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

Agencies:	National Marine Fisheries Service, with the United States (U.S.) Navy as Action Agency and Applicant for a Federal Authorization
Activities Considered:	The U.S. Navy research, development, test, and evaluation (RDT&E) activities at the U.S. Naval Surface Warfare Center, Panama City, Florida, from January 2011 to January 2012 2011 Letter of Authorization (LOA) for the U.S. Navy to "take" marine mammals incidental to the conduct of RDT&E activities at the U.S. Naval Surface Warfare Center, Panama City, Florida, from January 2011 to January 2012
Consultation Conducted by:	Endangered Species Division of the Office of Protected Resources, National Marine Fisheries Service

Approved by: _____ **Date:** JAN - 7 2011

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1539(a)(2)) requires each federal agency to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action "may affect" a protected species, that agency is required to consult formally with the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending on the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR 402.14(a)).

This is the second annual (of an anticipated five) biological opinions (Opinion) for the issuance of an annual LOA pursuant to the Marine Mammal Protection Act of 1972 (MMPA) related to a five-year programmatic consultation on RDT&E activities at the U.S. Naval Surface Warfare Center – Panama City Division (NSWC PCD) Study Area, Panama City, Florida. The LOA would authorize the U.S. Navy to take (*sensu* MMPA) marine mammals incidental to those RDT&E activities by NMFS' Office of Protected Resources – Permits, Conservation, and Education Division (Permits Division) from January 2011 through January 2012.

A complete administrative record for this consultation is on file at NMFS' Office of Protected Resources.

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Consultation History

The U.S. Navy and NOAA's National Marine Fisheries Service (NMFS) have been working together to ensure that Naval research, development, training, and evaluation (RDT&E) activities conducted in the Naval Surface Warfare Center – Panama City Division (NSWC PCD) Study Area, Panama City, Florida are authorized under the Federal Endangered Species Act (ESA). A summary of the consultation history is provided in Table 1.

A five-year (2009-2014) programmatic consultation on the Navy's proposal to conduct RDT&E activities at the NSWC PDC Study Area was completed and a biological opinion was issued in 2009 on activities inclusive of the activities proposed for 2011 (NMFS 2009b).

On January 21, 2010, NMFS issued a biological opinion on activities similar to what was considered in the programmatic consultation, but 1) included the action of issuing a letter of authorization (LOA) for activities to be conducted from January 2010 to January 2011 and 2) resulted in the issuance of an Incidental Take Statement (ITS) (NMFS 2010b). An ITS was included because incidental take of marine mammals was authorized under section 101(a)(5) of the MMPA via the LOA.

On September 2, 2010, the U.S. Navy submitted an application to NMFS Permits Division requesting annual renewal of the MMPA letter of authorization for incidental "take" of marine mammals and requested initiation of ESA consultation for ESA-listed species related to proposed RDT&E activities in the NSWC PCD Study Area for January 2011 through January 2012 (Navy 2010b).

On October 29, 2010, NMFS Permits Division requested NMFS' Endangered Species Division initiate ESA consultation on the issuance of an annual LOA for the Navy's RDT&E from January 2010 to January 2011 activities and provided a draft annual LOA.

On December 17, 2010, NMFS Endangered Species Division provided the U.S. Navy and the Permits Division with copies of the draft biological and conference opinions on the suite of activities that would be authorized by the draft LOA. On December 28, 2010, the U.S. Navy submitted comments on the draft Opinions. NMFS has reviewed all comments submitted and revised the Opinions as warranted.

Table 1. Time-line of Endangered Species Act section 7 consultation research, development, test, and evaluation (RDT&E) activities related to the Naval Surface Warfare Center – Panama City Division (NSWC-PCD) Study Area, Panama City, Florida.

