostris*), pantropical spotted dolphin (*S. attenuata*), striped dophin (*S. coeruleoalba*), melon-headed whale (*Peponocephala spp*.), Blaineville's beaked whale (*Mesoplodon densirostris*), Cuvier's beaked whale (*Ziphius cavirostris*), Longman's beaked whale (*Indopacetus pacificus*), killer whale (*Orcinus orca*), false killer whale (*Pseudorca crassidens*), and pygmy killer whale (*Feresa attenuata*).

Pinnipeds: Hawaiian monk seal (*Monachus schauinslandi*)

The proposed authorization prohibits the "take" (as that term is defined by the Marine Mammal Protection Act of 1972, as amended) of any of these marine mammal species or of any species of marine mammal by Level A harassment, serious injury or death. Such "take" may result in the modification, suspension or revocation of the proposed authorization.

Mitigative Measures Proposed by the U.S. Navy for RIMPAC

The U.S. Navy's operational order (Environmental Annex) for the proposed RIMPAC exercises places numerous requirements on exercise participants. The following listing summarizes only those requirements specifically related to threatened and endangered species under the jurisdiction of NMFS and critical habitat that has been designated for them. For a complete description of all of the measures applicable to the proposed exercises, readers should refer to the U.S. Navy's 2002 *Rim of the Pacific Programmatic Environmental Assessment* and the 2006 *Supplement* to that document.

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

    1.1 Avoid critical habitats, marine sanctuaries, and the Humpback Whale Sanctuary (see Annex A to Appendix L-3 of the Operational Order).

    1.2. Surface vessels only: Use observers to visually survey for and avoid operating active sonar when sea turtles and/or marine mammals are observed.

    1.3 Submarines and surface units: Monitor acoustic detection devices for indications of close aboard marine mammals (high bearing rate biologic contacts). When a surface combatant or a submarine conducting active sonar training detects a marine mammal close aboard, reduce maximum sonar transmission level to avoid harassment in accordance with the following specific actions.

        1.3.1 When marine mammals are detected by any means (aircraft, observer, or aurally) within 600 ft (183 m) of the sonar dome, the ship or submarine will limit active transmission levels to at least 4 dB below their equipment maximum for sector search modes.

        1.3.2 Ship and submarines will continue to limit maximum transmission levels by this 4 dB factor until they determine the marine mammal is no longer within 600 ft (183 m) of the sonar dome.

        1.3.3 Should the marine mammal be detected closing to inside 300 ft (92 m) of the sonar dome, the principal risk to the mammal changes from acoustic harassment to one of potential physical injury from collision. Accordingly, ships and submarines shall maneuver to avoid collision. Standard whale strike avoidance procedures apply.

        1.3.4 When seals are detected by any means within 1,050 ft (320 m) of the sonar dome, the ship or submarine shall limit active transmission levels to at least 4 dB below equipment maximum for sector search mode. Ships or submarines shall continue to limit maximum ping levels by this 4 dB factor until the ships and submarines determine that the seal is no longer within 1,050 ft (320 m) of the sonar dome.

2. *Measures Applicable to Helo Dipping Sonar-Training Operations*

2.1 Helos shall observe/survey the intended exercise area for marine mammals and sea turtles for a 10-minute duration before dipping active sonar transducer in the water.

2.2 Helos shall not dip their active sonar transducer within 600 ft (183 m) of a marine mammal or sea turtle.

2.3 If a marine mammal or sea turtle is detected while the helo has its sonar dipped and pinging, secure pinging if the marine mammal/sea turtle is located closing inside of 150 ft (46 m).

3. *Measures Applicable to Underwater Explosives*

3.1 To ensure protection of these animals, all shoreline and water areas, which may be affected by the detonation of explosive charges or the use of explosive munitions, must be determined to be clear of protected marine species prior to detonation or discharge. Commands planning or sponsoring any type of underwater detonations must include COMNAVREG Hawaii N00L as an info addressee on all requests for underwater detonations.

3.2 All mine warfare and mine countermeasure operations involving the use of explosive charges must include safe zones for marine mammals (including humpback whales) and sea turtles to prevent physical and/or acoustic harm to those species.

3.3 For DEMO, pre-exercise survey shall be conducted within 30 minutes prior to the commencement of the scheduled explosive event. Appendix 4 (of the Annex to the Operational Order) provides information on areas to be cleared with respect to explosive charge weights.

3.4 The survey may be conducted from the surface, by divers, and/or from the air, and personnel shall be alert to the presence of any marine mammal or sea turtle. Should such an animal be present within the survey area, the exercise shall be paused until the animal voluntarily leaves the area.

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

3.6 Pre- and post-exercise surveys shall be reported to the Commander Third Fleet Judge Advocate and the COMNAVREG Hawaii environmental counsel at (808) 473-4731. Negative reports for post operations surveys are required. Any evidence of a marine mammal or sea turtle that may have been injured or killed by the action shall be reported immediately in accordance with procedures listed in Section 4.e(2) (that are applicable) of this document.

4. *Measures Applicable to Ships and Aircraft that are Underway*

4.1 No ship is to approach within 300 ft (90 m) of a humpback whale, and no any aircraft is to operate within 1,000 ft (300 m) or less of a humpback whale. Humpbacks are naturally inquisitive and historically have initiated close encounters despite best efforts to avoid them. Naval operations in the waters of the Hawaiian Islands Humpback Whale National Marine Sanctuary are authorized based in part on the Navy's practice of taking all reasonable precautions to avoid collisions with these endangered animals.

4.2 Ensure observers are briefed on the possible presence of marine mammals and that all sightings are reported to the bridge. Whales often travel in groups and a sighting indicates the possibility of others in the vicinity.

4.3 Upon sighting a whale, adjust course and speed as necessary to maintain a safe distance from the whales consistent with prudent seamanship.

4.4 Sightings of all whales shall be passed to other ships in the area to alert them to the possibility of the whales' presence.

4.5 In the event of a collision, if possible, take video and/or photographs of the stricken whale.

5. *Measures Applicable to Practice Bombing (explosive and non-explosive)*

5.1 Establish a buffer zone around the intended target zone. See Appendix 4 to the Operational Order for information. In the future should similar information be required for other exercises or training evolutions not covered in Appendix 4 (of the Operational Order), SPAWAR should be contacted at (619) 553-0021 for assistance. For SINKEX, a buffer zone with a 2.9 miles (4.6 km) radius around the intended target is required to be clear of non-exercise vessels, marine mammals, and sea turtles.

5.2 Visually survey the buffer zone for marine mammals and sea turtles one hour prior to and post (as safety allows) the exercise.

5.3 Visual survey to be conducted at an altitude of 1,500 ft (500 m) or lower to accomplish clearance survey of the impact area, if safe to do so, and at the slowest safe speed.

5.4 Survey aircraft should employ most effective search tactics and capabilities to increase the probability that marine mammals and sea turtles will be detected.

5.5 Conduct exercise only if the buffer zone is clear of marine mammals and sea turtles.

5.6 Do not release ordnance through cloud cover. Aircraft must be able to actually see ordnance impact areas.

6. *Measures Applicable to Mine Countermeasures* (mine hunting/mine sweeping/bottom mapping and survey, emplacement and retrieval of shallow water mines in littoral areas [e.g., Marine Corps Training Area Bellows (MCTAB)])

6.1. During small boat operations, note the presence of sea turtles and marine mammals.

6.2 Craft and personnel shall avoid direct contact with any marine mammal, sea turtle, or living coral.

6.3 Living coral reef development and where placement or removal or the shapes would not adversely impact adjacent living corals. See paragraph 11.c for additional information.

6.4 At MCTAB, mine shapes shall not be placed in water of a depth less than 10 feet (9 m) MLLW (mean lower low water), nor closer to shore than 300 ft (91 m). The top of the mine shape shall be a minimum of 7 ft (2.1 m) below MLLW.

7. *Measures Applicable to Sea Turtles and Hawaiian Monk Seals On Beaches*. Amphibious landings at MCTAB and PMRF shall adhere to all guidance regarding protection of sea turtles and Hawaiian monk seals on the beach relative to those areas. Mitigation measures shall be instituted to assure minimal impacts to these species. Specifically, prior to conducting a landing exercise, an inspection and survey protocol will include:

7.1 Within one hour prior to the commencement of an amphibious landing exercise, observer(s) shall survey affected beaches for sea turtles, sea turtle nesting sites, and Hawaiian monk seals. Sea turtle nesting sites shall be marked and no trespassing by persons or vehicles within 50 ft (15 m) of the nest shall be allowed.

7.2 Should sea turtles or Hawaiian monk seals be found on the beach, the landing shall be

7.2.1 delayed until the animal(s) have voluntarily left the area; or

7.2.2 moved to another location free of such animals.

7.2 Landing craft and AAV crews shall be made aware of the potential presence of these endangered and threatened species.

Mitigation Measures Imposed by the Incidental Harassment Authorization

The proposed Incidental Harassment Authorization contains the following mitigation and monitoring measures on the U.S. Navy during the proposed RIMPAC exercises:

1. All RIMPAC participants will receive the following marine mammal training/briefing during the port phase of RIMPAC:

1.1 Exercise participants (CO/XO/Ops) will review the C3F Marine Mammal Brief, available OPNAV N45 video presentations, and a NOAA brief presented by C3F on marine mammal issues in the Hawaiian Islands.

1.2 NUWC will train observers on marine mammal identification observation techniques.

1.3 Third fleet will brief all participants on marine mammal mitigation requirements.

1.4 Participants will receive video training on marine mammal awareness.

2. Navy watchstanders, the individuals responsible for detecting marine mammals in the Navy's standard operating procedures, will participate in marine mammal observer training by a NMFS-approved instructor. Training will focus on identification cues and behaviors that will assist in the detection of marine mammals and the recognition of behaviors potentially indicative of injury or stranding. Training will also include information aiding in the avoidance of marine mammals and the safe navigation of the vessel, as well as species identification review (with a focus on beaked whales and other species most susceptible to stranding). At least one individual who has received this training will be present, and on watch, at all times during operation of tactical mid-frequency sonar, on each vessel operating mid-frequency sonar..

3. All ships and surfaced submarines participating in the RIMPAC ASW exercises will have personnel on lookout with binoculars at all times when the vessel is moving through the water (or operating sonar). These personnel will report the sighting of any marine species, disturbance to the water's surface, or object (unknown or otherwise) to the Officer in Command.

4. All aircraft participating in RIMPAC ASW events will conduct and maintain, whenever possible, surveillance for marine species prior to and during the event. Sightings will be immediately reported to ships in the vicinity of the event as appropriate.

5. Submarine sonar operators will review detection indicators of close-aboard marine mammals prior to the commencement of ASW operations involving active mid-frequency sonar. Marine mammals detected by passive acoustic

6. *Safety Zones*: When marine mammals are detected by any means (aircraft, lookout, or acoustically) within 1,000 m of the sonar dome (the bow), the ship or submarine will limit active transmission levels to at least 6 dB below normal operating levels. Ships and submarines will continue to limit maximum ping levels by this 6-dB factor until the animal has been seen to leave the area, has not been seen for 30 minutes, or the vessel has transited more than 2000 m beyond the location of the sighting.

   Should a marine mammal be detected within or closing to inside 500 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 area, has not been seen for 30 minutes, or the vessel has transited more than 1500 m beyond the location of the sighting.

   Should the marine mammal be detected within or closing to inside 200 m of the sonar dome, active sonar transmissions will cease. Sonar will not resume until the animal has been seen to leave the area, has not been seen for 30 minutes, or the vessel has transited more than 1,200 m beyond the location of the sighting.

If the Navy is operating sonar above 235 dB and any of the conditions necessitating a powerdown arise, the Navy shall follow the requirements as though they were operating at 235 dB - the normal operating level (i.e., the first powerdown will be to 229 dB, regardless of at what level above 235 sonar was being operated)

7. In strong surface ducting conditions, the Navy will enlarge the safety zones such that a 6-dB power-down will occur if a marine mammal enters the zone within a 2000 m radius around the source, a 10-dB power-down will occur if an animal enters the 1000 m zone, and shut down will occur when an animal closes within 500 m of the sound source.

   A strong surface duct (half-channel at the surface) is defined as having the all the following factors: (1) A delta SVP between 0.6 to 2.0 m/s occurring within 20 fathoms of the surface with a positive gradient (upward refracting); (2) Sea conditions no greater than Sea State 3 (Beaufort Number 4); and (3) Daytime conditions with no more than 50% overcast (otherwise leading to diurnal warming). This applies only to surface ship mid-frequency active mainframe sonar.

8. In low visibility conditions (i.e., whenever the entire safety zone cannot be effectively monitored due to nighttime, high sea state, or other factors), the Navy will use additional detection measures, such as infrared or enhanced passive acoustic detection. . If detection of marine mammals is not possible out to the prescribed safety zone, the Navy will power down sonar (per the safety zone criteria above) as if marine mammals are present immediately beyond the extent of detection. (For example, if detection of marine mammals is only possible out to 700 m, the Navy must implement a power down to 229 dB, as though an animal is present at 701 m, which is inside the 1000 m safety zone).

9. Helicopters shall observe/survey the vicinity of an ASW exercise for 10 minutes before deploying active (dipping) sonar in the water. Helicopters shall not dip their sonar within 200 yards of a marine mammal and shall cease pinging if a marine mammal closes within 200 yards after pinging has begun.

10. The Navy will operate sonar at the lowest practicable level, not to exceed 235 dB, except for occasional short periods of time to meet tactical training objectives.

11. With the exception of three specific “choke-point” exercises (special measures outlined in item (13)), the Navy will not conduct sonar activities in constricted channels or canyon-like areas.

12. With the exception of three specific “choke-point” exercises (special measures outlined in item (13)), and events occurring on range areas managed by PMRF, the Navy will not operate mid-frequency sonar within 25 km of the 200 m isobath.

13. The Navy will conduct no more than three “choke-point exercises”. These exercises will occur in the Kaulakahi Channel (between Kauai and Niihau) and the Alenuihaha Channel

(between Maui and Hawaii). These exercises will not be conducted in a constricted channel like was present in the Bahamas, but will fall outside of the requirements listed above; that is, avoid canyon-like areas and to operate sonar farther than 25 km from the 200 m isobath. The additional measures required for these three choke-point exercises are as follows:

13.1 The Navy will provide NMFS (Stranding Coordinator and Protected Resources, Headquarters) and the Hawaii marine patrol with information regarding the time and place for the choke-point exercises in advance of the exercises.

13.2 The Navy will have at least one dedicated Navy observer that has received the NMFS-approved training mentioned above, on board each ship and conducting observations during the operation of mid-frequency tactical sonar during the choke-point exercises. The Navy has also authorized the presence of two experienced marine mammal observers (non-Navy personnel) to embark on Navy ships for observation during the exercise.

13.3 Prior to start up or restart of sonar, the Navy will ensure that a 2000 m radius around the sound source is clear of marine mammals.

13.4 The Navy will coordinate a focused monitoring effort around the choke-point exercises, to include pre-exercise monitoring (2 hours), during-exercise monitoring, and post-exercise monitoring (1-2 days). This monitoring effort will include at least one dedicated aircraft or one dedicated vessel for real-time monitoring from the pre- through post-monitoring time period, except at night. The vessel or airplane may be operated by either dedicated Navy personnel, or non-Navy scientists contracted by the Navy, who will be in regular communication with a Tactical Officer with the authority to shut-down, power-down, or delay the start-up of sonar operations. These monitors will communicate with this Officer to ensure the safety zones are clear prior to sonar start-up, to recommend power-down and shut-down during the exercise, and to extensively search for potentially injured or stranding animals in the area and down-current of the area post-exercise.

13.4 The Navy will further contract an experienced cetacean researcher to conduct systematic aerial reconnaissance surveys and observations before, during, and after the choke-point exercises with the intent of closely examining local populations of marine mammals during the RIMPAC exercise.

13.5 Along the Kaulakahi Channel (between Kauai and Niihau), shoreline reconnaissance and nearshore observations will be undertaken by a team located at Kekaha (the approximate mid point of the Channel). Additional observations will be made on a daily basis by range vessels while enroute from Port Allen to the range at PMRF (a distance of approximately 16 nauticam miles) and upon their return at the end of each day's activities. Finally, surveillance of the beach shoreline and nearshore waters bounding PMRF will occur randomly around the clock a minimum four times in each 24 hour period.

13.6 In the Alenuihaha Channel (between Maui and Hawaii), the Navy will conduct shoreline reconnaissance and nearshore observations by a team rotating between Mahukona and Lapakahi before, during, and after the exercise.

14. The Navy will conduct will conduct five exercises in the Pacific Missile Range Facilities that fall within 25 km of the 200 m isobath. The live sonar component of these 5 exercises will total approximately 6.5 hours. During these exercises, the Navy will conduct the monitoring described in (13)(1), (2), and (3).

15. The Navy will continue to coordinate with NMFS on the "Communications and Response Protocol for Stranded Marine Mammal Events During Navy Operations in the Pacific Islands Region" that is currently under preparation by NMFS PIRO to facilitate communication during RIMPAC. The Navy will coordinate with the NMFS Stranding Coordinator for any unusual marine mammal behavior, including stranding, beached live or dead cetacean(s), floating marine mammals, or out-of-habitat/milling live cetaceans that may occur at any time during or shortly after RIMPAC activities. After RIMPAC, NMFS and the Navy will prepare a coordinated report on the practicality and effectiveness of the protocol that will be provided to Navy/NMFS leadership.

Reporting

The proposed Incidental Harassment Authorization would require the U.S. Navy to:

1. Submit a report to the Division of Permits, Conservation, and Education, Office of Protected Resources, NMFS, and the Pacific Islands Regional Office, NMFS, within 90 days of the completion of RIMPAC. This report must contain and summarize the following information:

   1.1 An estimate of the number of marine mammals impacted by the RIMPAC exercises and a discussion of the nature of the effects, if observed, based on both modeled results of real-time exercises and sightings of marine mammals.

   1.2 An assessment of the effectiveness of the mitigation and monitoring measures with recommendations of how to improve them.

   1.3 Results of all of the marine species monitoring (real-time Navy monitoring from all platforms, independent aerial monitoring, shore-based monitoring at chokepoints, etc.) before, during, and after the RIMPAC exercises.

   1.4 As much unclassified information as the Navy can provide including, but not limited to, where and when sonar was used (including sources not considered in take estimates, such as submarine and aircraft sonars) in relation to any measured received levels (such as at sonobuoys or on PMRF range), source levels, numbers of sources, and frequencies, so it can be coordinated with observed cetacean behaviors.

2. In the unanticipated event that a stranding occurs during the RIMPAC ASW exercises, NMFS will implement protocols to modify, suspend, or revoke the proposed Incidental Harassment Authorization. That protocol (see Appendix 1 of this Opinion) is designed to investigate strandings that occur during the proposed RIMPAC exercises to distinguish normal standing

incidents (which include physical examinations of stranded animals, evaluations of environmental conditions to identify other potential causal agents like disease, ship strikes, prey depletion, etc.) from stranding incidents that might have been caused by the RIMPAC exercises. The protocol commits NMFS to investigate all marine mammal stranding incidents that occur during the RIMPAC exercises, verify any "uncommon stranding events" and inform the Navy to shut down RIMPAC ASW exercises in portions of the Action Area for up to 4 days until an investigation of an "uncommon stranding event" is complete.

If a RIMPAC ASW exercises is ruled out as a possible cause of an "uncommon stranding event," NMFS will inform the Navy that the exercises may resune. If NMFS determines that RIMPAC ASW exercises may have contributed to an "uncommon marine mammal stranding event," NMFS will determine whether the Incidental Harassment Authorization should be modified, suspended, or revoked.

Approach to the Assessment

NMFS approaches its section 7 analyses through a series of steps. The first step identifies those aspects of proposed actions that are likely to have direct and indirect effect on the physical, chemical, and biotic environment of an action area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The results of this step represents the action area for the consultation. The second step of our analyses identifies the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our *exposure analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an Action's effects and the populations or subpopulations those individuals represent. Once we identify which listed resources are likely to be exposed to an action's effects and the nature of that exposure, 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*).

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

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

We measure risks to listed individuals using the individual's "fitness," which are changes in an individual's growth, survival, annual reproductive success, and lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable responses to an Action's effects on the environment (which we identify during our response analyses) are likely to have consequences for the individual's fitness.

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

If, however, we conclude that listed plants or animals are likely to experience reductions in their fitness, our assessment tries to determine if those fitness 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.

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 high-, mid-, and low-frequency sonar and their effects on marine mammals and other marine life has become available. Many investigators have studied potential responses of marine mammals and other marine organisms to human-generated sounds in marine environments (for example, Bowles *et al*. 1994; Croll *et al*. 1999, 2001; Frankel and Clark 1998; Gisiner 1998, McCauley and Cato 2001; Norris 1994; Reeves 1992, Tyack 2000; Whitlow *et al*. 1997).

To supplement that body of knowledge, we used literature searches using the Library of Congress' *First Search* and *Dissertation Abstracts* databases, SCOPUS, *Web of Science*, and Cambridge Abstract's *Aquatic Sciences and Fisheries Abstracts* (ASFA) database services. The

First Search databases provide access to general biological literature, master's theses, and doctoral dissertations back to 1980; ASFA provides access to journal articles, magazine articles, and conference proceedings back to 1964. Our searches specifically focus on the *ArticleFirst*, *BasicBiosis*, *Dissertation Abstracts*, *Proceedings* and *ECO* databases, which index the major journals dealing with issues of ecological risk (for example, the journals *Environmental Toxicology and Chemistry*, *Human and Ecological Risk Assessment*), marine mammals (*Journal of Mammalogy*, *Canadian Journal of Zoology*, *Marine Mammal Science*), ecology (*Ambio*, *Bioscience*, *Journal of Animal Ecology*, *Journal of Applied Ecology*, *Journal of the Marine Biological Association of the UK*, *Marine Pollution Bulletin*), and bioacoustics (*Journal of the Acoustical Society of America*).

Our prior experience demonstrated that electronic searches produce the lowest number of false positive (references produced by a search that are not relevant) and false negative (references not produced by a search that are relevant) results if we use paired combinations of the keywords sonar, mid-frequency sonar, acoustic, marine acoustic, military exercises, sound, and noise paired with the keywords cetacean, dolphin, marine mammal, pinniped, porpoise, sea turtle, seal, and whale. To expand these searches, we modify these keyword pairs with the keywords effect, impact, mortality event, response, stranding, unusual mortality event.

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

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

We ranked the results of these searches based on the quality of their study design, sample sizes, level of scrutiny prior to and during publication, and study results. Carefully-designed field experiments (for example, experiments that control potentially confounding variables) were rated higher than field experiments that are not designed to control those variables. Carefully-designed field experiments were generally ranked higher than computer simulations. Studies that produce large sample sizes with small variances were generally ranked higher than studies with small sample sizes or large variances.

Despite the information that is available, this assessment involved a large amount of uncertainty. We had limited information on the basic hearing capabilities of marine mammals; how marine mammals use natural sound to communicate; 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 harm marine mammals (see NRC 2000 for further discussion of these unknowns). Finally, we do not know — and, perhaps, cannot know — how marine mammals interpret sound (including human-generated sounds) and how sound affects their cognitive processes and their behavior.

The primary sources of information on the effects of sound on marine mammals were reviews conducted by the National Research Council (NRC 1994 1996, 2000, 2005), Richardson *et al*. (1995) on marine mammals and noise, the Navy's Low Frequency Sound Scientific Research Program, Marine Mammal Research Program (which was developed to address questions associated with the Advanced Research Projects Agency's Acoustic Thermometry of Ocean Climate project, which also uses low frequency sound), and numerous scientific papers (Croll *et al*. 1999 and 2001; Frankel and Clark 1998; Richardson *et al*. 1995; Tyack 2000; Whitlow *et al*. 1997).

Application of this Approach in this Consultation

NMFS initially identified several aspects of the proposed RIMPAC exercises that represent potential hazards to threatened or endangered species or critical habitat that has been designated for them: (1) the ships and ship traffic associated with the proposed exercise; (2) the mid-frequency active sonar systems that would be employed during the exercise; (3) aircraft operations, (4) amphibious landings, (5) gunfire and missile exercises, (6) mining and demolition activities, (7) hulk sinking exercise, (8) salvage, (9) special warfare, and (10) humanitarian operations. After reviewing the mitigation measures the Navy proposes to implement and information from earlier exercises, NMFS concluded that the measures associated with Elements 3 – 10 can be expected to avoid the likelihood of adversely affecting threatened or endangered species or critical habitat that has been designated for them (these conclusions are summarized in the *Status of the Species* section of this opinion).

This assessment focuses on two aspects of the proposed RIMPAC exercises — ship traffic and mid-frequency sonar. We analyze the potential risks associated with the ship traffic by assessing the probability of a ship strike. We analyze the potential risks associated with sonars that are likely to be employed during anti-submarine warfare exercises by treating the acoustic energy produced by those sonar as a pollutant introduced into the ocean environment. The first step of our analysis evaluates the available evidence to determine the likelihood of listed species or critical habitat being exposed to sound pressure levels associated with mid-frequency sonar, which includes estimating the intensity, duration, and frequency of exposure (for other examples of exposure assessments, see Wu and Schaum 2000). Our analysis assumed that mid-frequency sonar poses no risk to listed species or critical habitat if they are not exposed to sound pressure levels from the mid-frequency sound sources (we recognize that the sonar could have indirect, adverse effects on listed species or critical habitat by disrupting marine food chains, a species' predators, or a species' competitors; however, we did not identify situations where this concern might apply to species under NMFS' jurisdiction). Our analyses also assumed that the potential consequences of exposure to mid-frequency sonar on individual animals would be a function of the intensity (measured in both sound pressure level in decibels and frequency), duration, and frequency of the animal's exposure to the mid-frequency transmissions.

For our exposure analyses, NMFS relied primarily on the results of acoustic models the U.S. Navy used as part of its NEPA compliance for the proposed RIMPAC exercises (see U.S. Navy 2001a, 2001b, 2001c). Once we identified which listed resources were likely to be exposed to the sonar 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. The remainder of our analyses proceeded using the approach we described in the previous section.

A Brief Background on Sound

Sound is a wave of pressure variations propagating through a medium (for the sonar considered in this opinion, the medium is marine water). Pressure variations are created by compressing and relaxing the medium. Sound measurements can be expressed in two forms: *intensity* and *pressure*. Acoustic intensity is the average rate of energy transmitted through a unit area in a specified direction and is expressed in watts per square meter (W/m^2). Acoustic intensity is rarely measured directly, it is derived from ratios of *pressures*; the standard reference pressure for underwater sound is 1 microPascal (μPa); for airborne sound, the standard reference pressure is 20 μPa (Richardson *et al*., 1995).

Acousticians have adopted a logarithmic scale for sound intensities, which is denoted in decibels (dB). Decibel measurements represent the ratio between a measured pressure value and a reference pressure value (in this case 1 μPa or, for airborne sound, 20 μPa.). The logarithmic nature of the scale means that each 10 dB increase is a ten-fold increase in power (e.g., 20 dB is a 100-fold increase, 30 dB is a 1,000-fold increase). Humans perceive a 10 dB increase in noise as a doubling of sound level, or a 10 dB decrease in noise as a halving of sound level. The term "sound pressure level" implies a decibel measure and a reference pressure that is used as the denominator of the ratio. Throughout this opinion, we use 1 microPascal (denoted re: 1μPa) as a standard reference pressure unless noted otherwise.

It is important to note that decibels underwater and decibels in air are not the same and cannot be directly compared. Because of the different densities of air and water and the different decibel standards in water and air, a sound with the same intensity (i.e., power) in air and in water would be approximately 63 dB quieter in air. Thus a sound that is 160 dB loud underwater would have the same effective intensity as a sound that is 97 dB loud in air.

Sound frequency is measured in cycles per second, or Hertz (abbreviated Hz), and is analogous to musical pitch; high-pitched sounds contain high frequencies and low-pitched sounds contain low frequencies. Natural sounds in the ocean span a huge range of frequencies: from earthquake noise at 5 Hz to harbor porpoise clicks at 150,000 Hz. These sounds are so low or so high in pitch that humans cannot even hear them; acousticians call these infrasonic and ultrasonic sounds, respectively. A single sound may be made up of many different frequencies together. Sounds made up of only a small range of frequencies are called "narrowband", and sounds with a broad range of frequencies are called “broadband”; airguns are an example of a broadband sound source and sonars are an example of a narrowband sound source.

When considering the influence of various kinds of noise on the marine environment, it is necessary to understand that different kinds of marine life are sensitive to different frequencies of sound. Most dolphins, for instance, have excellent hearing at very high frequencies between 10,000 and 100,000 Hz. However, their sensitivity at lower frequencies below 1000 Hz is quite poor. On the other hand, the hearing sensitivity of most fish is best at frequencies between 100 Hz and 1000 Hz. Thus, fish might be expected to suffer more harmful effects from loud, low frequency noise than would dolphins.

Because ears adapted to function underwater are physiologically different from human ears, comparisons using decibels would still not be adequate to describe the effects of a sound on a whale. When sound travels away from its source, its loudness decreases as the distance traveled by the sound increases. Thus, the loudness of a sound at its source is higher than the loudness of that same sound a kilometer distant. Acousticians often refer to the loudness of a sound at its source as the *source level* and the loudness of sound elsewhere as the *received level*. For example, a humpback whale 3 kilometers from an airgun that has a source level of 230 dB may only be exposed to sound that is 160 dB loud. As a result, it is important not to confuse source levels and received levels when discussing the loudness of sound in the ocean.

As sound moves away from a source, its propagation in water is influenced by various physical characteristics, including water temperature, depth, salinity, and surface and bottom properties that cause refraction, reflection, absorption, and scattering of sound waves. Oceans are not homogeneous and the contribution of each of these individual factors is extremely complex and interrelated. The physical characteristics that determine the sound’s speed through the water will change with depth, season, geographic location, and with time of day (as a result, in actual sonar operations, crews will measure oceanic conditions, such as sea water temperature and depth, to calibrate models that determine the path the sonar signal will take as it travels through the ocean and how strong the sound signal will be at given range along a particular transmission path).

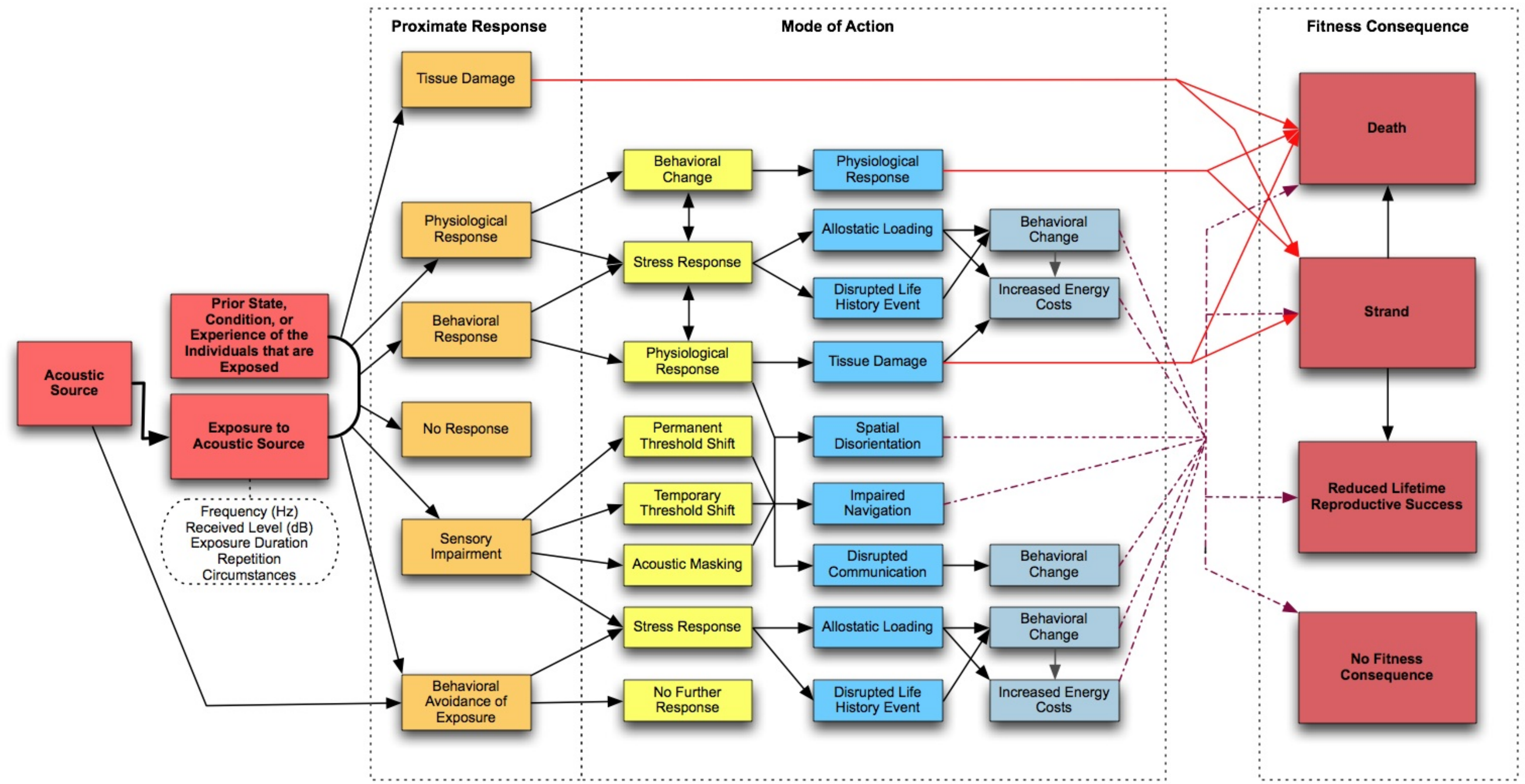


Figure 1: Conceptual model for assessing the effects of mid-frequency sonar exposures on marine mammals

Sound tends to follow many paths through the ocean, so that a listener would hear multiple, delayed copies of transmitted signals (Navy 2001, Richardson *et al*. 1995). Echoes are a familiar example of this phenomenon in air. In order to determine what the paths of sound transmission are, one rule is to seek paths that deliver the sound to the receiver the fastest. These are called acoustic rays. If the speed of sound were constant throughout the ocean, acoustic rays would consist of straight-line segments, with reflections off the surface and the bottom. However, because the speed of sound varies in the ocean, most acoustic rays are curved.

Sound speed in seawater is about 1,500 m/s (5,000 ft/s) and varies with water density, which is affected by water temperature, salinity (the amount of salt in the water), and depth (pressure). The speed of sound increases as temperature and depth (pressure), and to a lesser extent, salinity, increase. The variation of sound speed with depth of the water is generally presented by a "sound speed profile," which varies with geographic latitude, season, and time of day.

In shallow waters of coastal regions and on continental shelves, sound speed profiles become influenced by surface heating and cooling, salinity changes, and water currents. As a result, these profiles tend to be irregular and unpredictable, and contain numerous gradients that last over short time and space scales. As sound travels through the ocean, the intensity associated with the wavefront diminishes, or attenuates. This decrease in intensity is referred to as propagation loss, also commonly called transmission loss.

Action Area

The action area for this biological opinion encompasses the main Hawaiian Islands — Hawaii, Kahoolawe, Kauai, Lanai, Maui, Molokai, Niihau, and Oahu — at the easternmost edge of the Hawaiian Archipelago (see Figure 1). With the exception of beach areas that might be occupied by Hawaiian monk seals, this action area is limited to those marine, coastal, and estuarine waters that are sea-ward of the mean higher high water line within this geographic area. With the exception of monk seals, we assume that any of the proposed activities that are likely to occur landward of the mean higher high water line — including activities that may affect threatened or endangered species of sea turtle landward of the mean higher high water line — are addressed in separate section 7 consultations with the U.S. Fish and Wildlife Service.

Status of Listed Resources

NMFS has determined that the actions considered in this biological opinion may affect the following species provided protection under the ESA:

Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
North Pacific right whale	*Eubalaena japonica*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Hawaiian monk seal	*Monachus schauislandii*	Endangered
Green sea turtle	*Chelonia mydas*	Threatened
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Endangered

Loggerhead sea turtle	*Caretta caretta*	Endangered
Pacific ridley sea turtle	*Lepidochelys olivacea*	Endangered

In addition to these species, critical habitat that has been designated for Hawaiian monk seals also occurs in the action area. In May 1988, NMFS designated critical habitat for the Hawaiian monk seal out from shore to 20 fathoms in 10 areas of the northwestern Hawaiian Islands. Critical habitat for these species includes all beach areas, sand spits and islets, including all beach crest vegetation to its deepest extent inland, lagoon waters, inner reef waters, and ocean waters out to a depth of 20 fathoms around the following: Kure Atoll, Midway Islands, except Sand Island and its harbor, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island (50 CFR 226.201). None of the proposed exercises are scheduled to occur in critical habitat of the Hawaiian monk seal (i.e., ocean waters out to 20 fathoms depth). In addition, the proposed naval exercises are not likely to adversely affect prey species of the Hawaiian monk seals. As a result, the proposed exercises are not likely to adversely affect the conservation value of the critical habitat that has been designated for Hawaiian monk seals.

The information on the hearing capabilities of endangered Hawaiian monk seals is somewhat limited, but they appear to have their most sensitive hearing at 12 to 28 kHz. Below 8 kHz, their hearing is less sensitive than that of other pinnipeds. Their sensitivity to high frequency sound drops off sharply above 30 kHz (Thomas *et al.* 1990, Richardson *et al.* 1995). An underwater audiogram for Hawaiian monk seal, based on a single animal whose hearing may have been affected by disease or age, was best at 12 to 28 kHz and 60 to 70 kHz (Reeves et al. 2001, Thomas *et al.* 1990). The hearing showed relatively poor hearing sensitivity, as well as a narrow range of best sensitivity and a relatively low upper frequency limit (Thomas *et al.* 1990). Because the sonar that would be used during the proposed RIMPAC anti-submarine warfare exercises transmits at frequencies below hearing thresholds for Hawaiian monk seals, monk seals that are exposed to those transmissions are not likely to respond to that exposure.

Hawaiian monk seals might also occur on beaches and in nearshore areas where demolition exercises, amphibious exercises, and gunnery exercises would occur during the proposed RIMPAC exercises. However, the Navy's protocols for surveying these areas one hour prior to conducting these exercises and either relocating or delaying an exercise if those surveys discover monk seals, makes it unlikely that monk seals will be exposed to potential hazards associated with the exercises. Consequently, we conclude that the proposed RIMPAC exercises may affect, but are not likely to adversely affect endangered Hawaiian monk seals so this species will not be considered in greater detail in the remainder of this opinion.

The information on the hearing capabilities of sea turtles is also limited, but the information available suggests that the auditory capabilities of sea turtles are centered in the low-frequency range (<1 kHz) (Ridgway *et al.* 1969; Lenhardt *et al.* 1983; Bartol *et al.* 1999, Lenhardt 1994, O'Hara and Wilcox 1990). Ridgway *et al.* (1969) concluded that green turtles have a useful hearing span of perhaps 60 Hz to 1,000 Hz, but hear best from about 200 Hz to 700 Hz. These values probably apply to all four of the hardshell turtles (i.e., the green, loggerhead, hawksbill, and Kemp's ridley turtles). No audiometric data are available for the leatherback, but we assume that leatherback sea turtles have hearing ranges similar to those of other sea turtles (or at least,

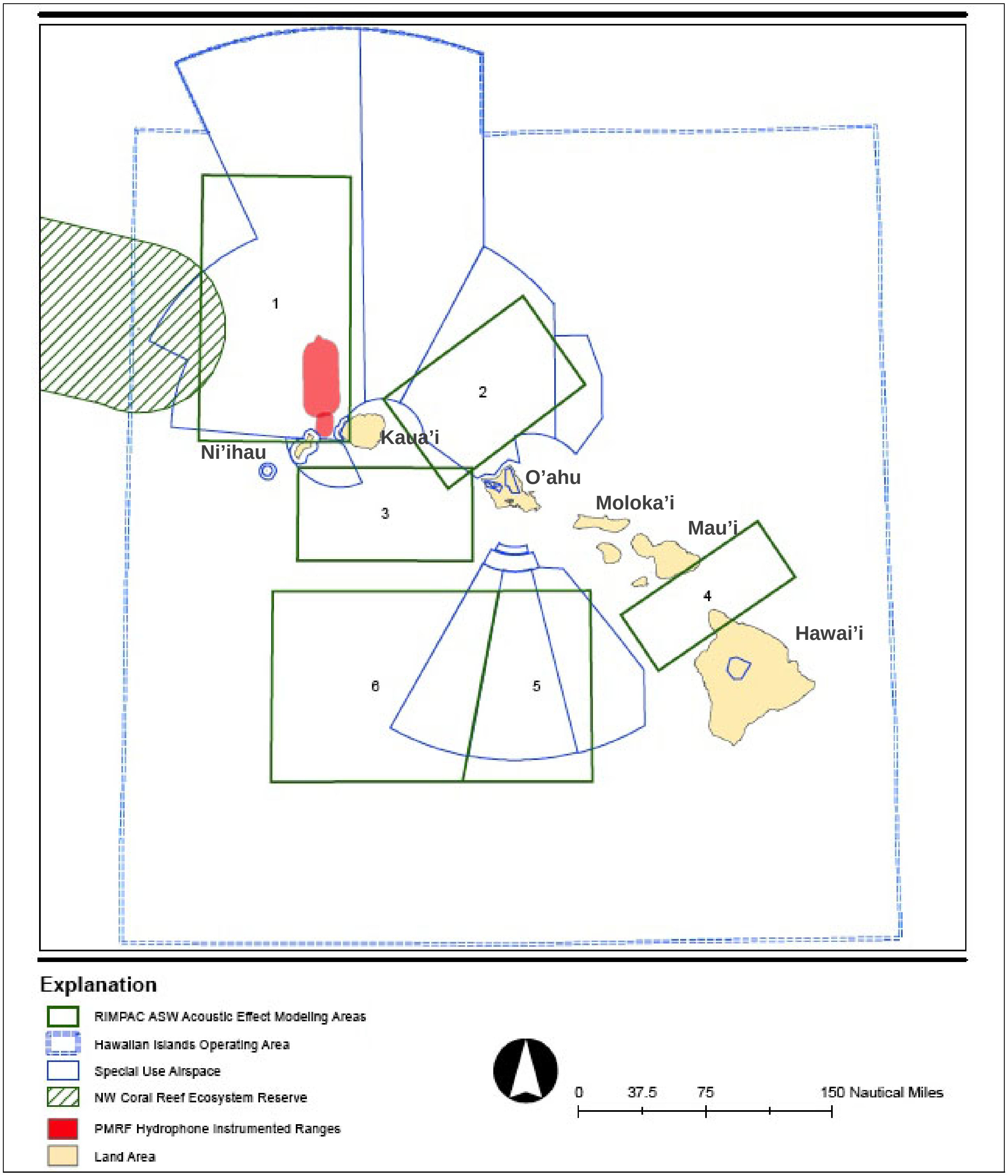


Figure 2. Action area for the proposed 2006 Rim of the Pacific exercises and areas the Navy included in its models of the potential acoustic effects of the proposed exercises

their hearing is more likely to be similar to other sea turtles than other species). Based on this information sea turtles exposed to received levels of active mid-frequency sonar are not likely to hear mid-frequency (1 kHz–10 kHz) sounds; therefore, they are not likely to respond physiologically or behaviorally to those received levels.

A recent study on the effects of airguns on sea turtle behavior also suggests that sea turtles are most likely to respond to low-frequency sounds. McCauley *et al.* (2000) reported that green and loggerhead sea turtles will avoid air-gun arrays at 2 km and at 1 km with received levels of 166 dB re 1 μPa and 175 db re 1 μPa, respectively. The sea turtles responded consistently: above a level of approximately 166 dB re 1 μPa $_{rms}$ the turtles noticeably increased their swimming activity compared to non-airgun operation periods. Above 175 dB re 1 μPa mean squared pressure their behavior became more erratic possibly indicating the turtles were in an agitated state. Because the sonar that would be used during the proposed RIMPAC anti-submarine warfare exercises transmits at frequencies above hearing thresholds for sea turtles, sea turtles that are exposed to those transmissions are not likely to respond to that exposure. [As noted previously, we assume that the effects of the proposed RIMPAC exercises on sea turtles using beaches in the Action Area have been or will be addressed in separate consultations with the U.S. Fish and Wildlife Service.]

A population or "stock" of endangered blue whales occurs in waters surrounding the Hawaiian archipelago (from the main Hawaiian Islands west to at least Midway Island). In these waters, blue whales appear to be rare. The only reliable report of this species in the central North Pacific was a sighting made from a scientific research vessel about 400 km northeast of Hawaii in January 1964 (NMFS 1998). However, acoustic monitoring has recorded blue whales off Oahu and the Midway Islands (Barlow *et al.* 1994, McDonald and Fox 1999, Northrop *et al.* 1971; Thompson and Friedl 1982). The recordings made off Oahu showed bimodal peaks throughout the year, suggesting that the animals were migrating into the area during summer and winter (Thompson and Friedl 1982; McDonald and Fox 1999). Twelve aerial surveys were flown from 1993-1998 within 25 nm^2 of the main Hawaiian Islands and no blue whales were sighted in these waters. There are no reports of blue whales strandings in Hawaiian waters. The apparent rarity of blue whales in Hawaiian waters, as evidenced by the absence of reliable observations of these whales in vessel and aircraft surveys that have been conducted in Hawaiian waters since the mid-1960s and the rarity of detections using acoustic monitoring, suggests that blue whales have a very low probability of being exposed to mid-frequency sonar transmissions and ship traffic associated with the proposed RIMPAC exercises.