Date	Agency	Activity	Comments
1 Apr 2008	U.S. Navy	Submitted application to NMFS Permits Division requesting authorization for incidental "take" of marine mammals from RDT&E activities over the next five years	
22 Dec 2008	U.S. Navy	Submitted biological evaluation to NMFS Endangered Species Division for ESA section 7 consultation	
9 Feb 2009	U.S. Navy	Submitted an addendum to the application requesting authorization for incidental "take" of marine mammals from RDT&E activities over the next five years	
30 Apr 2009	NMFS	Proposed rule published in the Federal Register (FR) on the U.S. Navy's request for a five year MMPA regulation to allow for annual letters of authorization for the Navy's RDT&E activities	74 FR 20155
29 Jul 2009	NMFS Permits Division	Provided NMFS' Endangered Species Division with a final draft of the five year MMPA regulations	
15 Sep 2009	NMFS Endangered Species Division	Issued a five year programmatic ESA biological opinion on the Navy's activities and NMFS Permits Division's MMPA regulations covering 2009-2014	
25 Sep 2009	U.S. Navy	NSWC PCD mission activities Environmental Impact Statement/Overseas Environmental Impact Statement Final dated January 2010 published	
14 Jan 2010	NMFS Permits Division	Issued final rule issuing regulations to govern the unintentional taking of marine mammals incidental to activities conducted at the NSWC PCD for the period of January 2010 through January 2015	
14 Jan 2010	NMFS Endangered Species Division	Issued a one year ESA biological opinion on the Navy's activities and NMFS Permits Division's LOA covering January 2010 to January 2011	
21 Jan 2010	NMFS	Final rule issuing regulations to govern the unintentional taking of marine mammals incidental to activities conducted at the NSWC PCD for the period of January 2010 through January 2015 published in the Federal Register	75 FR 3395
21 Jan 2010	NMFS	Issued the annual LOA for the unintentional taking of marine mammals incidental to activities conducted at the NSWC PCD for January 2010 through January 2011	
2 Sep 2010	U.S. Navy	Submitted application to NMFS Permits Division requesting annual renewal of the MMPA letter of authorization for incidental "take" of marine mammals from R,D,T&E activities for January 2011 through January 2012	
29 Sep	U.S. Navy	Submitted annual monitoring report to NMFS Permits	No monitoring

Date	Agency	Activity	Comments
2010		Division and NMFS Endangered Species Division for activities that occurred from January 2010 through August 2010	occurred in 2010, only planning for 2011 was done
29 Oct 2010	NMFS Permits Division	Requested NMFS' Endangered Species Division initiate ESA consultation on the issuance of an annual LOA for the Navy's RDT&E from January 2010 to January 2011 activities by providing draft annual LOA and cover letter	

BIOLOGICAL AND CONFERENCE OPINIONS

This is the second (of an anticipated five) annual ESA biological opinion (Opinion) related to a five year programmatic ESA consultation on RDT&E activities in the NSWC PCD Study Area. The programmatic consultation evaluated 1) the issuance of an LOA, pursuant to the MMPA, that would authorize the U.S. Navy to "take" marine mammals incidental to RDT&E activities carried out by the U.S. Navy in the NSWC PCD Study Area by NMFS' Permits Division in each of the five years the programmatic consultation remains in effect and 2) the U.S. Navy's RDT&E activities in the NSWC PCD Study Area.

This Opinion and incidental take statement were prepared by NMFS Endangered Species Division in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, et seq.), and implementing regulations at 50 CFR 402.

The Opinion is in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Data Quality Act) (44 U.S.C. 3504 (d)(1) and 3516), and underwent pre-dissemination review.

This Opinion is based on information provided in the *Final Environmental Impact Statement/Overseas Environmental Impact Statement, Naval Surface Warfare Center, Panama City Division, Florida* (Navy 2009), and *Final Environmental Impact Statement and Overseas Environmental Impact Statement on Atlantic Fleet Active Sonar Training* (Navy 2008), applications for the proposed permit, previous ESA consultations on similar actions, mission and monitoring reports from the Navy, published and unpublished scientific information on the biology and ecology of threatened and endangered whales, endangered and threatened sea turtles, and gulf sturgeon that occur in the Gulf of Mexico and the Gulf coast of Florida, and other sources of information.

1 Description of the Proposed Action

In a letter to NMFS, received on September 2, 2010, the U.S. Navy requested 1) the issuance of the LOA for the incidental take of marine mammals pursuant to the MMPA for the period of

January 2010 through January 2011, and 2) the initiation of consultation under the Federal ESA for the incidental take of listed species pursuant to the ESA.