In the event blue whales are exposed to mid-frequency sonar, the information available on blue whales exposed to received levels of active mid-frequency sonar suggests that they are not likely to hear mid-frequency (1 kHz–10 kHz) sounds. Blue whales vocalizations include a variety of sounds described as low frequency moans or long pulses in the 10-100 Hz band (Cummings and Thompson 1971; Edds 1982; Thompson and Friedl 1982; McDonald *et al.* 1995; Clark and Fristrup 1997; Rivers 1997). The most typical signals are very long, patterned sequences of tonal infrasonic sounds in the 15-40 Hz range. Ketten (1997) reports the frequencies of maximum energy between 12 and 18 Hz. Short sequences of rapid calls in the 30-90 Hz band are associated with animals in social groups (Clark pers. obs., McDonald pers. comm.). The context for the 30-90 Hz calls suggests that they are used to communicate but do not appear to be related to reproduction. Blue whale moans within the frequency range of 12.5-200 Hz, with pulse duration up to 36 seconds, have been recorded off Chile (Cummings and Thompson 1971). The whale produced a short, 390 Hz pulse during the moan. Based on this information blue whales exposed to received levels of active mid-frequency sonar are not likely to hear mid-frequency sounds; if they do not hear the sounds, they are not likely to respond physiologically or behaviorally to those received levels. Consequently, we conclude that the proposed RIMPAC exercises may affect, but are not likely to adversely affect endangered blue whales so this species will not be considered in greater detail in the remainder of this opinion.

Historically, the endangered North Pacific right whale occurred in waters north of the Hawaiian archipelago (Clapham et al. 2004; Scarff 1986). However, the extremely low population numbers of this species and the rarity of reports from Hawaiian waters (despite intensive whale surveys in Hawaii, the only sighting in recent years was reported from the late 1970s as reported by Hermann *et al*. 1980) suggests that these right whales have a very low probability of being exposed to mid-frequency sonar transmissions and ship traffic associated with the proposed RIMPAC exercises.

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

The following narratives summarize the biology and ecology of the threatened and endangered species in the action area that is relevant to the effects analysis in this biological opinion. Summaries of the global status and trends of each species are presented to provide a foundation for the analysis.

Fin whale

Species description and distribution
Fin whales are distributed widely in the world's oceans. In the northern hemisphere, most migrate seasonally from high Arctic feeding areas in summer to low latitude breeding and calving areas in winter. Other groups may remain year-round in a particular area, depending on food supply. However, NMFS treats the population structure of fin whales in the North Pacific as uncertain, and provisionally recognizes three populations: (1) Alaska (northeast Pacific), (2) California/Oregon/Washington, and (3) Hawaii (Barlow *et al*. 1997, Hill and DeMaster 1998).

Fin whales were reported as occurring immediate offshore throughout the North Pacific from central Baja California to Japan and as far north as the Chukchi Sea (Rice 1974). Fin whales occurred in high densities in the northern Gulf of Alaska and southeastern Bering Sea from May to October, with some movement through the Aleutian passes into and out of the Bering Sea (Reeves *et al*. 1985). Fin whales were observed and taken by Japanese and Soviet whalers off eastern Kamchatka and Cape Navarin, both north and south of the eastern Aleutians, and in the northern Bering and southern Chukchi seas (Berzin and Rovnin 1966, Nasu 1974). In 1999, vessel surveys of the central Bering Sea reported 75 fin whale sightings (totaling 346 whales) clustered along the outer Bering Sea shelf break, primarily near the 200m isobath (Moore *et al*. 2000). In the Gulf of Alaska, fin whales appear to congregate in the waters around Kodiak Island and south of Prince William Sound (Calkins 1986).

In recent years, small numbers of fin whales have been observed south of the Aleutian Islands (Forney and Brownell 1996), in the Gulf of Alaska (including Shelikof Strait), and in the southeastern Bering Sea (Leatherwood *et al*. 1986, Brueggeman *et al*. 1990). Their regular occurrence has also been noted in recent years around the Pribilof Islands in the northern Bering Sea (Baretta and Hunt 1994). Fin whale concentrations in the northern areas of the North Pacific and Bering Sea generally form along frontal boundaries, or mixing zones between coastal and oceanic waters, which themselves correspond roughly to the 200-m isobath (which is the shelf edge; Nasu 1974).

Fin whales have been observed year-round off central and southern California, with peak numbers in the summer and fall. Peak numbers of fin whales have also been seen during the summer off Oregon and in summer and fall in the Gulf of Alaska and southeastern Bering Sea (*in* Perry *et al*, 1999). Rice (1974) reported that several fin whales tagged from November to January off southern California were later killed by whalers in May to July off central California, Oregon, and British Columbia and in the Gulf of Alaska, suggesting possible southern California wintering areas and summering areas further north. Although fin whale abundance is lower in winter/spring off California, and higher in the Gulf of California, further research and surveys need to be conducted in order to determine whether fin whales found off southern and central California migrate to the Gulf of California for the winter (Forney *et al*. 2000).

Life history information

Fin whales become sexually mature between six to ten years of age, depending on density-dependent factors (Gambell 1985b). Reproductive activities for fin whales occur primarily in the winter. Gestation lasts about 12 months and nursing occurs for 6 to 11 months (Perry *et al*. 1999). The age distribution of fin whales in the North Pacific is unknown.

Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggest annual natural mortality rates may range from 0.04 to 0.06 (based on studies of northeast Atlantic fin whales). The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in fin whales and may be preventing some fin whale stocks from recovering from whaling (Lambertsen 1992, as cited in Perry *et al*. 1999). Killer whale or shark attacks may result in serious injury or death in very young and sick whales (Perry *et al*. 1999). NMFS has no records of fin whales being killed or injured by commercial fisheries operating in the North Pacific (Ferrero *et al*. 2000).

Vocalizations and hearing

Underwater sounds produced by fin whales are one of the most studied *Balaenoptera* sounds. Fin whales produce a variety of low-frequency sounds in the 10-200 Hz band (Watkins 1981; Watkins *et al.* 1987a; Edds 1988; Thompson *et al.* 1992). The most typical signals are long, patterned sequences of short duration (0.5-2s) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton 1964). Estimated source levels are as high as 190 dB (Patterson and Hamilton

1964; Watkins *et al.* 1987a; Thompson *et al.* 1992; McDonald *et al.* 1995). In temperate waters intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Short sequences of rapid pulses in the 20-70 Hz band are associated with animals in social groups (McDonald *et al.* 1995; Clark pers. comm.; McDonald pers. comm.). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

Particularly in the breeding season, fin whales produce series of pulses in a regularly repeating pattern. These bouts of pulsing may last for longer than one day (Tyack 1999). The seasonality and stereotype of the bouts of patterned sounds suggest that these sounds are male reproductive displays (Watkins *et al.* 1987a), while the individual counter-calling data of McDonald *et al.* (1995) suggest that the more variable calls are contact calls. Some authors feel there are geographic differences in the frequency, duration and repetition of the pulses (Thompson *et al.* 1992). As with other mysticete sounds, the function of vocalizations produced by fin whales is unknown. Hypothesized functions include: (1) maintenance of inter-individual distance, (2) species and individual recognition, (3) contextual information transmission (e.g. feeding, alarm, courtship), (4) maintenance of social organization (e.g. contact calls between females and offspring), (5) location of topographic features, and (6) location of prey resources (review by Thompson *et al.* 1992). Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by fin whales have the potential to travel over long distances, and it is possible that long-distance communication occurs in fin whales (Payne and Webb 1971; Edds-Walton 1997). Also, there is speculation that the sounds may function for long-range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

Cetaceans have an auditory anatomy that follows the basic mammalian pattern, with some changes to adapt to the demands of hearing in the sea. The typical mammalian ear is divided into an outer ear, middle ear, and inner ear. The outer ear is separated from the inner ear by a tympanic membrane, or eardrum. In terrestrial mammals, the outer ear, eardrum, and middle ear 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.

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

Listing status
In the North Pacific, the IWC began management of commercial whaling for fin whales in 1969; fin whales were fully protected from commercial whaling in 1976 (Allen 1980). Fin whales were

listed as endangered under the ESA in 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. Fin whales are listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). Critical habitat has not been designated for fin whales.

Population status and trends
Prior to exploitation by whaling vessels, the North Pacific population consisted of an estimated 42,000 to 45,000 fin whales (Ohsumi and Wada 1974). Between 1914 and 1975, over 26,040 fin whales were harvested throughout the North Pacific (Braham 1991, as cited in Perry *et al*. 1999). Catches in the North Pacific and Bering Sea ranged from 1,000 to 1,500 fin whales annually during the 1950s and 1960s. However, not all Soviet catches were reported (Yablokov 1994, as cited in Ferrero *et al*. 2000). In the early 1970s, the entire North Pacific population had been reduced to between 13,620 and 18,630 fin whales (Ohsumi and Wada 1974).

During the early 1970s, 8,520 to 10,970 fin whales were surveyed in the eastern half of the North Pacific (Braham 1991). Moore *et al*. (2000) conducted surveys for whales in the central Bering Sea in 1999 and tentatively estimated the fin whale population was about 4,951 animals (95% C.I.: 2,833-8,653). If these historic estimates are statistically reliable, the population size of fin whales has not increased significantly over the past 20 years despite an international ban on whaling in the North Pacific. The strongest contrary evidence comes from investigators conducting seabird surveys around the Pribilof Islands in 1975-1978 and 1987-1989. These investigators observed more fin whales in the second survey and suggested they were more abundant in the survey area (Baretta and Hunt 1994). However, observations of increased counts of fin whales in an area do not support a conclusion that there are more fin whales until changes in distribution have been ruled out first.

Impacts of human activity on fin whales
As early as the mid-seventeenth century, the Japanese were capturing fin, blue (*Balaenoptera musculus*), and other large whales using a fairly primitive open-water netting technique (Tønnessen and Johnsen 1982, Cherfas 1989). In 1864, explosive harpoons and steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species. The North Pacific and Antarctic whaling operations soon added this >modern' equipment to their arsenal. After blue whales were depleted in most areas, the smaller fin whale became the focus of whaling operations and more than 700,000 fin whales were landed in the twentieth century.

In the North Atlantic the IWC has set catch limits for a small subsistence fishery off West Greenland. Catches of fin whales from West Greenland in 2004 were 5 males and 6 females; 2 additional animals were struck and lost. In 2003 the catches were 2 males, 4 females; 2 additional animals were struck and lost (IWC 2005). The IWC previously set a catch limit for west Greenland fin whales of up to 19 fin whales for the period 2003-2007 (IWC 2005), however, without an abundance estimate for fin whales in the North Atlantic the IWC's scientific comments recommended limiting the number of fin whale harvests to 1 to 4 individuals.

The incidental take of fin whales in fisheries is extremely rare. In the California/Oregon drift gillnet fishery, observers recorded the entanglement and mortality of one fin whale, in 1999, off southern California (NMFS 2000). Based on a worst-case scenario, NMFS estimates that a maximum of 6 fin whales (based on calculations that adjusted the fin whale observed entangled and killed in 1999 by the number of sets per year) in a given year could be captured by the California-Oregon drift gillnet fleet and killed (NMFS 2000). Anecdotal observations from fishermen, suggest that large whales swim through their nets rather than get caught in them (NMFS 2000). Because of their size and strength, fin whales probably punch through fishing nets which is why their entanglement is probably no more than a rare event.

Sei Whale

Species description and distribution

Sei whales are distributed in all of the world's oceans, except the Arctic Ocean. The IWC's Scientific Committee groups all of the sei whales in the entire North Pacific Ocean into one population (Donovan 1991). However, some mark-recapture, catch distribution, and morphological research indicated that more than one population exists; one between 175 W and 155 W longitude, and another east of 155 W longitude (Masaki 1976, 1977). During the winter, sei whales are found from 20 - 23 N and during the summer from 35° - 50° N (Masaki 1976, 1977). Horwood (1987) reported that 75-85% of the total North Pacific population of sei whales resides east of 180° longitude.

In the North Pacific Ocean, 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 (Nasu 1974, Leatherwood *et al*. 1982). Sei whales have been occasionally reported from the Bering Sea and in low numbers on the central Bering Sea shelf (Hill and DeMaster 1998). Masaki (1977) reported sei whales concentrating in the northern and western Bering Sea from July through September, although other researchers question these observations because no other surveys have ever reported sei whales in the northern and western Bering Sea. Horwood (1987) evaluated the Japanese sighting data and concluded that sei whales rarely occur in the Bering Sea.

Life history information

Reproductive activities for sei whales occur primarily in winter. Gestation is about 12.7 months and the calving interval is about 3 years (Rice 1977). Sei whales become sexually mature at about age 10 (Rice 1977). The age structure of the sei whale population is unknown. Rice (1977) estimated total annual mortality for adult females as 0.088 and adult males as 0.103. Andrews (1916) suggested that killer whales attacked sei whales less frequently than fin and blue whales in the same areas. Sei whales in the North Pacific feed on euphausiids and copepods, which make up about 95% of their diets (Calkins 1986). 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). 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.

Vocalizations and hearing

No studies have been published on the vocal behavior of sei whales. No studies have directly measured the sound sensitivity of sei whales (Croll *et al.* 1999). A general description of the anatomy of the ear for cetaceans is provided in the description of the blue whale above.

Listing status

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

Population status and trends

Sei whale abundance prior to commercial whaling in the North Pacific has been estimated at 42,000 sei whales (Tillman 1977). Japanese and Soviet catches of sei whales in the North Pacific and Bering Sea increased from 260 whales in 1962 to over 4,500 in 1968 and 1969, after which the sei whale population declined rapidly (Mizroch *et al*. 1984). When commercial whaling for sei whales ended in 1974, the population of sei whales in the North Pacific had been reduced to between 7,260 and 12,620 animals (Tillman 1977). Current abundance or trends are not known for sei whales in the North Pacific.

Impacts of human activity on sei whales

From 1910 to 1975, approximately 74,215 sei whales were caught in the entire North Pacific Ocean (Horwood 1987, Perry *et al*. 1999). From the early 1900s, Japanese whaling operations consisted of a large proportion of sei whales: 300-600 sei whales were killed per year from 1911 to 1955. The sei whale catch peaked in 1959, when 1,340 sei whales were killed. In 1971, after a decade of high sei whale catch numbers, sei whales were scarce in Japanese waters. In the eastern north Pacific, the sei whale population appeared to number about 40,000 animals until whaling began in 1963; by 1974, the sei whale population had been reduced to about 8,000 animals (Tilman 1977). No recent reports indicate sei whales are being killed or seriously injured as a result of fishing activities in any eastern North Pacific fishery (Perry *et al*. 1999). However, Barlow *et al*. (1997) note that a conflict may exist in the offshore drift gillnet fishery.

In 2000, the Japanese Whaling Association announced that it planned to kill 10 sperm whales and 50 Bryde’s whales in the Pacific Ocean for research purposes, which would be the first time sperm whales would be taken since the international ban on commercial whaling took effect in 1987. In 2002, the Japanese Whaling Association expanded this research program to include sei whales. According to the Japanese Institute of Cetacean Research (Institute of Cetacean Research undated), 39 sei whales were killed for research in 2002 – 2003. The consequences of these deaths on the status and trend of sei whales remains uncertain; however, the renewal of a program that intentional targets and kills sei whales before we can be certain the population has recovered from earlier harvests places this species at risk in the foreseeable future.

Sperm whale

Species description and distribution

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

Sperm whales are rarely found in waters less than 300 meters in depth. They are often concentrated around oceanic islands in areas of upwelling, and along the outer continental shelf and mid-ocean waters. Because they inhabit deeper pelagic waters, these whales generally remain offshore in the eastern Aleutian Islands and Gulf of Alaska.

Sperm whales are widely distributed throughout the Hawaiian Islands year-round (Rice 1960; Shallenberger 1981; Lee 1993; and Mobley *et al.* 2000). Sperm whale clicks recorded from hydrophones off Oahu confirm the presence of sperm whales near the Hawaiian Islands throughout the year (Thompson and Friedl 1982). The primary area of occurrence for the sperm whale is seaward of the shelf break in the Hawaiian Islands Hawaiian Islands Operating Area. There is a rare occurrence of sperm whales from the shore to the shelfbreak.

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

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

Life history information

Female sperm whales become sexually mature at about 9 years of age (Kasuya 1991). Male sperm whales take between 9 and 20 years to become sexually mature, but will require another

10 years to become large enough to successfully compete for breeding rights (Kasuya 1991). Adult females give birth after about 15 months gestation and nurse their calves for 2 to 3 years. The calving interval is estimated to be about four to six years (Kasuya 1991). The age distribution of the sperm whale population is unknown, but sperm whales are believed to live at least 60 years (Rice 1978). Estimated annual mortality rates of sperm whales are thought to vary by age, but previous estimates of mortality rate for juveniles and adults are now considered unreliable (IWC 1980).

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

The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate (Carder and Ridgway 1991). These data suggest that neonatal sperm whales respond to sounds from 2.5-60 kHz. Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975; Watkins *et al.* 1985). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Sperm whales have moved out of areas after the start of air gun seismic testing (Davis *et al.* 1995). Seismic air guns produce loud, broadband, impulsive noise (source levels are on the order of 250 dB) with "shots" every 15 seconds, 240 shots per hour, 24 hours per day during active tests. Because they spend large amounts of time at depth and use low frequency sound sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll *et al* 1999). Furthermore, because of their apparent role as important predators of mesopelagic squid and fish, changes in their abundance could affect the distribution and abundance of other marine species.

Listing status
Sperm whales have been protected from commercial harvest by the IWC since 1981, although the Japanese continued to harvest sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). Sperm whales were listed as endangered under the ESA in 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. Critical habitat has not been designated for sperm whales.

Population status and trends
Current estimates for population abundance, status, and trends for the Alaska stock of sperm whales are not available (Hill and DeMaster 1999). Approximately 258,000 sperm whales in the

North Pacific were harvested by commercial whalers between 1947 and 1987 (Hill and DeMaster 1999). However, this number may be negatively biased by as much as 60% because of under-reporting by Soviet whalers (Brownell *et al*. 1998). In particular, the Bering Sea population of sperm whales (consisting mostly of males) was severely depleted (Perry *et al*. 1999). Catches in the North Pacific continued to climb until 1968, when 16,357 sperm whales were harvested. Catches declined after 1968, in part through limits imposed by the IWC (Rice 1989).

Impacts of human activity on sperm whales
In U.S. waters in the Pacific, sperm whales are known to have been incidentally taken only in drift gillnet operations, which killed or seriously injured an average of 9 sperm whales per year from 1991-1995 (Barlow *et al*. 1997). Of the eight sperm whales observed taken by the California/Oregon drift gillnet fishery, three were released alive and uninjured (37.5 percent), one was released injured (12.5 percent), and four were killed (50 percent) (NMFS 2000). Therefore, approximately 63 percent of captured sperm whales could be killed accidentally or injured (based on the mortality and injury rate of sperm whales observed taken by the U.S. fleet from 1990-2000). Based on past fishery performance, sperm whales are not observed taken in every year; they were observed taken in four out of the last ten years (NMFS 2000). During the three years the Pacific Coast Take Reduction Plan has been in place, a sperm whale was observed taken only once (in a set that did not comply with the Take Reduction Plan; NMFS 2000).

Interactions between longline fisheries and sperm whales in the Gulf of Alaska have been reported over the past decade (Rice 1989, Hill and DeMaster 1999). Observers aboard Alaskan sablefish and halibut longline vessels have documented sperm whales feeding on longline-caught fish in the Gulf of Alaska (Hill and Mitchell 1998) and in the South Atlantic (Ashford and Martin 1996). During 1997, the first entanglement of a sperm whale in Alaska's longline fishery was recorded, although the animal was not seriously injured (Hill and DeMaster 1998). The available evidence does not indicate sperm whales are being killed or seriously injured as a result of these interactions, although the nature and extent of interactions between sperm whales and long-line gear is not yet clear. Ashford and Martin (1996) suggested that sperm whales pluck, rather than bite, the fish from the long-line,.

In 2000, the Japanese Whaling Association announced that it planned to kill 10 sperm whales and 50 Bryde's whales in the Pacific Ocean for research purposes, which would be the first time sperm whales would be taken since the international ban on commercial whaling took effect in 1987. Despite protests from the U.S. government and members of the IWC, the Japanese government harvested 5 sperm whales and 43 Bryde's whales in the last six months of 2000. According to the Japanese Institute of Cetacean Research (Institute of Cetacean Research undated), another 5 sperm whales were killed for research in 2002 – 2003. The consequences of these deaths on the status and trend of sperm whales remains uncertain; however, the renewal of a program that intentional targets and kills sperm whales before we can be certain the population has recovered from earlier harvests places this species at risk in the foreseeable future.

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

Natural Mortality

Natural mortality rates in cetaceans, especially large whale species, are largely unknown. Although factors contributing to natural mortality cannot be quantified at this time, there are a number of suspected causes, including parasites, predation, red tide toxins and ice entrapment. For example, the giant spirurid nematode (*Crassicauda boopis*) has been attributed to congestive kidney failure and death in some large whale species (Lambertson *et al*. 1986). A well-documented observation of killer whales attacking a blue whale off Baja, California proves that blue whales are at least occasionally vulnerable to these predators (Tarpy 1979). Evidence of ice entrapment and predation by killer whales has been documented in almost every population of bowhead whales although the percentage of whales entrapped in ice is considered to be small in this strongly ice-associated species (Tomilin 1957; Mitchell and Reeves 1982; Nerini *et al*. 1984; Philo *et al*. 1993). Other stochastic events, such as fluctuations in weather and ocean temperature affecting prey availability, may also contribute to large whale natural mortality.

Nitta (1991) reported that between 1936 and 1988, 8 humpback whales, 1 fin whale, and 5 sperm whales stranded in the Hawaiian Archipelago. In a partial update of that earlier report, Maldini *et al*. (2005) identified 202 toothed cetaceans that had stranded between 1950 and 2002. Sperm whales represented 10 percent of that total. Although these two studies did not specify the cause or causes of death in these cases, we include these strandings in this discussion of sources of natural mortality because the causes of death remain unknown. Because most of these stranding events consisted of individual animals or because many of the multiple stranding events identified in these reports occurred prior to the mid-1960s (4 of the 8 multiple stranding events identified by Maldini et al. occurred between 1957 and 1959, 3 of 8 occurred in 1976, and 1 occurred in 1981), we assume the strandings had either natural causes. Nevertheless, we discuss possible relationships between stranding events in Hawaii and the RIMPAC exercises in the *Effects of Action* section of this biological opinion.

Human-Induced Mortality

Commercial Whaling and Subsistence Hunting

Large whale population numbers in the proposed action areas have historically been impacted by commercial exploitation, mainly in the form of whaling. Prior to current prohibitions on whaling, such as the International Whaling Commission’s 1966 moratorium, most large whale species had been depleted to the extent it was necessary to list them as endangered under the ESA of 1966.

For example, from 1900 to 1965 nearly 30,000 humpback whales were taken in the Pacific Ocean with an unknown number of additional animals taken prior to 1900 (Perry *et al.* 1999). Sei whales are estimated to have been reduced to 20% (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific (Tillman 1977). In addition, 9,500 blue whales were reported killed by commercial whalers in the North Pacific between 1910-1965 (Ohsumi and Wada 1972); 46,000 fin whales between 1947-1987 (Rice 1984); and 25,800 sperm whales (Barlow *et al* 1997). North Pacific right whales once numbered 11,000 animals but commercial whaling has now reduced their population to 29-100 animals (Wada 1973). Although commercial whaling no longer targets the large, endangered whales in the proposed action areas, historical whaling may have altered the age structure and social cohesion of these species in ways that continue to influence them.

Entrapment and Entanglement in Commercial Fishing Gear

Entrapment and entanglement in commercial fishing gear is one of the most frequently documented sources of human-caused mortality in large whale species. For example, an estimated 78 rorquals were killed annually in the offshore southern California drift gillnet fishery during the 1980s (Heyning and Lewis 1990). From 1996-2000, 22 humpback whales of the Central North Pacific population were found entangled in fishing gear (Angliss *et al*. 2002).

In 1996, a vessel from Pacific Missile Range Facility in Hawaii rescued an entangled humpback, removing two crab-pot floats from the whale. The gear was traced to a recreational fisherman in southeast Alaska (R. Inouye, *personal communication*). To date, no sei whales have been killed in interactions with any eastern North Pacific fisheries, but the true mortality rate must be considered unknown because of unobserved mortality. Sperm whale interactions with the longline fisheries in the Gulf of Alaska are increasing in frequency with the first documented entanglement occurring in June of 1997 (Hill and Mitchell 1998).

The offshore drift gillnet fishery interacts with fin whales: in 1999, one fin whale was killed as a result of interactions with gear that is being used in the Bering Sea/Aleutian Island groundfish trawl fishery. Because the size of the fin whale population remains unknown, the effect of that whale's death on the trend of the fin whale population is uncertain.

Ship Strikes

Collisions with commercial ships are an increasing threat to many large whale species, particularly as shipping lanes cross important large whale breeding and feeding habitats or migratory routes. 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 – 1998, two fin whales were presumed to have been killed in ship strikes.

Despite these reports, the magnitude of the risks commercial ship traffic poses to large whales in the Action Area is difficult to quantify or estimate. We struggle to estimate the number of whales that are killed or seriously injured in ship strikes within the U.S. Exclusive Economic Zone and have virtually no information on interactions between ships and commercial vessels outside of

U.S. waters in the North Pacific Ocean. With the information available, we know those interactions occur but we cannot estimate their significance to the different species of whales in the Action Area

Habitat Degradation
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 a lower reproduction fitness (Durbin *et al.* 2002). Other human activities, including discharges from wastewater systems, dredging, ocean dumping and disposal, aquaculture and additional impacts from coastal development are also known to impact marine mammals and their habitat. In the North Pacific, undersea exploitation and development of mineral deposits, as well as dredging of major shipping channels pose a continued threat to the coastal habitat of right whales. Point-source pollutants from coastal runoff, offshore mineral and gravel mining, at-sea disposal of dredged materials and sewage effluent, potential oil spills, as well as substantial commercial vessel traffic, and the impact of trawling and other fishing gear on the ocean floor are continued threats to marine mammals in the proposed action area.

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

Anthropogenic Noise. The marine mammals that occur in the action area are regularly exposed to several sources of natural and anthropogenic sounds. Anthropogenic noises that could affect ambient noise arise from the following general types of activities in and near the sea, any combination of which can contribute to the total noise at any one place and time. These noises include transportation, dredging, construction; oil, gas, and mineral exploration in offshore areas; geophysical (seismic) surveys; sonars; explosions; and ocean research activities (Richardson *et al*. 1995). Table 4 shows the source levels for selected sources of anthropogenic low frequency underwater noise.

Noise in the marine environment has received a lot of attention in recent years and is likely to continue to receive attention in the foreseeable future. Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years ((Jasny *et al*. 2005; NRC 1994, 1996, 2000, 2003, 2005; Richardson *et al*. 1995). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003). The military uses sound to test the construction of new vessels as well as for naval operations. In some areas where oil and gas production takes place, noise originates from the drilling and production platforms, tankers, vessel and aircraft support, seismic surveys, and the explosive removal of platforms (NRC 2003). Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construct-ion, geological explorations, etc. (Richardson *et al.* 1995). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Baker *et al.* 1983; Bauer and Herman 1986; Hall 1982; Krieger and Wing 1984), but the long-term effects, if any, are unclear or not detectable. Carretta *et al.* (2001) and Jasny *et al.* (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate.

Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans (Simmonds and Hutchinson 1996). The Navy estimated that the 60,000 vessels of the world's merchant fleet annually emit low frequency sound into the world's oceans for the equivalent of 21.9 million days, assuming that 80 percent of the merchant ships at sea at any one time (U.S. Navy 2001). The radiated noise spectrum of merchant ships ranges from 20 to 500 Hz and peaks at approximately 60 Hz. Ross (1976) has estimated that between 1950 and 1975 shipping had caused a rise in ambient ocean noise levels of 10 dB. He predicted that this would increase by another 5 dB by the beginning of the 21st century. NRC (1997) estimated that the background ocean noise level at 100 Hz has been increasing by about 1.5 dB per decade since the advent of propeller-driven ships.

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

Deep Water Ambient Noise. Urick (1983) provided a discussion of the ambient noise spectrum expected in the deep ocean. Shipping, seismic activity, and weather are primary causes of deep-water ambient noise. Noise levels between 20 and 500 Hz appear to be dominated by distant shipping noise that usually exceeds wind-related noise. Above 300 Hz, the level of wind-related noise might exceed shipping noise. Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500 to 50,000 Hz. The 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.

Table 4. Summary and comparison of source levels for selected sources of anthropogenic low frequency underwater noise

Sound Source (Transient)	Source Level in dB
Seismic Survey - Air gun array (32 guns) (Impulsive - Peak)	259[1] Broadband

Explosions (Impulsive)		
0.5 kg (1.1 lb) TNT		267[1] Broadband
2 kg (4.4 lb) TNT	Peak	271[1] Broadband
20 kg (44 lb) TNT	Peak	279[1] Broadband
4,536 kg (10,000 lb) TNT	Peak	>294[2] Broadband
Ocean Acoustics Studies		
Heard Island Test		220[1] Spectrum Level
ATOC		195[1] Spectrum Level
Vessels Underway		
Tug and Barge (18 km/hour)		171[1] Broadband
Supply Ship (*Kigoriak*)		181[1] Broadband
Large Tanker		186[1] Broadband
Icebreaking		193[1] Broadband

Notes: All dB re 1 μPa at 1 m.
Sources: 1. Richardson *et al*. 1995b.
2. Urick 1983.

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

Commercial and Private Marine Mammal Watching
In addition to the federal vessel operations, private and commercial shipping vessels, vessels (both commercial and private) engaged in marine mammal watching also have the potential to impact whales in the proposed action area. A recent study of whale watch activities worldwide has found that the business of viewing whales and dolphins in their natural habitat has grown rapidly over the past decade into a billion dollar ($US) industry involving over 80 countries and territories and over 9 million participants (Hoyt 2001). In 1988, a workshop sponsored by the Center for Marine Conservation and the NMFS was held in Monterey, California to review and evaluate whale watching programs and management needs (CMC and NMFS 1988). That workshop produced several recommendations for addressing potential harassment of marine mammals during wildlife viewing activities that include developing regulations to restrict operating thrill craft near cetaceans, swimming and diving with the animals, and feeding cetaceans in the wild.
Since then, NMFS has promulgated regulations at 50 CFR 224.103 that specifically prohibit: (1) the negligent or intentional operation of an aircraft or vessel, or the doing of any other negligent or intentional act which results in disturbing or molesting a marine mammal; (2) feeding or attempting to feed a marine mammal in the wild; and (3) approaching humpback whales in

Hawaii and Alaska waters closer than 100 yards (91.4 m). In addition, NMFS launched an education and outreach campaign to provide commercial operators and the general public with responsible marine mammal viewing guidelines which in part state that viewers should: (1) remain at least 50 yards from dolphins, porpoise, seals, sea lions and sea turtles and 100 yards from large whales; (2) limit observation time to 30 minutes; (3) never encircle, chase or entrap animals with boats; (4) place boat engine in neutral if approached by a wild marine mammal; (5) leave the water if approached while swimming; and (6) never feed wild marine mammals. In January 2002, NMFS also published an official policy on human interactions with wild marine mammals which states that: "*NOAA Fisheries cannot support, condone, approve or authorize activities that involve closely approaching, interacting or attempting to interact with whales, dolphins, porpoises, seals or sea lions in the wild. This includes attempting to swim with, pet, touch or elicit a reaction from the animals.*"

Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational and scientific benefits, marine mammal watching is not without potential negative impacts. One concern is that animals may become more vulnerable to vessel strikes once they habituate to vessel traffic (Swingle *et al*. 1993; Wiley *et al*. 1995). Another concern is that preferred habitats may be abandoned if disturbance levels are too high. In the Notice of Availability of Revised Whale Watch Guidelines for Vessel Operations in the Northeastern United States (64 FR 29270; June 1, 1999), NMFS noted that whale watch vessel operators seek out areas where whales concentrate, which has led to numbers of vessels congregating around groups of whales, increasing the potential for harassment, injury or even the death of these animals.

Several investigators have studied the effects of whale watch vessels on marine mammals (Amaral and Carlson 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al*. 2002, Richter *et al*. 2003, Scheidat *et al*. 2004, Simmonds 2005, Watkins 1986, Williams *et al*. 2002). The whale's behavioral responses to whale watching vessels depended on the distance of the vessel from the whale, vessel speed, vessel direction, vessel noise, and the number of vessels. The whales' responses changed with these different variables and, in some circumstances, the whales did not respond to the vessels, but in other circumstances, whales changed their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions.

Scientific Research

Marine mammals have been the subject of field studies for decades. The primary objective of most of these studies has generally been monitoring populations or gathering data for behavioral and ecological studies. Over time, NMFS has issued dozens of permits for various non-lethal forms of "take" of marine mammals in the proposed action area from a variety of activities, including aerial and vessel surveys, photo-identification, remote biopsy sampling, and attachment of scientific instruments (see Table 5 for species-specific estimates of the number of individual whales that have been authorized to be "taken" for various types of studies).

Table 5 identifies the total number of interactions currently authorized by various permits that NOAA has issued for various studies and research. For example, existing permits authorized different investigators to harass, pursue, shoot, and wound about 400 endangered North Pacific right whales each year for photo-identification and behavioral observation; harass, pursue, and shoot up to 60 of these right whales per year to place tags; harass, pursue, shoot, and wound 15 cows and calves to take biopsy samples; and harass and pursue 2,300 of these whales incidental to other activities. Since the right whale population in the North Pacific has been estimated to consist of between 29 and 100 individuals (less than 30 individual whales have been identified since the 1950s), existing permits allow investigators to harass each of these endangered whales several times for different research purposes.

Existing permits authorize investigators to make close approaches of other endangered whales species for photographic identification, behavioral observations, passive acoustic recording, aerial photogrammetry, and underwater observation (Table 4, row 3). Existing permits authorize up to 6740 close approaches of blue whales, 13680 close approaches of fin whales, 24490 close approaches of humpback whales, 400 close approaches of north Pacific right whales, 3000 close approaches of sei whales, and 20020 close approaches of sperm whales per year in the Pacific Ocean for these purposes. In addition, existing permits authorize close approaches to collect biopsy samples of 985 blue whales, 2385 fin whales, 3210 humpback whales, 60 north Pacific right whales, 520 sei whales, and 1325 sperm whales per year in the Pacific Ocean.

The actual number of close approaches does not appear to have closely approximated the number of close approaches authorized by existing permits. Nevertheless, because existing permits authorize the number of close approaches identified in Table 4, nothing prevents the different whale species from being exposed to those levels of close approaches by different investigators each year.

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

The Impact of the Baseline on Listed Resources

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

Historically, commercial whaling had occurred in the action area and had caused all of the large whales to decline to the point where the whales faced risks of extinction that were high enough to list them as endangered species. Since the end of commercial whaling, the primary threat to these

Table 5. The total number of the different endangered species of whale that have been authorized to be harassed, pursued, shot, wounded, etc. associated with different categories of activity

Activity	Species							
	Blue Whale		Fin Whale		Right Whale[a]		Sperm Whale	
	Current	Proposed	Current	Proposed	Current	Proposed	Current	Proposed
Audiometric & sonocular on stranded animals	15	0	15	0	15	0	15	0
Photo-ID, Behavioral Observation, Passive Acoustic, Aerial Photogrammetry, and Underwater Observation.	6740	250	13680	250	400	0	20020	0
Biopsy	985	0	2385	0	60	0	1325	0
Biopsy of cows & calves	0	0	0	0	15	0	0	0
Tagging	155	20	150	20	10	0	135	0
Incidental Harassment	1220	0	1220	0	20	0	1220	0
Non-target incidental harassment	0	0	0	0	0	0	0	0
Critter-cam	0	0	0	0	0	0	0	0
Playback exposure	0	0	0	0	0	0	0	0
Unintentional playback exposure	0	0	0	0	0	0	0	0
Collection of parts from dead animals	0	0	0	0	0	0	0	0

a. North Pacific right whale

Estimated Number of Whales Exhibiting Responses to Close Approaches for Photo-Identification, Behavioral Observation, Passive Acoustic, Aerial Photogrammetry, and Underwater Observation at authorized level (does not include close approaches for biopsy sampling or incidental harassment)

No Responses	472	18	958	18	28	0	1,401	0
Low-level Responses	1,806	67	3,666	67	107	0	5,365	0
Moderate responses	4,084	152	8,290	152	242	0	12,132	0
Strong responses	377	14	766	14	22	0	1,121	0
Total	6,740	250	13,680	250	400	0	20,020	0

b Relative frequency of responses based on results from Weinrich et al. 1992 species has been eliminated. However, all of the whale species have not recovered from those historic declines and scientists cannot determine if those initial declines continue to influence current populations of most large whale species. Species like Pacific right whales have not begun to recover from the effects of commercial whaling on their populations and continue to face very high risks of extinction in the foreseeable future because of their small population sizes (on the order of 50 individuals) and low population growth rates. Relationships between potential stressors in the marine environments and the responses of these species that may keep their populations depressed are unknown.

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

The trends of whale populations in the Hawaiian Archipelago remains uncertain and changes in those trends may reflect improvements in sampling techniques or changes in their geographic distribution. For example, there is still almost no information on the distribution, population size and trend of blue whale population in the Hawaiian Islands; without that information, it would be impossible to determine if this population is increasing or not. Some of the evidence available suggests that the central North Pacific sub-population of humpback whales has been increasing, while other evidence available suggests that the western North Pacific population is declining.

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

Gauthier and Sears (1999), Weinrich *et al.* (1991, 1992), Clapham and Mattila (1993), Clapham *et al.* (1993) concluded that close approaches for biopsy samples or tagging did cause humpback whales to respond or caused them to exhibit "minimal" responses when approaches were "slow and careful." This caveat is important and is based on studies conducted by Clapham and Mattila (1993) of the reactions of humpback whales to biopsy sampling in breeding areas in the

Caribbean Sea. These investigators concluded that the way a vessel approaches a group of whales had a major influence on the whale's response to the approach; particularly cow and calf pairs. Based on their experiments with different approach strategies, they concluded that experienced, trained personnel approaching humpback whales slowly would result in fewer whales exhibiting responses that might indicate stress.

At the same time, several lines of evidence suggest that these human activities might 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 *et al.* (1981) found that both fin and humpback whales appeared to react to vessel approach by increasing swim speed, exhibiting a startled reaction, and moving away from the vessel with strong fluke motions.

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

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

Jahoda *et al*. (2003) studied the response of 25 fin whales in feeding areas in the Ligurian Sea to close approaches by inflatable vessels and to biopsy samples. They concluded that close vessel approaches caused these whales to stop feeding and swim away from the approaching vessel. The whales also tended to reduce the time they spent at surface and increase their blow rates, suggesting an increase in metabolic rates that might indicate a stress response to the approach. In their study, whales that had been disturbed while feeding remained disturbed for hours after the exposure ended. They recommended keeping vessels more than 200 meters from whales and having approaching vessels move a low speeds to reduce visible reactions in these whales. Beale and Monaghan (2004) concluded that the significance of disturbance was a function of the distance of humans to the animals, the number of humans making the close approach, and the frequency of the approaches. These results would suggest that the cumulative effects of the various human activities in the action area would be greater than the effects of the individual activity. None of the existing studies examined the potential effects of numerous close approaches on whales or gathered information of levels of stress-related hormones in blood samples that are more definitive indicators of stress (or its absence) in animals.

There is mounting evidence that wild animals respond to human disturbance in the same way that they respond to predators (Beale and Monaghan 2004, Frid 2003, Frid and Dill 2002, Gill *et al*. 2000, Gill and Sutherland 2001, Harrington and Veitch 1992, Lima 1998, Romero 2004). These responses manifest themselves as stress responses (in which an animal perceives human activity as a potential threat and undergoes physiological changes to prepare for a flight or fight response or more serious physiological changes with chronic exposure to stressors), interruptions of essential behavioral or physiological events, alteration of an animal's time budget, or some combinations of these responses (Frid and Dill 2002, Romero 2004, Sapolsky *et al*. 2000, Walker *et al*. 2005). These responses have been associated with abandonment of sites (Sutherland and Crockford 1993), reduced reproductive success (Giese 1996, Mullner *et al*. 2004), and the death of individual animals (Daan *et al*. 1996, Feare 1976, Waunters *et al*. 1997).

The 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. With the exception of some sea turtles and Hawaiian monk seals, the age composition, gender ratios, population abundance, and changes in that abundance over time remain unknown. With the exception of captures, deaths, and injuries associated with commercial fisheries in Hawaiian waters, there is limited information on the outcomes of interactions between threatened and endangered animals in the Hawaiian Archipelago and natural and anthropogenic hazards in this region. What little information is available does not allow us to identify potential consequences on the physiological, behavioral, and social ecology of threatened and endangered species in Hawaii, all of which have important consequences for the status and trend of populations of these species. 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.

Effects of the Proposed Action

The Endangered Species Act does not define harassment nor has NMFS defined this term, pursuant to the ESA, through regulation. However, the Marine Mammal Protection Act of 1972, as amended, defines harassment as any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [16 U.S.C. 1362(18)(A)]. For military readiness activities, this definition of harassment has been amended to mean "any act that disrupts or is likely to disturb a marine mammal or marine mammal stock by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significatly altered" (Public Law 106-136, 2004). The latter portion of these definitions (that is, "...causing disruption of behavioral patterns including... migration, breathing, nursing, breeding, feeding, or sheltering") is almost identical to the U.S.

Fish and Wildlife Service's regulatory definition of harass[3].

For this biological opinion, we define harassment similarly: an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents. We are particularly concerned about behavioral disruptions that may result in animals that fail to feed or breed successfully or fail to complete their life history because these responses are likely to have population-level consequences.

Potential Stressors

During our assessment, we considered several potential stressors associated with the proposed action: potential ship strikes, discharges and potential pollutants associated with the vessels that will participate in the proposed RIMPAC exercises, sounds generated by the vessels' engines, and acoustic energy introduced into the marine environment by the active sonar systems those vessels will employ. Based on our review of the data available, the proposed RIMPAC exercises are likely to cause two primary stressors: (1) the ship traffic and associated risks of ship strikes or collisions, and (2) acoustic energy introduced into the marine environment by active sonar systems (active sonar systems AN/SQ-53C and AN/SQ-56). The narratives that follow describe these two stressors in greater detail, describe the probability of listed species being exposed to these stressors based on the best scientific and commercial evidence available, then describe the probable responses of listed species, given probable exposures, based on the evidence available.

Based on our review of the data available, threatened or endangered species under NMFS' jurisdiction are either not likely to be exposed to two stressors or those exposures are not likely to occur because of the measures proposed by the U.S. Navy or imposed on the Navy through the Incidental Harassment Authorization (see further discussion of these conclusions in the *Consultation History* and *Status of the Species* sections of this opinion).

Ship Traffic

The proposed RIMPAC exercises will involve between 20 and 60 surface vessels moving at differing speeds in the Action Area. Given the speeds at which these vessels are likely to move, they pose potential hazards to marine mammals. In addition, the exercises will involve between 1 and 10 submarines that pose a potential hazard to whales when they are moving at the water surface.

The Navy's operational orders for ships (and aircraft) that are underway are designed to prevent collisions between surface vessels participating in the RIMPAC exercises and endangered whales that might occur in the action area. These measures, which include observers on the bridge of ships, requirements for course and speed adjustments to maintain safe distances from whales, and having any ship that observes whales to alert other ships in the area, have historically been effective measures for avoiding collisions between surface vessels and whales. The additional requirements contained in the proposed Incidental Harassment Authorization are likely to insure

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

that surface vessels and surfaces submarines have personnel on lookout when a vessel is moving through water or operating sonar, that Navy observers have been trained to identify whales, other marine mammals and their behavior, and the imposition of safety zones should reduce the likelihood of collisions between these vessels and endangered whales that might be in the area.

Although the probability of a collision seem fairly small given the measures that are in place, the close proximity of 20 to 60 additional surface vessels engaged in training maneuvers in the Action Area poses some risk of disturbing large whales that might occur in the Action Area. Particularly when that traffic is placed in the context of animals that are likely to have had extensive prior experience with existing levels of vessel traffic associated with inter-island transportation, commercial ship traffic, whale-watching vessels, leisure cruises, and research vessels that were discussed in the *Environmental Baseline* of this Opinion.

We assume that fin, sei, and sperm whales that might be exposed to mid-frequency sonar associated with the anti-submarine elements of the proposed RIMPAC exercises might be close enough to the exercises to be aware of the vessel traffic and related activities associated with surface ship maneuvers (see Table 5 for estimates of the number of whales that might be affected by these maneuvers). We also assume that whales that are closer to those exercises have a greater probability of exhibiting behavioral responses to the ship traffic.

We expect fin, sei, and sperm whales to respond to the ship traffic associated with the maneuvers might approximate their responses to whale watch vessels. As discussed in the Environmental Baseline section of this Opinion, those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver. Particular whales' might not respond to the vessels, while in other circumstances, whales are likely to change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Amaral and Carlson 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al*. 2002, Richter *et al*. 2003, Scheidat *et al*. 2004, Simmonds 2005, Watkins 1986, Williams *et al*. 2002).

Mid-Frequency Sonar

Naval sonars operate on the same basic principle as fish-finders (which are also a kind of sonar): brief pulses of sound, or "pings," are projected into the ocean and an accompanying hydrophone system in the sonar device listens for echoes from targets such as ships, mines or submarines. Several sonar systems are likely to be employed during the proposed RIMPAC exercises, but two systems in particular pose potential risks to listed resources (we should note that other navies that might be involved in the proposed exercises, such as Canada, employ similar active sonar systems as well, but we do not have the information necessary to describe those systems).

The AN/SQS-53 is a large active-passive bow-mounted sonar that has been operational since 1975. AN/SQS-53 is the U.S. Navy's most powerful surface ship sonar and is installed on Spruance (10 units), Ticonderoga (27 units), and Arleigh Burke I/II/IIIa class vessels in the U.S. Navy (Polmar 2001, D`Spain *et al*. 2006). This sonar transmits at center frequencies of 2.6 kHz and 3.3 kHz at sources levels up to 235 dB_{RMS} re: 1 μPa at 1 meter. The sonar has pulse durations between 1 and 2 seconds, with about 24-second intervals between pulses. AN/SQS-53 operates at depths of about 8 meters.