In a separate but related activity, NMFS' Permits Division in a letter dated October 29, 2010, requested the initiation of ESA section 7 consultation on their proposed action to issue a LOA to the U.S. Navy to take marine mammals for a one-year period beginning in January 2011 and ending in January 2012 incidental to the RDT&E at the NSWC PCD Study Area.

As described in previous consultations on nearly identical actions, the proposed action can be divided into four components: the Navy's RDT&E activities, NMFS' Permits Division's issuance of the LOA, the Navy's mitigation and monitoring activities relative to their RDT&E activities, and NMFS' Permits Division mitigation and monitoring requirements for the Navy. Below we describe each of these components of the proposed action.

1.1 U.S. Navy Research, Development, Training, and Evaluation Activities

The U.S. Navy proposes to continue RDT&E activities in the NSWC PCD Study Area that support U.S. Navy activities related to expeditionary maneuver warfare, operations in extreme environments, mine warfare, maritime operations, and coastal operations. The proposed activities for this consultation are similar to the activities considered in the biological opinion on the previous LOA (NMFS 2010b). Further, they are the same activities described and considered in the five year programmatic biological opinion (NMFS 2009b). In particular, RDT&E activities at the U.S. Navy's NSWC PCD Study Area primarily consist of eight operations: (1) air operations, (2) surface operations, (3) subsurface operations, (4) sonar operations, (5) electro-magnetic operations, (6) laser operations, (7) ordnance operations, and (8) projectile firing.

1.1.1 Air Operations

The U.S. Navy proposes to continue to conduct five kinds of RDT&E activities from aircraft platforms in the NSWC PCD Study Area:

1. Support activities for clearance and monitoring;
2. Towing of an object that contains active or passive sensors towed in the water column;
3. Captive carriage to test the handling of aircraft during transport, separation, and release of objects;
4. Aerial delivery and separation of objects to test inert objects, rockets, or mines and the aircraft's flight effects on deployment of such items; and
5. Live aerial expendables activities, which include only gun firing at predetermined targets from a helicopter.

The majority of the aircraft the U.S. Navy proposes to employ to support these activities would continue to be helicopters (MH-53, MH-60, UH-1, and variants). In some cases, a test might involve a single aircraft; in other cases, a test might involve multiple aircraft. When the U.S. Navy employs multiple aircraft to support a test, one aircraft would normally be designated as

the test aircraft while the other aircraft would be used to survey and monitor a particular test site to be certain the test site is clear of other aircraft or surface vessels.

The U.S. Navy proposes to conduct about 1,116 hours of air operations in the NSWC PCD Study Area in 2011. Of this total, 771 hours (representing about 69 percent of the total hours) involve helicopter operations within territorial waters, 330 hours involve helicopter operations beyond territorial waters (representing another 30 percent of the total hours), and the balance involves fixed-wing aircraft in territorial and non-territorial waters (see Table 2.).

1.1.2 Surface Operations

The U.S. Navy proposes to continue to conduct four kinds of RDT&E activities from surface platforms at the NSWC PCD Study Area:

1. Support activities would include surface vessels that carry test equipment and personnel to and from test sites and to secure and monitor designated test areas;
2. Tow test events would involve surface vessels used as tow platforms for mine warfare systems tests that can be deployed from ships;
3. Launch and recovery activities include surface craft that would be used to deploy and recovery unmanned underwater vehicles, sonobuoys, inert mines, mine-like objects, versatile exercise mine systems and other test systems.
4. Developmental and operational testing that would involve tests of navigation and communication systems associated with various surface vessels, including some unmanned surface vessels.

The U.S. Navy proposes to engage in about 7,443 hours of surface operations at the Naval Surface Warfare Center in 2011. Of this total, 5,418 hours (representing about 73 percent of the total hours) involve boats within territorial waters, 1,806 hours involve boats beyond territorial waters (representing another 24 percent of the total hours), and the balance involves Landing Craft Air Cushions (see Table 2.).

1.1.3 Subsurface Operations

The U.S. Navy proposes to continue to conduct diving operations, salvage operations, robotic vehicles, unmanned underwater vehicles, and mooring and burying of mines. The U.S. Navy would conduct diving operations as part of research related to underwater life support equipment and systems and testing manned undersea mobility systems, underwater guidance, and navigation systems. The proposed salvage operations would include planting and recovering targets and locating RDT&E equipment that had been jettisoned into in the area (or placed there). Tests that would employ robotic vehicles, such as crawlers and unmanned underwater vehicles would be used to locate and classify underwater objects and mines while rejecting miscellaneous clutter that would not pose a potential threat.