The AN/SQS-56 is a lighter active-passive bow-mounted sonar that has been operational since 1977. AN/SQS-56 is installed on FFG-7 (33 units) class guided missile frigates in the U.S. Navy (Polmar 2001, D`Spain *et al*. 2006). This sonar transmits at center frequencies of 6.8 kHz, 7.5 kHz, and 8.2 kHz. at 223 dB_{RMS} re: 1 μPa at 1 meter source level. This sonar also has pulse durations between 1 and 2 seconds, with about 24-second intervals between pulses. AN/SQS-56 operates at depths of about 6 meters.

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

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

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

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

Exposure Analysis

As discussed in the Approach to the Assessment section of this opinion, exposure analyses are designed to identify the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence. In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an Action's effects and the populations or subpopulations those individuals represent.

The U.S. Navy developed and ran computer simulations to estimate the number of marine mammals that might be exposed to different received levels of mid-frequency sonar (U.S. Navy 2006; see Appendix C of that document for a more detailed presentation of the Navy's modeling procedures). The Navy's models assumed ship speeds of 10 knots for all exercises except those taking place in Area 4 where speeds were modeled at 20 knots. All active sonar was modeled using the operational characteristics of the AN/SQS-53C. The Navy models made several assumptions related to potential exposure of marine mammals to this acoustic source:

1. acoustic energy would be constant throughout the vertical water column at a given horizontal range from the source;
2. marine mammal hearing is omni-directional;
3. marine mammals were static (not moving) at the maximum acoustic energy depth at any range.

The Navy's model included several other considerations or assumptions about marine mammals. First, the model considered the density and hearing of marine mammals (it did not consider their distribution or diving behavior). However, their analysis made no attempt to predict animal behavior in response to sound in the water or their location relative to the point where the source initiates operation. That is, the model did not assume that a marine mammal would leave an area once it heard the sonar. Second, the model assumed that mammals were exposed to the maximum received levels calculated for the horizontal distance to the source at any water depth for that distance although direct path sound transmission was not always likely.

Based on their simulations, the Navy concluded that cetaceans would not be exposed to received levels that might result in their death or injury. The Navy estimated that three endangered whales — fin whales, sei whales, and sperm whales — might be exposed to received levels between 173 dB and 215 dB (Table 6).

We interpret the estimates in Table 6 as the number of times whales might experience exposures that accumulate energy to a particular exposure level (which we call the number of exposure events). Using fin whales as an example, we interpret Table 6 to mean that we can expect about 61 instances in which a fin whale might experience exposures equivalent to a single, one-second exposure between 173 and 195 dB (which we define as an "exposure event"). However, we believe it would be unrealistic to assume that each exposure event involves a different whale; some whales are likely to be exposed once while other whales are more likely to be exposed on multiple days. To estimate the probability of individual whales being exposed multiple times we assumed that exposure events would be distributed normally and allocated the Navy's estimates

Table 6. Estimated number of times whales of the different species might accumulate energy that is equivalent to >173, 173 -195, and 195 - 215 dB rms^2 for 1 second (from U.S. Navy 2006)				
Species	**Estimated Abundance**	**Estimated No. of Exposure Events**		
		173 - 195 dB	**195 - 215 dB**	**> 173**
Fin whale	~ 174	61	3	64
Sei whale	~ 77	27	1	28
Sperm whale	~ 7,000	1417	34	1,451

of the number of times whales might experience exposures that accumulate to a particular exposure level according to the areas contained within the different standard deviations of a normal distribution.

Continuing to use fin whales as an example, the Navy estimated that there might be 61 instances in which fin whales might accumulate energy equivalent to a single, one-second exposure between 173 and 195 dB. We assumed that 68.26% of these instances would involve a single whale exposed to that energy equivalent once, 27.18% of these instances would involve a single whale that exposed to that energy equivalent twice, 4.28% of these exposures would involve a single whale exposed to that energy equivalent three times, and 0.2636% would involve a single whale exposed to that energy equivalent four times (which generally applied only to sperm whales).

Fin whales. The Navy's simulations identified 61 instances in which fin whales might accumulate energy that is equivalent to between 173 and 195 dB during the proposed RIMPAC exercises (a total of 64 instances in which fin whales might accumulate energy equivalent to more than 173 dB). Based on our analyses, we assume that 42 of these instances might involve a single, individual fin whale accumulates energy equivalent to between 173 and 195 dB on one occasion; another 8 instances in which a single, individual fin whales accumulates this energy equivalent on two occasions; and once instance in which a single, individual fin whale accumulates this energy equivalent on three occasions.

The Navy's simulations also identified 3 instances in which fin whales might accumulate energy equivalent to 195 – 215 dB. Based on our analyses, we assume that 2 of these instances might involve a single, individual fin whale accumulates energy equivalent to between 173 and 195 dB on one occasion; once instance in which a single, individual fin whale accumulates this energy equivalent on three occasions.

The fin whales that might be exposed to the proposed RIMPAC exercises, particular mid-frequency sonar transmissions and ship traffic, would represent individuals from the Hawaiian population (or "stock"). We assume that any age or gender might be exposed to those received levels.

Sei Whales. The Navy's simulations identified 27 instances in which sei whales might accumulate energy that is equivalent to between 173 and 195 dB. Based on our analyses, we assume that 18 of these instances might involve a single, individual fin whale accumulates energy equivalent to between 173 and 195 dB on one occasion; another 4 instances in which a single, individual fin whales accumulates this energy equivalent on two occasions; and once instance in which a single, individual fin whale accumulates this energy equivalent on three occasions. The Navy's simulations also identified 1 instance in which a sei whale might accumulate energy equivalent to 195 – 215 dB (a total of 28 instances in which sei whales might accumulate energy equivalent to more than 173 dB).

Sperm Whales. The Navy's simulations identified 1,417 instances in which sperm whales might accumulate energy that is equivalent to between 173 and 195 dB during the proposed RIMPAC exercises. Based on our analyses, we assume that 967 of these instances might involve a single, individual sperm whale accumulates energy equivalent to between 173 and 195 dB on one occasion; 193 of these instances might involve a single, individual sperm whale accumulates energy equivalent to between 173 and 195 dB on two occasions; 20 of these instances might involve a single, individual sperm whale accumulates energy equivalent to between 173 and 195 dB on 3 occasions; and 1 instance in which a single, individual sperm whale accumulates this energy equivalent on one occasion.

The Navy's simulations also identified 34 instances in which sperm whales might accumulate energy that is equivalent to between 195 and 215 dB during the proposed RIMPAC exercises. Based on our analyses, we assume that 23 of these instances might involve a single, individual sperm whale accumulates energy equivalent to between 173 and 195 dB on one occasion; 5 of these instances might involve a single, individual sperm whale accumulates energy equivalent to between 173 and 195 dB on two occasions; and 1 instance in which a single, individual sperm whale accumulates this energy equivalent on one occasion.

Data on the hearing range of sperm whales were developed using evoked potentials from a stranded neonate (Carder and Ridgway 1991). These data suggest that neonatal sperm whales respond to sounds from 2.5-60 kHz.

The sperm whales that might be exposed to the proposed RIMPAC exercises, particular mid-frequency sonar transmissions and ship traffic, would represent individuals from a Hawaiian population (or "stock"). Sperm whales are widely distributed throughout the Hawaiian Islands year-round (Rice 1960; Shallenberger 1981; Lee 1993; and Mobley *et al.* 2000). Sperm whale clicks recorded from hydrophones off Oahu confirm the presence of sperm whales near the Hawaiian Islands throughout the year (Thompson and Friedl 1982). The primary area of occurrence for the sperm whale is seaward of the shelf break in the Hawaiian Islands Hawaiian Islands Operating Area. Sperm whales rarely occur from the shore to the shelf break.

Response Analysis

As discussed in the approach to the assessment section of this biological opinion, response analyses determine how listed resources are likely to respond after being exposed to an Action's effects on the environment or directly on listed species themselves. For the purposes of consultations on activities involving sonar, our assessments try to detect the probability of lethal responses, sensory impairment (permanent and temporary threshold shifts and acoustic masking), physiological responses (particular stress responses), behavioral responses, and social responses that might result in reducing the fitness of listed individuals. Ideally, our response analyses consider and weigh evidence of adverse consequences, beneficial consequences, or the absence of such consequences.

Responses to Mid-Frequency Sonar Exposures. Naval sonars are designed for three primary functions: submarine hunting, mine hunting and shipping surveillance. There are two classes of sonars employed by navies: *active* sonars and *passive* sonars. Passive sonars generate no noise at all (they locate submarines and ships merely by listening for them) and are therefore not a concern. Active sonars, in contrast, can generate a considerable amount of high intensity noise and are of definite concern, with regards to their effect on marine wildlife.

The effects of naval sonars on marine wildlife have not been studied as extensively as the effects of airguns used in seismic surveys. In the Caribbean, avoidance reactions were observed for sperm whales exposed to mid-frequency submarine sonar pulses, in the range 1000 Hz to 10,000 Hz. Recently, the US Navy sponsored tests of the effects of low-frequency active (LFA) sonar source, between 100 Hz and 1000 Hz, on blue, fin, and humpback whales. The tests demonstrated that whales exposed to sound levels up to 155 dB did not exhibit significant disturbance reactions, though there was evidence that humpback whales altered their vocalization patterns in reaction to the noise. Given that the source level of the Navy's LFA is reported to be in excess of 240 dB, the possibility exists that animals in the wild may be exposed to sound levels much higher than 155dB.

Acoustic exposures have been demonstrated to kill marine mammals, result in physical trauma, and injury (Ketten 2005). Animals in or near an intense noise source can die from profound injuries related to shock wave or blast effects. Acoustic exposures can also result in noise induced hearing loss that is a function of the interactions of three factors: sensitivity, intensity, and frequency. Loss of sensitivity is referred to as a threshold shift; the extent and duration of a threshold shift depends on a combination of several acoustic features and is specific to particular species. A shift may be temporary (temporary threshold shift or TTS) or it may be permanent (permanent threshold shift or PTS) depending on how the frequency, intensity and duration of the exposure combine to produce damage. In addition to direct physiological effects, noise exposures can cause impair an animal's sensory abilities (masking) or result in behavioral responses such as aversion or attraction.

Acoustic exposures can also result in the death of an animal by impairing its foraging, ability to detect predators or communicate, or by increasing stress, disrupting important physiological events. The narratives that follow evaluate the general information available on the variety of ways in which cetaceans have been reported to respond to sound, generally, and mid-frequency sonar, in particular. Then we assess the probable responses of fin, sei, and sperm whales given their probable exposure to mid-frequency sonar associated with the proposed RIMPAC exercises.

Stranding Events

A stranded marine mammal is defined as "any dead marine mammal on a beach or floating nearshore; any live cetacean on a beach or in water so shallow that it is unable to free itself and resume normal activity; any live pinniped which is unable or unwilling to leave the shore because of injury or poor heath" (Gulland *et al*. 2001, Wilkinson 1991). Marine mammals are known to strand for a variety of reasons, but the cause or causes of most stranding are largely unknown (Geraci *et al*. 1976, Eaton 1979, Odell *et al*. 1980, Best 1982). Several studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them the strand when exposed to another phenomenon. For example, several studies of stranded marine mammals suggest a linkage between unusual mortality events and body burdens of toxic chemicals in the stranded animals (Kajiwara *et al*. 2002, Kuehl and Haebler 1995, Mignucci-Giannoni *et al*. 2000). These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Chroussos 2000, Creel 2005, DeVries et al. 2003, Fair and Becker 2000, Foley *et al*. 2001, Moberg 2000, Relyea 2005a, 2005b, Romero 2004, Sih *et al*. 2004).

Those studies suggest that, in many animal species, disease, reproductive state, age, experience, stress loading, energy reserves, and genetics combine with other stressors like body burdens of toxic chemicals to create fitness consequences in individual animals that would not occur without these risk factors. The contribution of potential risk factors to stranding events still remains unknown, but the abundance of literature available suggests that a relationship almost certainly exists.

Over the past three decades, several "mass stranding" events – strandings 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 anthropgenic activities that introduce sound into the marine environment.

Although few of these events involve threatened or endangered species, we consider them in this Opinion to determine if listed cetaceans are likely to strand following potential exposure to mid-frequency sonar. To conduct our analyses, we collected information on mass stranding events (events in which two or more cetaceans stranded) that have occurred for which reports are available from the past 40 years and identified any causal agents that have been associated with those stranding events (see Table 7). As part of these analyses, we examined stranding information from the Hawaiian Islands that has been collected since the late 1930s. Because 19 RIMPAC exercises that have included anti-submarine warfare exercises that have used mid-frequency have occurred in the Hawaiian Islands since 1968, we examined the number and timing of stranding events in the Hawaiian Islands to detect potential relationships with the conduct of the RIMPAC exercises.

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 IWC (2005) identified ten mass stranding events of Cuvier's beaked whales had been reported and one mass stranding of four Baird's beaked whale (*Berardius bairdii*). The IWC concluded that, out of eight stranding events reported from the mid-1980s to the summer of 2003, seven have been associated with the use of mid-frequency sonar, one of those seven has been associated with the use of low-frequency sonar, and the remaining stranding event has been associated with the use of seismic airguns.

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

In our review of 70 reports of mass stranding events between 1960 and 2006, 48 (68%) involved beaked whales, 3 (4%) involved dolphins, and 14 (20%) involved whale species. Cuvier's beaked whales were involved in the greatest number of these events (48 or 68%), followed by sperm whales (7 or 10%), and Blainville and Gervais' beaked whales (4 each or 6%). Naval activities that might have involved tactical sonars are reported to have coincided with 9 (13%) or 10 (14%) of those stranding events. Between the mid-1980s and 2003 (the period reported by the IWC), 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.

In 1998, the North Atlantic Treaty Organization (NATO) Supreme Allied Commander, Atlantic Center Undersea Research Centre that conducted the sonar tests convened panels to review the data associated with the maneuvers in 1996 and beaked whale stranding events in the Mediterranean Sea. The report of these panels presented more detailed acoustic data than were available for beaked whales stranded in the Canary Islands (SACLANTCEN 1998). The NATO sonar transmitted two simultaneous signals lasting four seconds and repeating once every minute.

The simultaneous signals each were broadcast at source levels of just under 230 dB re 1 μPa at 1 m. One of the signals covered a frequency range from 450-700 Hz and the other one covered 2.8-3.3 kHz. The *Ziphius* strandings in the Kyparissiakos Gulf occurred during the first two sonar runs on each day of 12 and 13 May 1996. The close timing between the onset of sonar transmissions and the first stranding events suggests closer synchrony between the onset of the transmissions and the stranding events than was presented in Frantzis (1998). However, the Bioacoustics Panel convened by NATO was unable to reach a definitive conclusion due to the lack of evidence of direct physical injury because no viable tissue samples suitable for laboratory analysis were recovered from any of the animals. Their official finding was "An acoustic link can neither be clearly established nor eliminated as a direct or indirect cause for the May 1996 strandings."

Concern about potential causal relationships between low-frequency sonar and marine mammal stranding resurfaced after a beaked whale stranding in the Bahamas in 2000. Fox *et al*. (2001)

Table 7. Information on stranding events that have been correlated with or implicated sonar

	Type of Sonar				**Species Groups**				
Incident	**LFA**	**Other LF Source**	**MF Sonar**	**HF Sonar**	**Fish**	**Sea Turtle**	**Baleen Whale**	**Toothed Whale**	**Beaked Whale**
Canary Islands – 1980s (3)									
Present	no	no	yes		?	?	?	?	yes
Stranding event?									yes
Canary Islands – 1991									
Present	no	yes	yes		?	?	?	?	yes
Stranding event?									yes
Mediterranean – 1996									
Present	no	yes	yes		?	?	?	?	yes
Stranding event?									yes
Bahamas – 2000									
Present	no	no	yes	?	?	?	yes	yes	yes
Stranding event?							yes	yes	yes
California – 2002									
Present	no	airgun	no		?	?	?	?	yes
Stranding event?									yes
Puget Sound – 2003									
Present?	no	no	yes	?	?	?	?	yes	no
Stranding event?								yes	no
Hanalei Bay - 2004									
Present?	no	no	yes	?	?	?	?	?	yes
Stranding event?					?	?	no	no	yes
North Carolina - 2005									
Present?	no	no	yes						
Stranding event?				?	?	?	yes	yes	no

ruled out natural sound sources as a possible cause of the stranding, which pointed to an anthropogenic source. In 2001, the Joint Interim Report, Bahamas Marine Mammal Stranding Event of 14-16 March 2000 (U.S. Department of Commerce and Secretary of the Navy 2001) exonerated the low-frequency sonar but concluded that "tactical mid-range frequency sonars onboard U.S. Navy ships that were in use during the sonar exercise in question were the most plausible source of this acoustic or impulse trauma." The report also went on to conclude, "the cause of this stranding event was the confluence of Navy tactical mid-range frequency sonar and the contributory factors acting together." The contributory factors identified included "a complex acoustic environment that included the presence of a strong surface duct, unusual underwater bathymetry, intensive use of multiple sonar over an extended period of time, a constricted channel with limited access, and the presence of beaked whales that appear to be sensitive to the frequencies produced by these sonars."

Several unusual stranding events have also occurred in Chinese waters in 2004 during a period when large-scale naval exercises were taking place in nearby waters south of Taiwan (IWC 2005). Between 24 February and 10 March 2004, 9-10 short-finned pilot whales (*Globicephala macrorhynchus*), one ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*), one striped dolphin (*Stenella coeruleoalba*), seven short-finned pilot whales, and one short-finned pilot whale were reported to have stranded. The stranding events were unusual (with respect to the species involved) compared to previous stranding records since 1994 for the region. Gross examination of the only available carcass, the ginkgo-toothed beaked whale, revealed many unusual injuries to structures that are associated with, or related to acoustics or diving. The injuries, the freshness of the carcass, its discovery location and the coincidence of the event with a military exercise suggest that this beaked whale died from acoustic or blast trauma that may have been caused by exposure to naval activities south of Taiwan. Taiwanese newspapers reported that live ammunition was used during these exercises. At the same time, natural phenomena that might cause whales to strand – such as earthquakes and underwater volcanoes – have not been ruled out in these cases.

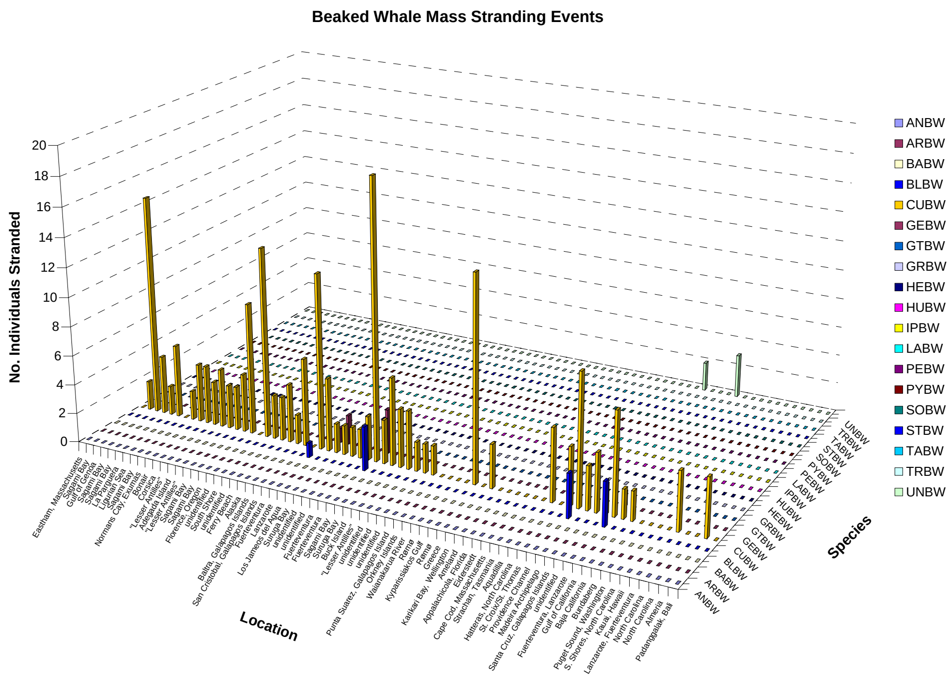
Several authors have noted similarities between some of these stranding incidents: they occurred in an islands or archipelagoes with deep water nearby, several appeared to have been associated with acoustic waveguides like surface ducting, and the sound fields created by ships transmitting mid-frequency sonar (Cox *et al*. 2006, D'Spain *et al*. 2006). Although Cuvier's beaked whales have been the most common species involved in these stranding events (81% of the total number of stranded animals and see Figure 3), other beaked whales (including *Mesoplodon europeaus*, *M. densirostris*, and *Hyperoodon ampullatus*) comprise 14% of the total. Other species (*Stenella coeruleoalba*, *Kogia breviceps* and *Balaenoptera acutorostrata*) have stranded, but in much lower numbers and less consistently than beaked whales. It is not clear whether (a) *Ziphius cavirostris* is more prone to injury from high-intensity sound than other species, (b) its behavioral response to sound makes it more likely to strand, or (c) it is substantially more abundant than the other affected species at the times and places of exposure. Because the association between the various sonars and stranding marine mammals is not consistent — some marine mammals strand without being exposed to sonar and some sonar transmissions are not associated with marine mammal strandings despite their co-occurrence — other risk factors or a groupings of risk factors probably contribute to these strandings.

Hawaiian Stranding Patterns. As discussed in the *Environmental Baseline* section of this opinion, Nitta (1991) reported that between 1936 and 1988, 8 humpback whales, 1 fin whale, and 5 sperm whales stranded in the Hawaiian Archipelago. In a partial update of that earlier report, Maldini *et al*. (2005) identified 202 toothed cetaceans that had stranded between 1950 and 2002. Sperm whales represented 10 percent of that total.

Until recently, however, there has been no correlation between the number of known stranding events and activities like RIMPAC exercises. The number of strandings have increased over time, but the number of strandings in the main Hawaiian Islands recorded between 1937 and 2002 is low compared with other geographic areas (although this may be an result of having large areas of coastline where no people or few people can report a stranding). Known strandings also occurred in all months with no significant temporal trend (Maldini *et al*. 2005).