Personnel at the Naval Surface Warfare Center develop, upgrade, and manage new underwater mine systems. As a result, temporary minefields would be placed at varying depths within the NSWC PCD Study Area in order to simulate bottom and moored mine threats and to test the

survivability and efficiency of underwater mine systems. These minefields typically consist of moored mine-like objects, inert mines, or versatile exercise mines. Mine-like objects and inert mines are any inert object or casing that resembles the shape of a mine but does not have an explosive component of an actual mine. Versatile exercise mines are mine casings that contain programmable electronics and sensors that simulate a mine while collecting data. In future tests that involve mine counter measures, the U.S. Navy might use live mines to test the efficiency and survivability of specific counter measures. Temporary mine fields remain in the water throughout a test cycle.

The U.S. Navy uses surface vessels or fixed-wing aircraft (depending on the type of mine used in a test) to moor targets. Moored mines deployed from fixed-wing aircraft enter the water and impact the bottom, becoming semi-submerged. Most moored mines deployed from surface ships are secured with up to a 1,225 kg (2,700 lbs) concrete mooring block. Upon impact, the mine casing separates and the semi-buoyant mine floats through the water column until it reaches the end of the mooring line. Bottom mines are typically positioned manually in shallow water (surf zone) and are allowed to free sink to the bottom to rest and are covered up with sand by the natural movement of sediments associated with wave action in the surf zone. Divers typically place bottom mines in deeper waters outside the surf zone.

All test minefields are deployed in accordance with and in cooperation with the United States Coast Guard including a Notice to Mariners and other safety measures as appropriate. Global Positioning System coordinates of the deployed mine-like objects and inert mines are identified and recorded to allow Navy personnel to recover the mine targets after a test is completed. All maintenance of mine-like objects, inert mines, and versatile exercise mines are conducted on shore.

The U.S. Navy proposes to deploy or retrieve about 798 targets in 2011. The U.S. Navy proposes to operate crawlers and unmanned underwater vehicles for about 114 and 1,506 hours, respectively (see Table 2.).

Table 2. Specific activities the U.S. Navy plans to conduct at the Naval Surface Warfare Center – Panama City, Florida each year from January 2011 through January 2012.

Activity	Occurrence in Territorial Waters	Occurrence in Non-Territorial Waters	Total
Aircraft operations (hours)			
Helicopters	771	330	1.101
Fixed wing	3	12	15
Surface operations (hours)			
Boats	5,418	1,806	7,224
Landing Craft Air Cushions	164	55	219
Sub-surface operations			
Mine-like objects (items)	559	239	798
Versatile exercise mine (items)	118	50	168
Crawlers (hours)	114	0	114
Unmanned underwater vehicles (hours)	1,506	0	1,506
Sonar operations (hours)			
Mid-frequency active	73	4	77
High-frequency active (>10 kHz)	822	455	1,277
Electromagnetic operations (hours)			
Electromagnetic energy	514	221	735
Laser operations (hours)			
Laser line scan	211	237	448
Light Imaging Detection and Ranging (LIDAR)	263	289	552
Directional	53	0	53
Ordnance operations (detonations)			
Ordnance weights 0.45 - 4.5 kg	51	0	51
Ordnance weights 5 - 34 kg	3	0	3
Ordnance weights 34 - 272 kg	0	16	16
Line charges (lines)	3	0	3
Projectile firing (rounds)			
5-inch	0	60	60
40 mm	0	480	480
30 mm	0	600	600
20 mm	0	2,967	2,967
76 mm	0	240	240
25 mm	0	525	525
Small arms	0	6,000	6,000

1.1.4 Sonar Operations

The U.S. Navy proposes to conduct sonar operations at the NSWC PCD Study Area that would involve testing various sonar systems in the ocean and the laboratory to demonstrate a system's capability to detect, locate, and characterize mine-like objects under various environmental conditions. Data the U.S. Navy collects during these tests are used to validate the effectiveness of these sonar systems and their ability to meet their mission.