RIMPAC exercises have occurred every second year since 1968 and anti-submarine warfare activities have occurred in each of the 19 exercises that have occurred thus far. If the mid-

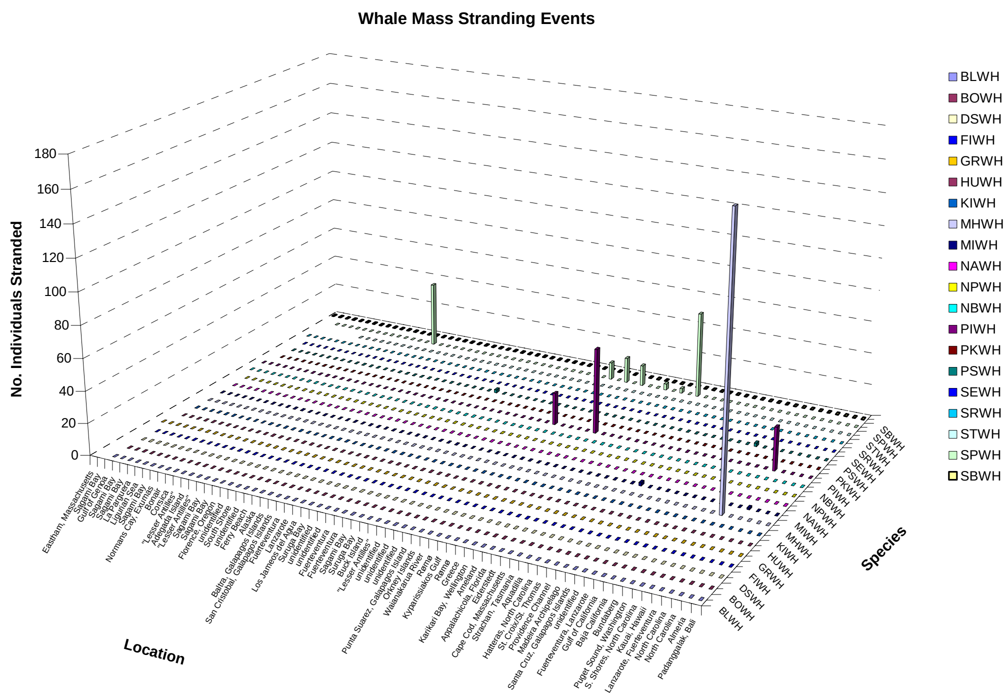
Figure 3. Estimates of the number of beaked whales involved in 70 mass stranding events reported from the 1960s to 2006. The vertical axis represents the number of animals reported in a particular event, the "location" axis is the location of the event, and the "species" axis represents the different beaked whale species. Three species have been reported in the 70 stranding events: Cuvier's, Blainville's, and Gervais' beaked whales, although two events included unidentified beaked whales (see text)



frequency sonar killed or injured whales whenever the whales encountered the sonar, it seems likely that some mass strandings would have occurred at least once or twice over the 38-year period since 1968. With one exception, there is little evidence of a pattern in the record of strandings reported for the main Hawaiian Islands. This may be an artifact of the number of observers relative to the area being observed — although strandings have been reported in the Hawaiian Islands since 1937, no toothed whales were found until 1950 —or it may be because only a fraction of the whales that are killed or injured in Hawaiian waters strand (as opposed to sinking, being transported to the open ocean by the strong currents that flow across the northern shore of the islands, or being eaten by predators like sharks). Or it may suggest that mid-frequency sonar transmissions pose a hazard to whales in certain circumstances, but not in others.

On 3 –4 July 2004, between 150 and 200 melon-headed whales (*Peponocephala electra*) occupied the shallow waters of Hanalei Bay, Kaua'i, Hawai'i for over 28 hours. The usually pelagic animals milled in the shallow confined bay and were returned to deeper water with human assistance. The whales were observed animals entering the Bay in a single wave formation on July 3, 2004 and were observed moving back into shore from the mouth of the Bay shortly thereafter. On the next morning, the animals were herded out of the Bay with the help of members of the community, the Hanalei Canoe Club, local and Federal employees, and volunteers/staff with the Hawaiian Islands Stranding Response Group and were out of visual sight later that morning.

Figure 4. Estimates of the number of large whales involved in 70 mass stranding events reported from the 1960s to 2006. The vertical axis represents the number of animals reported in a particular event, the "location" axis is the location of the event, and the "species" axis represents the different whale species. Sperm whales and minke whales were the most common large whales reported in the 70 stranding events (see text)



One whale, a calf, was known to have died following this event (on 5 July 2004). The animal was noted alive and alone in the Bay on the afternoon of 4 July 2004 and was found dead in the Bay the morning of 5 July 2004. A full necropsy was performed on the calf to determine the manner and cause of death. Although cause of death could not be definitively determined, it is likely that maternal separation, poor nutritional condition, and dehydration contributed to the whale's death.

Environmental factors, abiotic and biotic, were analyzed for any anomalous occurrences that would have contributed to the animals entering and remaining in Hanalei Bay. The bathymetry in the bay is similar to many other sites within the Hawaiian Island chain and dissimilar to that which has been associated with mass strandings in other parts of the U.S. The weather conditions appeared to be normal for the time of year with no fronts or other significant features noted. There was no evidence for unusual distribution or occurrence of predator or prey species or unusual harmful algal blooms. Weather patterns and bathymetry that have been associated with mass strandings elsewhere were not found to occur in this instance.

This event was spatially and temporally correlated with 2004 RIMPAC exercises. Official sonar training and tracking exercises in the Pacific Missile Range Facility (PMRF) warning area did not commence until about 0800 hrs (local time) on 3 July and were ruled out as a possible trigger for the initial movement into Hanalei Bay. However, the six naval surface vessels transiting to the operational area on 2 July had been intermittently transmitting active mid-frequency sonar [for ~9 hours total] as they approached from the south. After ruling out other phenomena that might have caused this stranding, NMFS concluded that the active sonar transmissions associated with the 2004 RIMPAC exercise were a plausible contributing causal factor in what may have been a confluence of events. Other factors that may have contributed to the stranding event include the presence of nearby deep water, multiple vessels transiting in a directed manner while transmitting active sonar over a sustained period, the presence of surface sound ducting conditions, or intermittent and random human interactions while the animals were in the Bay.

Potential Resonance Effects

Based on studies of lesions in beaked whales that have 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 strandings: tissue damage resulting from resonance effects (Ketten 2004, Cudahy and Ellison 2001) and tissue damage resulting from "gas and fat embolic syndrome" (Fernandez *et al*. 2005, Jepson *et al*. 2003, 2005). The former results from hydraulic damage in tissues that are filled with gas or air that resonates when exposed to acoustic signals, while the latter is believed to occur when tissues are supersaturated with dissolved nitrogen gas and diffusion facilitated by bubble-growth is stimulated within those tissues (the bubble growth results in embolisms analogous to the "bends" in human divers).

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

Crum and Mao (1996) hypothesized that received levels would have to exceed 190 dB in order for there to be the possibility of significant bubble growth due to supersaturation 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.

Threshold Shifts

Few studies examine the hearing impairment that can occur with exposure to a strong sound. Of the few studies available, very few studies have been conducted with free-living marine mammals. An animal can experience temporary threshold shift (TTS) or permanent threshold shift (PTS). Threshold shift refers to reduced sensitivity to sounds, so that a sound must be stronger for an animal to hear it. TTS can last from minutes or hours to days. When PTS occurs, there is physical damage to the sound receptors in the ear. This can result in total or partial deafness, or an animal's hearing can be impaired in specific frequency ranges.

Finneran and Schlundt (2004) analyze behavioral observations from related TTS studies (Schlundt *et al*., 2000; Finneran *et al*., 2001; 2003) to calculate cetacean behavioral reactions as a function of known noise exposure. During the TTS experiments, 4 dolphins and 2 white whales were exposed during a total of 224 sessions to 1-s pulses between 160 and 204 dB re 1μPa, at 0.4, 3, 10, 20, and 75 kHz.

A marine mammal within a radius of <100 meters around the seismic airgun might be exposed to a few seismic pulses with levels of >205 dB re 1 μPa which may cause TTS. There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammals. However, given the evidence that mammals close to an airgun array might incur TTS, there has been speculation about the possibility that some individuals very close to airguns might result in PTS (see Richardson *et al* 1995).

Richardson *et al*. (1995) hypothesized that marine mammals would have to be well within 100 m of an airgun array to be susceptible to immediate hearing damage based on measurements in the Beaufort Sea. However, numerous studies have demonstrated that baleen whales generally avoid sources of seismic airgun sounds. As a result, they have a low probability of being exposed to source pressure levels that might result in temporary threshold shifts.

Acoustic 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 2000). *Auditory Interference*, or masking, generally occurs when the interfering noise is louder than, and of a similar frequency to, the auditory signal received by the animal that is processing echolocation signals or other information from conspecifics. Masking these acoustic signals can disturb the behavior of individual animals, groups of animals, or entire populations. Richardson *et al*. (1995b) argued that the maximum radius of influence of 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., surf noise, prey noise, etc.; Richardson *et al*., (1995b)).

Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975; Watkins *et al.* 1985). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Sperm whales have moved out of areas after the start of air gun seismic testing (Davis *et al.* 1995). Seismic air guns produce loud, broadband, impulsive noise (source levels are on the order of 250 dB) with "shots" every 15 seconds, 240 shots per hour, 24 hours per day during active tests. Because they spend large amounts of time at depth and use low frequency sound sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll *et al* 1999). Furthermore, because of their apparent role as important predators of mesopelagic squid and fish, changes in their abundance could affect the distribution and abundance of other marine species.

The echolocation calls of toothed whales are subject to masking by high frequency sound. Human data indicate low frequency sound can mask high frequency sounds (i.e., upward masking). Studies on captive odontocetes by Au *et al*. (1974, 1985, 1993) indicate that some species may use various processes to reduce masking effects (e.g., adjustments in echolocation call intensity or frequency as a function of background noise conditions). There is also evidence that the directional hearing abilities of odontocetes are useful in reducing masking at the high frequencies used for echolocation, but not at the low-moderate frequencies used for 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 *et al*. 2005, Seyle 1950). Once an animal's central nervous system perceives a threat, it mounts a biological response or defense that consists of a combination of the four general biological defense responses: behavioral responses, autonomic nervous system responses, neuroendocrine responses, or immune response.

In the case of many stressors, the 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 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 a stressor involves its neuroendocrine systems, usually hormones associated with the hypothalmus-pituitary-adrenal system (most commonly 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. In the majority of stress studies, the HPA axis has been the primary neuroendocrine axis monitored. Stress-induced changes in the secretion of pituitary hormones have been implicated in failed reproduction (Moberg 1987, Rivier 1995) and altered metabolism (Elasser *et al*. 2000), immune competence (Blecha 2000) and behavior. Increases in the circulation of glucocorticosteroids (cortisol, corticosterone, and aldosterone in marine mammals) have been equated with stress for many years.

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

However, when an animal has insufficient biotic reserves to satisfy the biotic cost of a stress response, then resources must be shifted away from other biotic functions. When sufficient reserves are diverted from these functions, the functions are impaired. For example, when stress shifts metabolism away from growth, young animals no longer thrive and growth is stunted. When energy is shifted from supporting reproduction, reproductive success is diminished. In these cases, animals have entered a pre-pathological – pathological state and are experiencing "distress" (*sensu* Seyle 1950) or "allostatic loading" (*sensu* McEwen and Wingfield 2003). This period of distress will last until the animal replenishes its biotic reserves sufficient to restore normal function.

Relationships between these physiological mechanisms, animal behavior, and the costs of stress responses have also been documented fairly well through controlled experiment; because this physiology exists in every vertebrate that has been studied, it is not surprising that stress responses and their costs have been documented in both laboratory and free-living animals (for examples see, Holberton *et al*. 1996, Hood *et al*. 1998, Jessop *et al*. 2003, Krausman *et al*. 2004, Lankford *et al*. 2005, Reneerkens *et al*. 2002, Thompson and Hamer 2000). Although no information has been collected on the physiological responses of marine mammals upon exposure to anthropogenic sounds, studies of other marine animals and terrestrial animals would lead us to expect some marine mammals to experience physiological stress responses and, perhaps, physiological responses that would be classified as "distress" upon exposure to mid-frequency and low-frequency sounds.

For example, Jansen (1998) reported on the relationship between acoustic exposures and physiological responses that are indicative of stress responses in humans (for example, elevated respiration and increased heart rates). Jones (1998) reported on reductions in human performance when faced with acute, repetitive exposures to acoustic disturbance. Trimper *et al*. (1998) reported on the physiological stress responses of osprey to low-level aircraft noise while Krausman *et al*. (2004) reported on the auditory and physiology stress responses of endangered Sonoran pronghorn to military overflights. Smith *et al*. (2004a, 2004b) identified noise-induced physiological stress responses in hearing-specialist fish that accompanied short- (TTS) and long-term (PTS) hearing losses. Welch and Welch (1970), reported physiological and behavioral stress responses that accompanied damage to the inner ears of fish and several mammals.

As discussed in the *Approach to the Assessment* section of this Opinion, hearing is one of the primary senses cetaceans use to gather information about their environment and to communicate with conspecifics. 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.

Behavioral Responses
Based on the evidence available, marine animals are likely to exhibit several behavioral responses upon being exposed to sonar transmissions: they will try to avoid exposure, they will respond to the exposure as they would respond to other human activities (behavioral disturbance), they will experience social disruptions, they will exhibit behaviors associated with distress (see the preceding discussion), they will habituate to the stressors, or they will not respond. The narratives that follow summarize the information available on these behavioral responses.

When encountering disturbance stimuli, ranging from low-flying helicopter to the quiet wildlife photographer, an animal's response appears to follow the same economic principles used by prey when they encounter predators (Berger *et al*. 1983, Madsen 1994, Gill *et al*. 1996, 2001, Gill and Sutherland 2000). We call this verbal model the risk-disturbance hypothesis. It predicts that responses by disturbed animals track short-term changes in factors characterizing disturbance stimuli, with responses being stronger when perceived risk is greater. The level of perceived risk may result from a combination of factors that characterize disturbance stimuli, along with factors related to natural predation risk (e.g., Frid 2001a, Papouchis *et al*. 2001).

Existing studies of behavioral effects of man-made sounds in marine environments remain inconclusive, partly because of their limited ability to detect behavioral changes that are significant to the biology of the individual animals being observed. These studies are further complicated by the variety of responses that can occur within a single species of marine mammals, which can exhibit a wide range of responses to man-made noise that can vary by individuals and their circumstances. Under some circumstances, some individuals will continue the normal activities in the presence of high levels of man-made noise; in other circumstances, the same individual or other individuals may avoid an acoustic source at much lower received levels (Richardson *et al*. 1995).

Behavioral Avoidance. There are few empirical studies of avoidance responses of free-living cetaceans to mid-frequency sonars. Much more information is available on the avoidance responses of free-living cetaceans to other acoustic sources, like seismic airguns and low frequency sonar.

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. Systematic data on their reactions to airguns are generally lacking. Sightings by observers on seismic vessels off the United Kingdom suggest that, at times of good sightability, the number of blue, fin, sei, and humpback whales seen when airguns are shooting are similar to the numbers seen when the airguns are not shooting (Stone 1997, 1998, 2000, 2001). However, fin and sei whale sighting rates were higher when airguns were shooting, which may be due to a 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 reacted to military sonar, apparently from a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent and becoming difficult to approach (Watkins *et al.* 1985). 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 by geophysical surveys (Ridgway *et al.* 1997, Schlundt *et al.* 2000), and to shorter broadband pulsed signals (Finneran *et al.* 2000, 2002).

Behavioral changes typically involved what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Schlundt *et al.* 2000, Finneran *et al.* 2002). Dolphins exposed to 1-sec intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa rms and belugas did so at received levels of 180 to 196 dB and above. Received levels necessary to elicit such reactions to shorter pulses were higher (Finneran *et al.* 2000, 2002). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran *et al.* 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway *et al.* 1997, Schlundt *et al.* 2000).

The relevance of these data to free-ranging odontocetes is uncertain. In the wild, cetaceans some-times avoid sound sources well before they are exposed to the levels listed above, and reactions in the wild may be more subtle than those described by Ridgway *et al.* (1997) and Schlundt *et al.* (2000).

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.

Disturbance Responses. There is mounting evidence that wild animals respond to human disturbance in the same way that they respond to predators (Beale and Monaghan 2004, Frid 2003, Frid and Dill 2002, Gill *et al*. 2000, Gill and Sutherland 2001, Harrington and Veitch 1992, Lima 1998, Romero 2004). These responses manifest themselves as stress responses (in which an animal perceives human activity as a potential threat and undergoes physiological changes to prepare for a flight or fight response or more serious physiological changes with chronic exposure to stressors), interruptions of essential behavioral or physiological events, alteration of an animal’s time budget, or some combinations of these responses (Frid and Dill 2002, Romero 2004, Sapolsky *et al*. 2000, Walker *et al*. 2005). These responses have been associated with abandonment of sites (Sutherland and Crockford 1993), reduced reproductive success (Giese 1996, Mullner *et al*. 2004), and the death of individual animals (Daan *et al*. 1996, Feare 1976, Waunters *et al*. 1997).

Brownell (2004) reported observations of the effects of behavioral disturbance on the endangered western gray whale population off the northeast coast of Sakhalin Island associated with seismic activities in that region. In 1997, various behavioral disturbances concomitant with seismic activities were observed including changes in swimming speed and orientation, respiration rates, and distribution offshore. Cumulative impacts of these short-term disturbances are not known. In 2001, seismic activities were conducted in the known feeding area of these whales. It was observed that whales left the feeding ground during these activities and moved to areas farther south. They only returned to the feeding ground after the seismic activities ceased days later. The potential impacts on these whales, especially mother-calf pairs and "skinny whales", of being displaced to the south outside the normal feeding area are not known but are cause for concern. As reported previously, whales observed to be much skinnier than normal were first observed in 1999 and continue to be observed in the population but in smaller numbers. Any disruption of feeding can be expected to impact the ability of these animals to store sufficient food reserves prior to migration.

No Response. One study of blue whales reported that when pulses from air guns were produced off Oregon, blue whales continued vocalizing at the same rate as before the pulses, suggesting that at least their vocalization behavior was undisturbed by the sound (McDonald *et al*. 1993).

Probable Responses of Endangered Whales to Mid-Frequency Sonar

Based on the evidence available, the mid-frequency sonars associated with the ASW exercises that are proposed for the RIMPAC exercises are not likely to kill or injure threatened or endangered marine mammals. However, little is known about the effect of short-term disruptions of a marine mammal's normal behavior (Richardson *et al*. 1995). Most of the evidence available suggests that most sources of disturbance do not directly kill or injure marine mammals. The evidence available also does not lead us to expect threatened or endangered cetaceans to strand or suffer resonance effects from the mid-frequency sonars associated with the ASW exercises that will be included in RIMPAC.

Response of Fin whales. The Navy's simulations identified 61 instances in which fin whales might accumulate energy that is equivalent to between 173 and 195 dB during the proposed RIMPAC exercises (a total of 64 instances in which fin whales might accumulate energy equivalent to more than 173 dB). Based on our analyses, we assume that 42 of these instances might involve a single, individual fin whale that accumulates energy equivalent to between 173 and 195 dB on one occasion; another 8 instances in which a single, individual fin whale accumulates this energy equivalent on two occasions; and once instance in which a single, individual fin whale accumulates this energy equivalent on three occasions.

The Navy's simulations also identified 3 instances in which fin whales might accumulate energy equivalent to 195 – 215 dB. Based on our analyses, we assume that 2 of these instances might involve a single, individual fin that whale accumulates energy equivalent to between 173 and 195 dB on one occasion; once instance in which a single, individual fin whale accumulates this energy equivalent on three occasions. The fin whales that might be exposed to the proposed RIMPAC exercises, particular mid-frequency sonar transmissions and ship traffic, would represent individuals from the Hawaiian population (or "stock"). We assume that any age or gender might be exposed to those received levels.

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

Responses of Sei Whales. The Navy's simulations identified 27 instances in which sei whales might accumulate energy that is equivalent to between 173 and 195 dB. Based on our analyses, we assume that 18 of these instances might involve a single, individual sei whale that accumulates energy equivalent to between 173 and 195 dB on one occasion; another 4 instances in which a single, individual sei whales accumulates this energy equivalent on two occasions; and once instance in which a single, individual fin whale accumulates this energy equivalent on three occasions. The Navy's simulations also identified 1 instance in which a sei whale might accumulate energy equivalent to 195 – 215 dB (a total of 28 instances in which sei whales might accumulate energy equivalent to more than 173 dB).

As discussed in the *Status of the Species* section of this opinion, we have no specific information on the sounds produced by sei whales or their sensitivity to sounds in their environment. Based on their anatomical and physiological similarities to both blue and fin whales, we assume that the hearing thresholds of sei whales will be similar as well and will be centered on low-frequencies in the 10-200 Hz. This information would lead us to conclude that like, blue and fin whales, sei whales exposed to these received levels of active mid-frequency sonar are not likely to respond if they are exposed to mid-frequency (1 kHz–10 kHz) sounds.

Responses of Sperm Whales. The Navy's simulations identified 1,417 instances in which sperm whales might accumulate energy that is equivalent to between 173 and 195 dB during the proposed RIMPAC exercises. Based on our analyses, we assume that 967 of these instances might involve a single, individual sperm whale accumulates energy equivalent to between 173 and 195 dB on one occasion; 193 of these instances might involve a single, individual sperm whale accumulates energy equivalent to between 173 and 195 dB on two occasions; 20 of these instances might involve a single, individual sperm whale accumulates energy equivalent to between 173 and 195 dB on 3 occasions; and 1 instance in which a single, individual sperm whale accumulates this energy equivalent on one occasion.

Although there is no published audiogram for sperm whales, the evidence available suggests that sperm whale hearing includes high frequencies. Sperm whales would be expected to have good, high frequency hearing because their inner ear resembles that of most dolphins, and appears tailored for ultrasonic (>20 kHz) reception (Ketten 1994). The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate, which suggest that neonatal sperm whales respond to sounds from 2.5 to 60 kHz. Ridgway and Carder (2001) measured low-frequency, high amplitude clicks with peak frequencies at 500 Hz to 3 kHz from the sperm whale neonate. 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 (Weilgart and Whitehead 1993; Goold and Jones 1995).

There is some evidence of disruptions of clicking and behavior from sonars (Goold 1999, Watkins and Scheville1975, Watkins *et al*. 1985), pingers (Watkins and Scheville 1975), the Heard Island Feasability Test (Bowles *et al*. 1994), and the Acoustic Thermometry of Ocean Climate (Costa *et al*.1998). Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders (Watkins and Scheville 1975). Goold (1999) reported six sperm whales that were driven through a narrow channel using ship noise, echosounder, and fishfinder emissions from a flotilla of 10 vessels. Watkins and Scheville (1975) showed that sperm whales interrupted click production in response to pinger (6 to 13 kHz) sounds. They also 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).

As discussed previously, sperm whales reacted to military sonar, apparently from a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent and becoming difficult to approach (Watkins *et al.* 1985). Captive bottlenose dolphins and a white whale exhibited changes in behavior when exposed to 1 sec pulsed sounds at frequencies similar to those emitted by multi-beam sonar that is used in geophysical surveys (Ridgway *et al.* 1997, Schlundt *et al.* 2000), and to shorter broadband pulsed signals (Finneran *et al.* 2000, 2002). Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure or to avoid the location of the exposure site during subsequent tests (Schlundt *et al.* 2000, Finneran *et al.* 2002). Dolphins exposed to 1-sec intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa rms and belugas did so at received levels of 180 to 196 dB and above. Received levels necessary to elicit such reactions to shorter pulses were higher (Finneran *et al.* 2000, 2002). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran *et al.* 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway *et al.* 1997, Schlundt *et al.* 2000). The relevance of these data to free-ranging odontocetes is uncertain. In the wild, cetaceans some-times avoid sound sources well before they are exposed to the levels listed above, and reactions in the wild may be more subtle than those described by Ridgway *et al.* (1997) and Schlundt *et al.* (2000).

Other studies identify instances in which sperm whales did not respond to anthropogenic sounds. Sperm whales did not alter their vocal activity when exposed to levels of 173 dB re 1 μPa from impulsive sounds produced by 1 g TNT detonators (Madsen and Mohl 2000). Richardson *et al*. (1995) citing a personal communication with J. Gordon suggested that sperm whales in the Mediterranean Sea continued calling when exposed to frequent and strong military sonar signals. When Andre *et al*. (1997) exposed sperm whales to a variety of sounds to determine what sounds may be used to scare whales out of the path of vessels, sperm whales were observed to have startle reactions to 10 kHz pulses (180 db re 1 μPa at the source), but not to the other sources played to them.

Published reports identify instances in which sperm whales may have responded to an acoustic source and other instances in which they did not appear to respond behaviorally when exposed to seismic surveys. Mate *et al*. (1994) reported an opportunistic observation of the number of sperm whales to have decreased in an area after the start of airgun seismic testing. However, Davis *et al*. (2000) noted that sighting frequency did not differ significantly among the different acoustic levels examined in the northern Gulf of Mexico, contrary to what Mate *et al*. (1994) reported. In one DTAG deployment in the northern Gulf of Mexico on July 28, 2001, researchers documented that the tagged whale moved away from an operating seismic vessel once the seismic pulses were received at the tag at roughly 137 dB re 1 μPa (Johnson and Miller 2002). Sperm whales may also have responded to seismic airgun sounds by ceasing to call during some (but not all) times when seismic pulses were received from an airgun array >300 km away (Bowles *et al*. 1994).

A recent study offshore of northern Norway indicated that sperm whales continued to call when exposed to pulses from a distant seismic vessel. Received levels of the seismic pulses were up to 146 dB re 1 μPa peak-to-peak (Madsen *et al*. 2002). Similarly, a study conducted off Nova Scotia that analyzed recordings of sperm whale sounds at various distances from an active seismic program did not detect any obvious changes in the distribution or behavior of sperm whales (McCall Howard 1999). Recent data from vessel-based monitoring programs in United Kingdom waters suggest that sperm whales in that area may have exhibited some changes in behavior in the presence of operating seismic vessels (Stone 1997, 1998, 2000, 2001, 2003). However, the compilation and analysis of the data led the author to conclude that seismic surveys did not result in observable effects to sperm whales (Stone 2003). The results from these waters seem to show that some sperm whales tolerate seismic surveys.

Preliminary data from an experimental study of sperm whale reactions to seismic surveys in the Gulf of Mexico and a study of the movements of sperm whales with satellite-linked tags in relation to seismic surveys show that during two controlled exposure experiments in which sperm whales were exposed to seismic pulses at received levels up to 148 dB re 1 μPa over octave band with most energy, the whales did not avoid the vessel or change their feeding efficiency (National Science Foundation 2003). Although the sample size is small (4 whales in 2 experiments), the results are consistent with those off northern Norway.

These studies suggest that the behavioral responses of sperm whales to anthropogenic sounds are highly variable, but do not appear to result in the death or injury of individual whales or result in reductions in the fitness of individuals involved. Responses of sperm whales to anthropogenic sounds probably depend on the age and sex of animals being exposed, as well as other factors. There is evidence that many individuals respond to certain sound sources, provided the received level is high enough to evoke a response, while other individuals do not.

Aggregate Effects of Mid Frequency Sonar and Ambient Noise

Several investigators and organizations have expressed concern about the "cumulative impact" (in the NEPA sense of the term) of marine sounds on the ocean environment and its organisms (NRDC 1994, 2001, Richardson *et al*. 1995). Any man-made sound that is strong enough to be audible (detectable above natural background noise) will increase total background levels and could interfere with an animal's ability to detect sound signals if the signal is weak relative to total noise levels. Concern about the cumulative impact of man-made sounds focuses on impacts from individual actions that are insignificant or minor when considered in isolation, but combine to produce effects that are greater than any individual action (either because the effects are synergistic - effects that occur when two or more phenomena interact - multiplicative, or additive). In this opinion, our assessment has focused on the effect of adding mid-frequency sonar to underwater ambient noise levels.

The proposed RIMPAC exercises will add mid-frequency sound to ambient oceanic noise levels, which, in turn, could have cumulative impacts on the ocean environment, including listed species. During transmissions, mid-frequency sonar will add to regional noise levels. Unfortunately, there are no reliable methods for assessing these potential cumulative impacts. The U.S. Navy conducted computer simulations to assess the potential cumulative impacts of RIMPAC ASW sonar (Navy 2001; section 4.4.1 through 4.4.4). That assessment concluded that the "cumulative impacts" of mid-frequency sonar would be "extremely small" because the proposed RIMPAC ASW exercises would occur for a relatively short period of time every other year, for relatively short periods of time in any given area; the system would not be stationary, and the information available suggests that the effects of any mid-frequency exposure would stop when transmissions stop.

Although the proposed RIMPAC ASW exercises would add very small amounts of energy to the world's ocean environment, NMFS remains concerned about the potential cumulative impacts of these sound sources on the oceans and the biota that inhabit them. For example, underwater noise associated with extensive vessel traffic has been documented to have caused gray whales to abandon some of their habitat in California for several years (Gard 1974, Reeves 1977). Salden (1988) suggested that humpback whales avoid some nearshore waters in Hawaii for the same reason.

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

Richardson *et al*. (1995) also recommended several operational measures to minimize the effects of man-made sounds on marine mammals. These included minimizing source levels, minimizing duty cycles, and gradually increasing projected sound levels to allow animals to move away from the source before source levels peak. The Navy has clearly included these mitigative measures into the proposed RIMPAC ASW exercises and these measures are likely to minimize, but not eliminate, the potential cumulative impacts of mid-frequency sonar on marine mammals; the residual effects, although they are expected to be small, remain unknown.

Cumulative Effects

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

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

Integration and Synthesis of Effects

In the *Assessment Approach* section of this opinion, we stated that we measure risks to listed individuals using changes in the individuals' "fitness" or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When we do not expect listed plants or animals exposed to an action's effects to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (Anderson 2000, Mills and Beatty 1979, Brandon 1978, Stearns 1977, 1992). As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

The following discussions summarize the probable risks the proposed RIMPAC exercises, particular mid-frequency sonar transmissions and ship traffic, pose to threatened and endangered species that are likely to be exposed to those transmissions. These summaries integrate the exposure profiles presented previously with the results of the response analyses that were also presented previously.

Fin whales. The Navy's simulations identified 61 instances in which fin whales might accumulate energy that is equivalent to between 173 and 195 dB during the proposed RIMPAC exercises (a total of 64 instances in which fin whales might accumulate energy equivalent to more than 173 dB). Based on our analyses, we assume that 42 of these instances might involve a single, individual fin whale that accumulates energy equivalent to between 173 and 195 dB on one occasion; another 8 instances in which a single, individual fin whale accumulates this energy equivalent on two occasions; and once instance in which a single, individual fin whale accumulates this energy equivalent on three occasions.

The Navy's simulations also identified 3 instances in which fin whales might accumulate energy equivalent to 195 – 215 dB. Based on our analyses, we assume that 2 of these instances might involve a single, individual fin whale that accumulates energy equivalent to between 173 and 195 dB on one occasion; once instance in which a single, individual fin whale accumulates this energy equivalent on three occasions. The fin whales that might be exposed to the proposed RIMPAC exercises, particular mid-frequency sonar transmissions and ship traffic, would represent individuals from the Hawaiian population (or "stock"). We assume that any age or gender might be exposed to those received levels.

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

Fin whales in the action area seem likely to respond to the ship traffic associated with the maneuvers might approximate their responses to whale watch vessels. As discussed in the *Environmental Baseline* section of this Opinion, those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver. The closer fin whales are to these maneuvers and the greater the number of times they are exposed (using the Navy's estimates of the cumulative exposures to sounds equivalents > 173 dB as an index of potential exposures), the greater their likelihood of be exposed and responding to that exposure. Particular whales' might not respond to the vessels, while in other circumstances, fin whales are likely to change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Amaral and Carlson 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al*. 2002, Richter *et al*. 2003, Scheidat *et al*. 2004, Simmonds 2005, Watkins 1986, Williams *et al*. 2002). Some of these whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, because of the relatively short duration of the exercise, we do not expect these responses to continue long-enough to have fitness consequences for individual din whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and those of a stress physiology.

As a result, we conclude that the proposed RIMPAC exercises are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual fin whales in ways or to a degree that would reduce their fitness. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the proposed RIMPAC exercises would not be expected to appreciably reduce the fin whales' likelihood of surviving and recovering in the wild.

Sei Whales. The Navy's simulations identified 27 instances in which sei whales might accumulate energy that is equivalent to between 173 and 195 dB. Based on our analyses, we assume that 18 of these instances might involve a single, individual sei whale that accumulates energy equivalent to between 173 and 195 dB on one occasion; another 4 instances in which a single, individual sei whales accumulates this energy equivalent on two occasions; and one instance in which a single, individual sei whale accumulates this energy equivalent on three occasions. The Navy's simulations also identified 1 instance in which a sei whale might accumulate energy equivalent to 195 – 215 dB (a total of 28 instances in which sei whales might accumulate energy equivalent to more than 173 dB).

We assume that fin, sei, and sperm whales that might be exposed to mid-frequency sonar associated with the anti-submarine elements of the proposed RIMPAC exercises might be close enough to the exercises to be aware of the vessel traffic and related activities associated with surface ship maneuvers (see Table 5 for estimates of the number of whales that might be affected by these maneuvers). We also assume that whales that are closer to those exercises have a greater probability of exhibiting behavioral responses to the ship traffic.

Like fin whales, sei whales are likely to to respond to ship traffic associated with the maneuvers might approximate their responses to whale watch vessels. As discussed in the *Environmental Baseline* section of this Opinion, those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver. The closer sei whales are to these maneuvers and the greater the number of times they are exposed (using the Navy's estimates of the cumulative exposures to sounds equivalents > 173 dB as an index of potential exposures), the greater their likelihood of be exposed and responding to that exposure. Particular whales' might not respond to the vessels, while in other circumstances, sei whales are likely to change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Amaral and Carlson 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al*. 2002, Richter *et al*. 2003, Scheidat *et al*. 2004, Simmonds 2005, Watkins 1986, Williams *et al*. 2002). Some of these whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, because of the relatively short duration of the exercise, we do not expect these responses to continue long-enough to have fitness consequences for individual sei whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and those of a stress physiology.

As a result, we conclude that the proposed RIMPAC exercises are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual sei whales in ways or to a degree that would reduce their fitness. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the proposed RIMPAC exercises would not be expected to appreciably reduce the sei whales' likelihood of surviving and recovering in the wild.

Sperm Whales. These data suggest that neonatal sperm whales respond to sounds from 2.5-60 kHz. The Navy's simulations identified 1,181 instances in which sperm whales might accumulate energy that is equivalent to between 173 and 195 dB during the proposed RIMPAC exercises. Based on our analyses, we assume that 967 of these instances might involve a single, individual sperm whale that accumulates energy equivalent to between 173 and 195 dB on one occasion; 193 of these instances might involve a single, individual sperm whale that accumulates energy equivalent to between 173 and 195 dB on two occasions; 20 of these instances might involve a single, individual sperm whale that accumulates energy equivalent to between 173 and 195 dB on 3 occasions; and 1 instance in which a single, individual sperm whale accumulates this energy equivalent on one occasion.

The Navy's simulations also identified 28 instances in which sperm whales might accumulate energy that is equivalent to between 195 and 215 dB during the proposed RIMPAC exercises. Based on our analyses, we assume that 23 of these instances might involve a single, individual sperm whale accumulates energy equivalent to between 173 and 195 dB on one occasion; 5 of these instances might involve a single, individual sperm whale accumulates energy equivalent to between 173 and 195 dB on two occasions; and 1 instance in which a single, individual sperm whale accumulates this energy equivalent on one occasion.

Data on the hearing range of sperm whales were developed using evoked potentials from a stranded neonate (Carder and Ridgway 1991). These data suggest that neonatal sperm whales respond to sounds from 2.5-60 kHz.

The sperm whales that might be exposed to the proposed RIMPAC exercises, particular mid-frequency sonar transmissions and ship traffic, would represent individuals from a Hawaiian population (or "stock"). Sperm whales are widely distributed throughout the Hawaiian Islands year-round (Rice 1960; Shallenberger 1981; Lee 1993; and Mobley *et al.* 2000). Sperm whale clicks recorded from hydrophones off Oahu confirm the presence of sperm whales near the Hawaiian Islands throughout the year (Thompson and Friedl 1982). The primary area of occurrence for the sperm whale is seaward of the shelf break in the Hawaiian Islands Hawaiian Islands Operating Area. Sperm whales rarely occur from the shore to the shelfbreak, so they are not likely to be exposed in the shallower coastal waters around the main Hawaiian Islands.

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

Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975; Watkins *et al.* 1985). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Sperm whales have moved out of areas after the start of air gun seismic testing (Davis *et al.* 1995).

The evidence available suggests that sperm whales are likely to detect mid-frequency sonar transmissions. In most circumstances, sperm whales are likely to try to avoid that exposure or are likely to avoid areas specific areas. Those sperm whales that do not avoid the sound field created by the mid-frequency sonar might interrupt communications, echolocation, or foraging behavior. In either case, sperm whales that avoid these sound fields, stop communicating, echolocating or foraging would experience significant disruptions of normal behavior patterns that are essential to their individual fitness. Because of the relatively short duration of the acoustic transmissions associated with the proposed RIMPAC exercises, we do not, however, expect these disruptions to result in the death or injury of any individual animal or to result in physiological stress responses that rise to the level of distress.

Like fin and sei whales, individual sperm whales are also likely to respond to the ship traffic associated with the maneuvers might approximate their responses to whale watch vessels. As discussed in the *Environmental Baseline* section of this Opinion, those responses are likely to depend on the distance of a whale from a vessel, vessel speed, vessel direction, vessel noise, and the number of vessels involved in a particular maneuver. The closer sperm whales are to these maneuvers and the greater the number of times they are exposed (using the Navy's estimates of the cumulative exposures to sounds equivalents > 173 dB as an index of potential exposures), the greater their likelihood of be exposed and responding to that exposure. Particular whales' might not respond to the vessels, while in other circumstances, sperm whales are likely to change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Amaral and Carlson 2005; Au and Green 2000, Cockeron 1995, Erbe 2002, Félix 2001, Magalhães *et al*. 2002, Richter *et al*. 2003, Scheidat *et al*. 2004, Simmonds 2005, Watkins 1986, Williams *et al*. 2002). Some of these whales might experience physiological stress (but not "distress") responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, because of the relatively short duration of the exercise, we do not expect these responses to continue long-enough to have fitness consequences for individual sperm whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and those of a stress physiology.

As a result, we conclude that the proposed RIMPAC exercises are not likely to adversely affect individual sperm whales in ways or to a degree that would reduce their fitness. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual sperm whales would not be likely to reduce the viability of the populations those individual whales represent by reducing the population dynamics, behavioral ecology, and social dynamics of those populations (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the proposed RIMPAC exercises would not be expected to appreciably reduce the sperm whales’ likelihood of surviving and recovering in the wild.

Conclusion
After reviewing the current status of the endangered fin whale, sei whale, and sperm whale, the environmental baseline for the action area, the effects of the proposed research program, and the cumulative effects, it is NMFS’ biological opinion that the Navy’s proposed RIMPAC 2006 exercises in waters off the State of Hawaii and NMFS’ proposed issuance of an Incidental Harassment Authorization for the “take,” in the form of harassment, of marine mammals during the anti-submarine warfare portions of those exercises may adversely affect, but is not likely to jeopardize the continued existence of these threatened and endangered species under NMFS jurisdiction.

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), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

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

Amount or Extent of Take Anticipated
The effects analysis contained in this Biological Opinion concluded that individual fin whales, and sei whales have small probabilities of being exposed to and are likely to respond to ship traffic associated with the proposed RIMPAC exercises. The closer these whales are to these

maneuvers and the greater the number of times they are exposed (using the Navy's estimates of the cumulative exposures to sounds equivalents > 173 dB as an index of potential exposures), the greater their likelihood of be exposed and responding to that exposure. This biological Opinion also concluded that sperm whales are likely to be to exposed and likely to respond to that

Table 5. Estimated number of times whales of the different species might accumulate energy that is equivalent to >173, 173 -195, and 195 - 215 dB rms^2 for 1 second (from U.S. Navy 2006)

Species	Estimated Abundance	Estimated No. of Exposure Events		
		173 - 195 dB	195 - 215 dB	> 173
Fin whale	~ 174	61	3	64
Sei whale	~ 77	27	1	28
Sperm whale	~ 7,000	1417	34	1,451

exposure in ways that constitute "harassment" for the purposes of the ESA. NMFS does not expect any threatened or endangered species to be injured or killed as a result of exposure to the proposed RIMPAC exercises (refer to the *Effects of the Action* section of this Biological Opinion for further discussion).

For the purposes of this biological opinion and incidental take statement, we assumed that the Navy's estimated of the number of times whales might be exposed to mid-frequency sonar associated with anti-submarine warfare exercises and accumulate energy equivalents greater than 173 dB represent the number of times a whale might be "taken" in the form of harassment (see Table 5, below, for these estimates, by species). We do not anticipate any of these whale species to die or exhibit responses that might constitute harm or injury

Effect of the Take

In the accompanying biological opinion, NMFS determined that this level of anticipated take is not likely to result in jeopardy to the species. The proposed action would not likely result in destruction or adverse modification of critical habitat. Studies of marine mammals and sonar transmissions have shown behavioral responses by fin whales, sei whales, and sperm whales to sonar transmissions. Although the biological significance of the animal's behavioral responses remains unknown, exposure to sonar transmissions are likely to 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 sonar transmissions and any associated disruptions are expected to be temporary and is not likely to affect the reproduction, survival, or recovery of these species.

Reasonable and Prudent Measures

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

1. The authorization shall be valid for the period from 26 June 2006 through 28 July 2006.

2. The authorization shall be valid only for the unintentional taking of the species of marine mammals identified in NMFS' Incidental Harassment Authorization and shall be valid only for "take" of threatened and endangered species consistent with the terms and conditions set in NMFS' Incidental Harassment Authorization.

3. The Permits, Conservation and Education Division shall require the U.S. Navy to implement a program to mitigate the potential effects of mid-frequency sonar transmissions on threatened or endangered whale species.

4. The Permits, Conservation and Education Division shall require the U.S. Navy to implement a program to monitor potential interactions between mid-frequency sonar transmissions and threatened or endangered whale species.

Terms and Conditions

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

1. All RIMPAC participants will receive the following marine mammal training/briefing during the port phase of RIMPAC:

    1.1 Exercise participants (CO/XO/Ops) will review the C3F Marine Mammal Brief, available OPNAV N45 video presentations, and a NOAA brief presented by C3F on marine mammal issues in the Hawaiian Islands.

    1.2 NUWC will train observers on marine mammal identification observation techniques.

    1.3 Third fleet will brief all participants on marine mammal mitigation requirements.

    1.4 Participants will receive video training on marine mammal awareness.

2. Navy watchstanders, the individuals responsible for detecting marine mammals in the Navy's standard operating procedures, will participate in marine mammal observer training by a NMFS-approved instructor. Training will focus on identification cues and behaviors that will assist in the detection of marine mammals and the recognition of behaviors potentially indicative of injury or stranding. Training will also include information aiding in the avoidance of marine mammals and the safe navigation of the vessel, as well as species identification review (with a focus on beaked whales and other species likely to strand). At

least one individual who has received this training will be present, and on watch, at all times during operation of tactical mid-frequency sonar, on each vessel operating mid-frequency sonar.

3. All ships and surfaced submarines participating in the RIMPAC ASW exercises will have personnel on lookout with binoculars at all times when the vessel is moving through the water (or operating sonar). These personnel will report the sighting of any marine species, disturbance to the water's surface, or object (unknown or otherwise) to the Officer in Command.

4. All aircraft participating in RIMPAC ASW events will conduct and maintain, whenever possible, surveillance for marine species prior to and during the event. Sightings will be immediately reported to ships in the vicinity of the event as appropriate.

5. Submarine sonar operators will review detection indicators of close-aboard marine mammals prior to the commencement of ASW operations involving active mid-frequency sonar. Marine mammals detected by passive acoustic

6. *Safety Zones*: marine mammals are detected by any means (aircraft, lookout, or acoustically) within 1,000 m of the sonar dome (the bow), the ship or submarine will limit active transmission levels to at least 6 dB below normal operating levels. Ships and submarines will continue to limit maximum ping levels by this 6-dB factor until the animal has been seen to leave the area, has not been seen for 30 minutes, or the vessel has transited more than 2000 m beyond the location of the sighting.

   Should a marine mammal be detected within or closing to inside 500 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 area, has not been seen for 30 minutes, or the vessel has transited more than 1500 m beyond the location of the sighting.

   Should the marine mammal be detected within or closing to inside 200 m of the sonar dome, active sonar transmissions will cease. Sonar will not resume until the animal has been seen to leave the area, has not been seen for 30 minutes, or the vessel has transited more than 1,200 m beyond the location of the sighting.

   If the Navy is operating sonar above 235 dB and any of the conditions necessitating a powerdown arise ((f), (g), or (h)), the Navy shall follow the requirements as though they were operating at 235 dB - the normal operating level (i.e., the first powerdown will be to 229 dB, regardless of at what level above 235 sonar was being operated)..

7. In strong surface ducting conditions, the Navy will enlarge the safety zones such that a 6-dB power-down will occur if a marine mammal enters the zone within a 2000 m radius around the source, a 10-dB power-down will occur if an animal enters the 1000 m zone, and shut down will occur when an animal closes within 500 m of the sound source.

   A strong surface duct (half-channel at the surface) is defined as having the all the following factors: (1) A delta SVP between 0.6 to 2.0 m/s occurring within 20 fathoms of the surface with a positive gradient (upward refracting); (2) Sea conditions no greater than Sea State 3 (Beaufort Number 4); and (3) Daytime conditions with no more than 50% overcast (otherwise leading to diurnal warming). This applies only to surface ship mid-frequency active mainframe sonar.

8. In low visibility conditions (i.e., whenever the entire safety zone cannot be effectively monitored due to nighttime, high sea state, or other factors), the Navy shall use additional detection measures, such as infrared or enhanced passive acoustic detection. If detection of marine mammals is not possible out to the prescribed safety zone, the Navy will power down sonar as if marine mammals were present in the zones they cannot see (for example, at night, if night goggles allow detection out to 1000 m, power-down would not be necessary under normal conditions, however, in strong surface duct conditions, the Navy would need to power down 6 dB, as they could not effectively detect mammals out to 2000 m, the prescribed safety zone).

9. Helicopters shall observe/survey the vicinity of an ASW exercise for 10 minutes before deploying active (dipping) sonar in the water. Helicopters shall not dip their sonar within 200 yards of a marine mammal and shall cease pinging if a marine mammal closes within 200 yards after pinging has begun.

10. The Navy shall operate sonar at the lowest practicable level, not to exceed 235 dB, except for occasional short periods of time to meet tactical training objectives.

11. With the exception of three specific choke-point exercises (special measures outlined in item (13)), the Navy will not conduct sonar activities in constricted channels or canyon-like areas.

12. With the exception of three specific “choke-point” exercises (special measures outlined in item (13)), and events occurring on range areas managed by PMRF, the Navy will not operate mid-frequency sonar within 25 km of the 200 m isobath.

13. The Navy shall conduct no more than three “choke-point exercises”. These exercises will occur in the Kaulakahi Channel (between Kauai and Niihau) and the Alenuihaha Channel (between Maui and Hawaii). These exercises will not be conducted in a constricted channel like was present in the Bahamas, but will fall outside of the requirements listed above; that is, avoid canyon-like areas and to operate sonar farther than 25 km from the 200 m isobath. The additional measures required for these three choke-point exercises are as follows:

    13.1 The Navy shall provide NMFS (Stranding Coordinator and Protected Resources, Headquarters) and the Hawaii marine patrol with information regarding the time and place for the choke-point exercises in advance of the exercises.

    13.2 The Navy shall have at least one dedicated Navy observer that has received the NMFS-approved training mentioned above, on board each ship and conducting observations during the operation of mid-frequency tactical sonar during the choke-point exercises. The Navy has also authorized the presence of two experienced marine mammal observers (non-Navy personnel) to embark on Navy ships for observation during the exercise.

13.3 Prior to start up or restart of sonar, the Navy will ensure that a 2000 m radius around the sound source is clear of marine mammals.

13.4 The Navy will coordinate a focused monitoring effort around the choke-point exercises, to include pre-exercise monitoring (2 hours), during-exercise monitoring, and post-exercise monitoring (1-2 days). This monitoring effort will include at least one dedicated aircraft or one dedicated vessel for real-time monitoring from the pre- through post-monitoring time period, except at night. The vessel or airplane may be operated by either dedicated Navy personnel, or non-Navy scientists contracted by the Navy, who will be in regular communication with a Tactical Officer with the authority to shut-down, power-down, or delay the start-up of sonar operations. These monitors will communicate with this Officer to ensure the safety zones are clear prior to sonar start-up, to recommend power-down and shut-down during the exercise, and to extensively search for potentially injured or stranding animals in the area and down-current of the area post-exercise.

13.5 The Navy will further contract an experienced cetacean researcher to conduct systematic aerial reconnaissance surveys and observations before, during, and after the choke-point exercises with the intent of closely examining local populations of marine mammals during the RIMPAC exercise.

13.6 Along the Kaulakahi Channel (between Kauai and Niihau), shoreline reconnaissance and nearshore observations will be undertaken by a team located at Kekaha (the approximate mid point of the Channel). Additional observations will be made on a daily basis by range vessels while enroute from Port Allen to the range at PMRF (a distance of approximately 16 nauticam miles) and upon their return at the end of each day's activities. Finally, surveillance of the beach shoreline and nearshore waters bounding PMRF will occur randomly around the clock a minimum four times in each 24 hour period.

13.7 In the Alenuihaha Channel (between Maui and Hawaii), the Navy will conduct shoreline reconnaissance and nearshore observations by a team rotating between Mahukona and Lapakahi before, during, and after the exercise.

14. The Navy will conduct will conduct five exercises in the Pacific Missile Range Facilities that fall within 25 km of the 200 m isobath. The live sonar component of these 5 exercises will total approximately 6.5 hours. During these exercises, the Navy will conduct the monitoring described in (13)(1), (2), and (3).

15. The Navy will continue to coordinate with NMFS on the "Communications and Response Protocol for Stranded Marine Mammal Events During Navy Operations in the Pacific Islands Region" that is currently under preparation by NMFS PIRO to facilitate communication during RIMPAC. The Navy will coordinate with the NMFS Stranding Coordinator for any unusual marine mammal behavior, including stranding, beached live or dead cetacean(s), floating marine mammals, or out-of-habitat/milling live cetaceans that may occur at any time during or shortly after RIMPAC activities. After RIMPAC, NMFS and the Navy will prepare a

coordinated report on the practicality and effectiveness of the protocol that will be provided to Navy/NMFS leadership.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The following conservation recommendations would provide information for future consultations involving the issuance of marine mammal permits that may affect endangered whales as well as reduce harassment related to research activities:

1. *Cumulative Impact Analysis.* NMFS' Permits, Conservation and Education Division and the U.S. Navy should work with NMFS Endangered Species Division and other relevant stakeholders (the Marine Mammal Commission, International Whaling Commission, and the marine mammal research community) to develop a method for assessing the cumulative impacts of anthropogenic noise on cetaceans, pinnipeds, sea turtles, and other marine animals. This includes the cumulative impacts on the distribution, abundance, and the physiological, behavioral and social ecology of these species.

In order to keep NMFS Endangered Species Division informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Permits, Conservation and Education Division of the Office of Protected Resources should notify the Endangered Species Division of any conservation recommendations they implement in their final action.

REINITIATION NOTICE

This concludes formal consultation on the U.S. Navy's proposal to undertake the activities associated with the proposed RIMPAC 2006 exercises and NMFS' proposal to issue Permit No. to the U.S. Navy to authorize "take" of marine mammals, in the form of harassment, associated with the proposed RIMPAC 2006 exercises pursuant to the provisions of the Marine Mammal Protection Act. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of authorized take is exceeded, the U.S. Navy or NMFS Permits, Conservation and Education Division (or both) must immediately request reinitiation of section 7 consultation.

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Appendix 1: Incidental Harassment Authorization for the 2006 Rim of the Pacific Exercise

DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE

Incidental Harassment Authorization

The Commander, U.S. Pacific Fleet, 250 Makalapa Dr.,Pearl Harbor, HI 96860-3131, and his designees, is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C. 1371(a)(5)(D)) to harass marine mammals incidental to the Rim of the Pacific (RIMPAC) Anti-submarine warfare (ASW) exercises conducted in the Hawaiian Islands Operation Area (OpArea), June 26 – August 15, 2006:

1. This Authorization is valid from June 26, 2006, through August 15, 2006.

2. This Authorization is valid only for the operation of mid-frequency tactical sonar during designated RIMPAC ASW exercises within the Hawaiian Islands OpArea.

3. (a) The incidental take of marine mammals under the activity identified in Condition 2, by Level B harassment only, is limited to the following species:

(i) Mysticete Whales - fin whale (*Balaenoptera physalus*), Bryde's whale (*Balaenoptera edeni*), sei whale (*Balaenoptera borealis*)

(ii) Odontocete Whales - sperm whale (*Physeter macrocephalus*), dwarf and pygmy sperm whales (*Kogia simus* and *K. breviceps*), short-finned pilot whale (*Globicephala macrorhynchus*), Risso's dolphin (*Grampus griseus*), rough-toothed dolphin (*Steno bredanensis*), Fraser's dolphin (*Lagenodelphis hosei*), bottlenose dolphin (*Tursiops truncatus*), spinner dolphin (*Stenella longirostris*), pantropical spotted dolphin (*S. attenuata*), striped dophin (*S. coeruleoalba*), melon-headed whale (*Peponocephala spp*.), Blaineville's beaked whale (*Mesoplodon densirostris*), Cuvier's beaked whale (*Ziphius cavirostris*), Longman's beaked whale (*Indopacetus pacificus*), killer whale (*Orcinus orca*), false killer whale (*Pseudorca crassidens*), and pygmy killer whale (*Feresa attenuata*).

The taking by Level A harassment, serious injury or death of any of these species, or the taking of any species of marine mammal not listed in 3(a), is prohibited and may result in the modification, suspension or revocation of this Authorization.

(b) The taking of any marine mammal in a manner prohibited under this Authorization must be reported immediately to the Pacific Islands Regional Office, National Marine Fisheries Service (NMFS), at (808) 944-2200, and the Division of Permits, Conservation, and Education, Office of Protected Resources (NMFS), at (301) 713-2289.

4. The holder of this Authorization is required to cooperate with NMFS and any other Federal, state or local agency monitoring the impacts of the activity on marine mammals.

5. Mitigation and Monitoring

The holder of this Authorization is required to implement the following measures:

(a) All RIMPAC participants will receive the following marine mammal training/briefing during the port phase of RIMPAC:

(i) Exercise participants (CO/XO/Ops) will review the C3F Marine Mammal Brief, available OPNAV N45 video presentations, and a NOAA brief presented by C3F on marine mammal issues in the Hawaiian Islands.

(ii) Navy will train observers on marine mammal identification observation techniques.

(iii) Third Fleet will brief all participants on marine mammal mitigation requirements.

(iv) Participants will receive video training on marine mammal awareness.

(b) Navy watchstanders, the individuals responsible for detecting marine mammals in the Navy's standard operating procedures, will participate in marine mammal observer training by a NMFS-approved instructor. Training will focus on identification cues and behaviors that will assist in the detection of marine mammals and the recognition of behaviors potentially indicative of injury or stranding. Training will also include information aiding in the avoidance of marine mammals and the safe navigation of the vessel, as well as species identification review (with a focus on beaked whales and other species most susceptible to stranding). At least one individual who has received this training will be present, and on watch, at all times during operation of tactical mid-frequency sonar, on each vessel operating mid-frequency sonar.

(c) All ships and surfaced submarines participating in the RIMPAC ASW exercises will have personnel on lookout with binoculars at all times when the vessel is moving through the water (or operating sonar). These personnel will report the sighting of any marine species, disturbance to the water's surface, or object to the Officer in Command.

(d) All aircraft participating in RIMPAC ASW events will conduct and maintain, whenever possible, surveillance for marine species prior to and during the event. Marine mammal sightings will be immediately reported to ships in the vicinity of the event as appropriate.

(e) Submarine sonar operators will review detection indicators of close-aboard marine mammals prior to the commencement of ASW operations involving active mid-frequency sonar. Marine mammals detected by passive acoustic

(f) Safety Zones - When marine mammals are detected by any means (aircraft, lookout, or acoustically) within 1000 m of the sonar dome (the bow), the ship or submarine will limit active transmission levels to at least 6 dB below normal operating levels. Ships and submarines will continue to limit maximum ping levels by this 6-dB factor until the animal has been seen to leave the area, has not been seen for 30 minutes, or the vessel has transited more than 2000 m beyond the location of the sighting.

Should a marine mammal be detected within or closing to inside 500 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 area, has not been seen for 30 minutes, or the vessel has transited more than 1500 m beyond the location of the sighting.

Should the marine mammal be detected within or closing to inside 200 m of the sonar dome, active sonar transmissions will cease. Sonar will not resume until the animal has been seen to leave the area, has not been seen for 30 minutes, or the vessel has transited more than 1200 m beyond the location of the sighting.

If the Navy is operating sonar above 235 dB and any of the conditions necessitating a powerdown arise ((f), (g), or (h)), the Navy shall follow the requirements as though they were operating at 235 dB - the normal operating level (i.e., the first powerdown will be to 229 dB, regardless of at what level above 235 sonar was being operated).

(g) In strong surface ducting conditions defined below), the Navy will enlarge the safety zones such that a 6-dB power down will occur if a marine mammal enters the zone within a 2000 m radius around the source, a 10-dB powerdown will occur if an animal enters the 1000 m zone, and shut down will occur when an animal closes within 500 m of the sound source.

A strong surface duct (half-channel at the surface) is defined as having the all the following factors: (1) A delta SVP between 0.6 to 2.0 m/s occurring within 20 fathoms of the surface with a positive gradient (upward refracting); (2) Sea conditions no greater than Sea State 3 (Beaufort Number 4); and (3) Daytime conditions with no more than 50% overcast (otherwise leading to diurnal warming). This applies only to surface ship mid-frequency active mainframe sonar.

(h) In low visibility conditions (i.e., whenever the entire safety zone cannot be effectively monitored due to nighttime, high sea state, or other factors), the Navy will use additional detection measures, such as infrared (IR) or enhanced passive acoustic detection. If detection of marine mammals is not possible out to the prescribed safety zone, the Navy will power down sonar (per the safety zone criteria above) as if marine mammals are present immediately beyond the extent of detection. (For example, if detection of marine mammals is only possible out to 700 m, the Navy must implement a 6 dB powerdown, as though an animal is present at 701 m, which is inside the 1000 m safety zone)

(i) Helicopters shall observe/survey the vicinity of an ASW exercise for 10 minutes before deploying active (dipping) sonar in the water. Helicopters shall not dip their sonar within 200 yards of a marine mammal and shall cease pinging if a marine mammal closes within 200 yards after pinging has begun.

(j) The Navy will operate sonar at the lowest practicable level, not to exceed 235 dB, except for occasional short periods of time to meet tactical training objectives.

(k) With the exception of three specific choke-point exercises (special measures outlined in item (m)), the Navy will not conduct sonar activities in constricted channels or canyon-like areas.

(l) With the exception of three specific "choke-point" exercises (special measures outlined in item (m)), and events occurring on range areas managed by PMRF, the Navy will not operate mid-frequency sonar within 25 km of the 200 m isobath.

(m) The Navy will conduct no more than three "choke-point" exercises. These exercises will occur in the Kaulakahi Channel (between Kauai and Niihau) and the Alenuihaha Channel (between Maui and Hawaii). These exercises fall outside of the requirements listed above in (k) and (l), i.e., to avoid canyon-like areas and to operate sonar farther than 25 km from the 200 m isobath. The additional measures required for these three choke-point exercises are as follows:

(i) The Navy will provide NMFS (Stranding Coordinator and Protected Resources, Headquarters) and the Hawaii marine patrol with information regarding the time and place for the choke-point exercises 24 hours in advance of the exercises.

(ii) The Navy will have at least one dedicated Navy marine mammal observer who has received the NMFS-approved training mentioned above in (b), on board each ship and conducting observations during the operation of mid-frequency tactical sonar during the choke-point exercises. The Navy has also authorized the presence of two experienced marine mammal observers (non-Navy personnel) to embark on Navy ships for observation during the exercise.

(iii) Prior to start up or restart of sonar, the Navy will ensure that a 2000 m radius around the sound source is clear of marine mammals.

(iv) The Navy will coordinate a focused monitoring effort around the choke-point exercises, to include pre-exercise monitoring (2 hours), during-exercise monitoring, and post-exercise monitoring (1-2 days). This monitoring effort will include at least one dedicated aircraft or one dedicated vessel for realtime monitoring from the pre- through post-monitoring time period, except at night. The vessel or airplane may be operated by either dedicated Navy personnel, or non-Navy scientists contracted by the Navy, who will be in regular communication with a Tactical Officer with the authority to shut-down, power-down, or delay the start-up of sonar operations. These monitors will communicate with this Officer to ensure the 2000 m safety zone is clear prior to sonar start-up, to recommend power-down and shut-down during the exercise, and to extensively search for potentially injured or stranding animals in the area and down-current of the area post-exercise.

(v) The Navy will further contract an experienced cetacean researcher to conduct systematic aerial reconnaissance surveys and observations before, during, and after the choke-point exercises with the intent of closely examining local populations of marine mammals during the RIMPAC exercise.

(vi) Along the Kaulakahi Channel (between Kauai and Niihau), shoreline reconnaissance and nearshore observations will be undertaken by a team of observers located at Kekaha (the approximate mid point of the Channel). Additional observations will be made on a daily basis by range vessels while enroute from Port Allen to the range at PMRF (a distance of approximately 16 nmi) and upon their return at the end of each day's activities. Finally, surveillance of the beach shoreline and nearshore waters bounding PMRF will occur randomly around the clock a minimum four times in each 24 hour period.

(vii) In the Alenuihaha Channel (between Maui and Hawaii), the Navy will conduct shoreline reconnaissance and nearshore observations by a team of observers rotating between Mahukona and Lapakahi before, during, and after the exercise.

(n) The Navy will conduct five exercises in the Pacific Missile Range Facilities that fall within 25 km of the 200 m isobath. The live sonar component of these 5 exercises will total approximately 6.5 hours. During these exercises, the Navy will conduct the monitoring described in (m)(i), (ii), and (iii).

(o) The Navy will continue to coordinate with NMFS on the "Communications and Response Protocol for Stranded Marine Mammal Events During Navy Operations in the Pacific Islands Region" that is currently under preparation by NMFS PIRO to facilitate communication during RIMPAC. The Navy will coordinate with the NMFS Stranding Coordinator for any unusual marine mammal behavior, including stranding, beached live or dead cetacean(s), floating marine mammals, or out-of-habitat/milling live cetaceans that may occur at any time during or shortly after RIMPAC activities. After RIMPAC, NMFS and the Navy (CPF) will prepare a coordinated report on the practicality and effectiveness of the protocol that will be provided to Navy/NMFS leadership.

6. Reporting

The holder of this authorization is required to:

(a) Submit a report to the Division of Permits, Conservation, and Education, Office of Protected Resources, NMFS, and the Pacific Islands Regional Office, NMFS, within 90 days of the completion of RIMPAC. This report must contain and summarize the following information:

(i) An estimate of the number of marine mammals affected by the RIMPAC ASW exercises and a discussion of the nature of the effects, if observed, based on both modeled results of real-time exercises and sightings of marine mammals.

(ii) An assessment of the effectiveness of the mitigation and monitoring measures with recommendations of how to improve them.

(iii) Results of all of the marine species monitoring (real-time Navy monitoring from all platforms, independent aerial monitoring, shore-based monitoring at chokepoints, etc.) before, during, and after the RIMPAC exercises.

(iv) As much information (unclassified and, to appropriately cleared recipients, classified "secret") as the Navy can provide including, but not limited to, where and when sonar was used (including sources not considered in take estimates, such as submarine and aircraft sonars) in relation to any measured received levels (such as at sonobuoys or on PMRF range), source levels, numbers of sources, and frequencies, so it can be coordinated with observed cetacean behaviors.

7. In the event that a stranding occurs during the RIMPAC ASW exercises, NMFS will implement the attached shutdown protocols.

8. A copy of this Authorization must be in the possession of all contractors and marine mammal monitors operating under the authority of this Incidental Harassment Authorization.

____ ____________

James H. Lecky Date
Director
Office of Protected Resources
National Marine Fisheries Service

Attachment

Attachment to the Incidental Harassment Authorization: Shutdown Criteria

Pursuant to §101(a)(5)(D)(iv) of the MMPA, The Secretary shall modify, suspend, or revoke an authorization if the Secretary finds that the provisions of clauses (i) or (ii) of §101(a)(5)(D) are not being met. Marine mammal strandings are a common event in Hawaii and over the course of the 22 days of ASW exercises, NMFS expects that 1 or 2 single-animal strandings may occur that are not related to RIMPAC. To distinguish these strandings from a stranding that NMFS believes may occur as a result of exposure to the hull-mounted Mid-Frequency Active Sonar (MFAS) activities covered in this authorization, NMFS and the U.S. Navy have established this "shutdown criteria" to provide the necessary time for the Secretary to investigate the cause of uncommon marine mammal stranding events and determine whether the IHA should be modified, suspended, or revoked. The established protocols in place between NMFS Stranding Coordinator Pacific and COMPACFLT Environmental Coordinator are the basis for this document.

Definitions:

Shutdown area – An area within 50 km of the half of the island centered on the place where the animal was found.

Limited Chokepoint Shutdown – Temporary suspension of the hull-mounted MFAS during the choke point exercises.

Uncommon Stranding Event – An event involving any one of the following:

- Two or more individuals of a commonly stranded species found dead or live beached within a two day period (not including mother/calf pairs), or
- A single uncommonly stranded whale found dead or live beached, or
- A group of 10 or more animals milling out of habitat (e.g. such as occurred with melon headed whales in Hanalei Bay in 2004)-

Commonly Stranded Odontocete Species - spinner dolphin, striped dolphin, *Kogia* sp, *Tursiops* sp, melon-headed whale, pilot whale, and sperm whales.

Investigation – consists of the following components and can be conducted within 3 days of notification of a stranding event

- NMFS will undertake a survey around stranding site to search for other stranded/out of habitat animals
- Physical Exam of animal (and blood work if live animals) to investigate and verify presence or absences
    - of impacts on the hearing of live stranded mammals. If feasible and if medical condition of the animal allows, Acoustic Brainstem Response (ABR) and Auditory Evoke Potential (AEP) will be conducted to rapidly assess whether the hearing of a live stranded animal has been affected.
    - of long term illness (based on body condition), life threatening infection, blunt force traumas or fishery interaction that would indicate the likely cause of death

    - of gross lesions or CT/MRI findings that have been documented in previous sonar related strandings (i.e., gas emboli or fat emboli, hemorrhages in organs, hemorrhage in ears). Note: Care must be taken to control and document the conditions under which the carcass is handled. The investigation of microscopic histology can be compromised by the decomposition, freeze/thaw, transport conditions and subsequent necropsy of the mammal.
- Evaluation of environmental conditions (through remote sensing, modeling and direct observations) preceding and during the stranding or out of habitat event to determine if environmental factors that are known to contribute to such events were in place, such as fronts, swells, particular currents, Kona winds, prey abundance, seismic events, lunar phase, toxins or predators in area. Navy will assist in providing environmental data that is otherwise collected for tactical purposes.
    - Strong evidence of environmental factors that might contribute to stranding event were present
    - Weak to no evidence of environmental factors that might contribute to stranding were present
- Within 72 hours of notification of an Uncommon Stranding Event, Navy will provide information regarding where and what (or where not) the Navy was operating sonar leading up to the stranding.

Shutdown Protocol:

1. NMFS will respond to all reports of marine mammal strandings during the exercise. If a stranding is suspected to be an Uncommon Stranding Event, the NMFS Stranding Coordinator Pacific will immediately notify the COMPACFLT Environmental Coordinator. The Coordinators will utilize existing protocols as amplified by this document to verify whether or not an event constitutes an Uncommon Stranding Event.

2. If an Uncommon Stranding Event is verified, NMFS will inform the Navy and will identify the shutdown area. NMFS will also confirm with Navy the start time and duration of any recent choke-point exercises.

3. The Navy will cease hull-mounted MFAS activities in the shutdown area. Additionally, if the uncommon stranding event occurred during or within 48 hours of the end of a choke point exercise the Navy will invoke the limited choke point shutdown for up to 4 days.

4. NMFS will conduct its investigation and inform the Navy of its findings as soon as possible, but no later than 4 days from the date the Uncommon Stranding Event was verified.

5. If the results of the investigation indicate that the stranding resulted from causes other than activities covered by this authorization NMFS will inform the Navy that exercises authorized by this IHA may resume.

6. If NMFS determines that the Navy's activities authorized under the IHA may have contributed to the uncommon marine mammal stranding event NMFS will advise the Navy whether the IHA should be modified, suspended, or revoked.

Communication

Effective communication is critical to the successful implementation of this protocol.

- NMFS will provide Navy with a list of NMFS staff, empowered to inform the Navy to implement the appropriate shutdown protocol as described above. These individuals will be reachable 24 hours/day for 22 consecutive days (a pre-identified group will be on call in shifts to make these decisions and a phone tree will be available). Week-end on call will be designated for HQ staff by noon on Friday.
- Navy will provide NMFS a list of people empowered to implement the shut down protocol, at least one of whom will be reachable at any hour during the 22 days of ASW exercises prior to the initiation of the exercise