The various sonar systems to be tested in the NSWC PCD Study Area have source frequencies ranging from 1 kilohertz (kHz) to 5 megahertz (MHz) with source levels ranging from 200 to 235 decibels (dB) at 1 meter (m). The U.S. Navy does not propose to research, develop, test, or evaluate low-frequency sonar in the NSWC PCD Study Area.

The U.S. Navy proposes to conduct about 1,354 hours of sonar operations in the NSWC PCD Study Area in 2011. Of this total, 77 hours (about 6 percent of the total hours) would involve sonars that transmit in the mid-frequency range (1 kHz to 10 kHz) and 1,277 hours (about 94 percent of the total hours) involve sonars that transmit in the high-frequency range (> 10 kHz). Included with those hours would be about 53 hours involving jammers of mechanical mine-sweeping devices (which operate over a mid- to high-frequency range; see Table 2.).

1.1.5 Electromagnetic Operations

Electromagnetic operations that the U.S. Navy proposes to continue to conduct in the NSWC PCD Study Area would involve testing an array of magnetic sensors that generate electromagnetic fields used in mine countermeasures operations. Navy personnel would employ surface ships to conduct multiple sonar sweeps over specific test areas that contain tethered mine-like objects, buried mine-like objects or inert mines, and versatile exercise mine systems to demonstrate a sonar systems' ability to influence or trigger magnetic targets. The U.S. Navy proposes to conduct about 735 hours of electromagnetic operations in 2011 (see Table 2.).

1.1.6 Laser Operations

Laser test operations the U.S. Navy proposes to continue to conduct in the NSWC PCD Study Area would take place below and above the water surface. Laser systems include light imaging detection and ranging (LIDAR), laser line scan, and directional systems. Generally, the LIDAR systems are typically mounted on helicopters and emit a narrow, high-frequency laser beam; they are typically used to detect, classify, and localize drifting, floating, and near-surface moored threats. Directional laser systems are typically mounted on moving platforms and are identical to the LIDAR systems but employed under water. Laser line scan systems were developed for use on towed bodies and unmanned underwater vehicles so they are also employed under water.

The U.S. Navy proposes to conduct about 448 hours of operations that employ laser line scan systems, 552 hours that employ LIDAR systems, and 53 hours that employ directional systems (see Table 2.).

1.1.7 Ordnance Operations

The U.S. Navy uses live explosives in the NSWC PCD Study Area to demonstrate the capability and effectiveness of the mine counter measures systems during the development of those system. Depending on the specific test scenario, live testing might occur from the surf zone out to the outer perimeter of the NSWC PCD Study Area (see Figure 1).

The size and weight of explosives that would be used in a test would vary from a trinitrotoluene (TNT) equivalent net explosive weight (NEW) of 0.91 to a NEW of 272 kilograms (or 2 to 600 pounds). To meet the U.S. Navy's need to safely clear surf zones for sea based expeditionary operations, the Navy occasionally tests various surf zone clearing systems that use either line charges or explosive arrays to neutralize mine threats. These activities are only designed to develop these systems and assess the in-water components of testing. These charges consist of a 107 m (350 ft) detonation cord with explosives lined from one end to the other end in a series of 2 kg (5 lbs) increments.

Ordnance with a net explosive weight that is less than 34 kg (75 lbs) are typically detonated in territorial waters while ordnance with a net explosive weight that is greater than 34 kg are detonated in non-territorial waters. Line charge testing would only be conducted in the surf zone along the portion of Santa Rosa Island that is part of Eglin Air Force Base.

The U.S. Navy proposes to conduct 70 ordnance operations in 2011 in the NSWC PCD Study Area; these operations would involve charges with net explosive weights between 0.45 and 4.5 kg (1 and 10 lbs) (see Table 2.).

1.1.8 Projectile Firing Operations

The U.S. Navy proposes to fire about 10,870 rounds per year, including 5-inch, 40 mm, 30 mm, 20 mm 76 mm, 25 mm, and small arms fire in the NSWC PCD Study Area (see Table 2.). The projectiles associated with these rounds would mainly be armor piercing projectiles; with the exception that the 5-inch round would be a high explosive projectile containing approximately 3.63 kg (8 lbs) of explosive material.

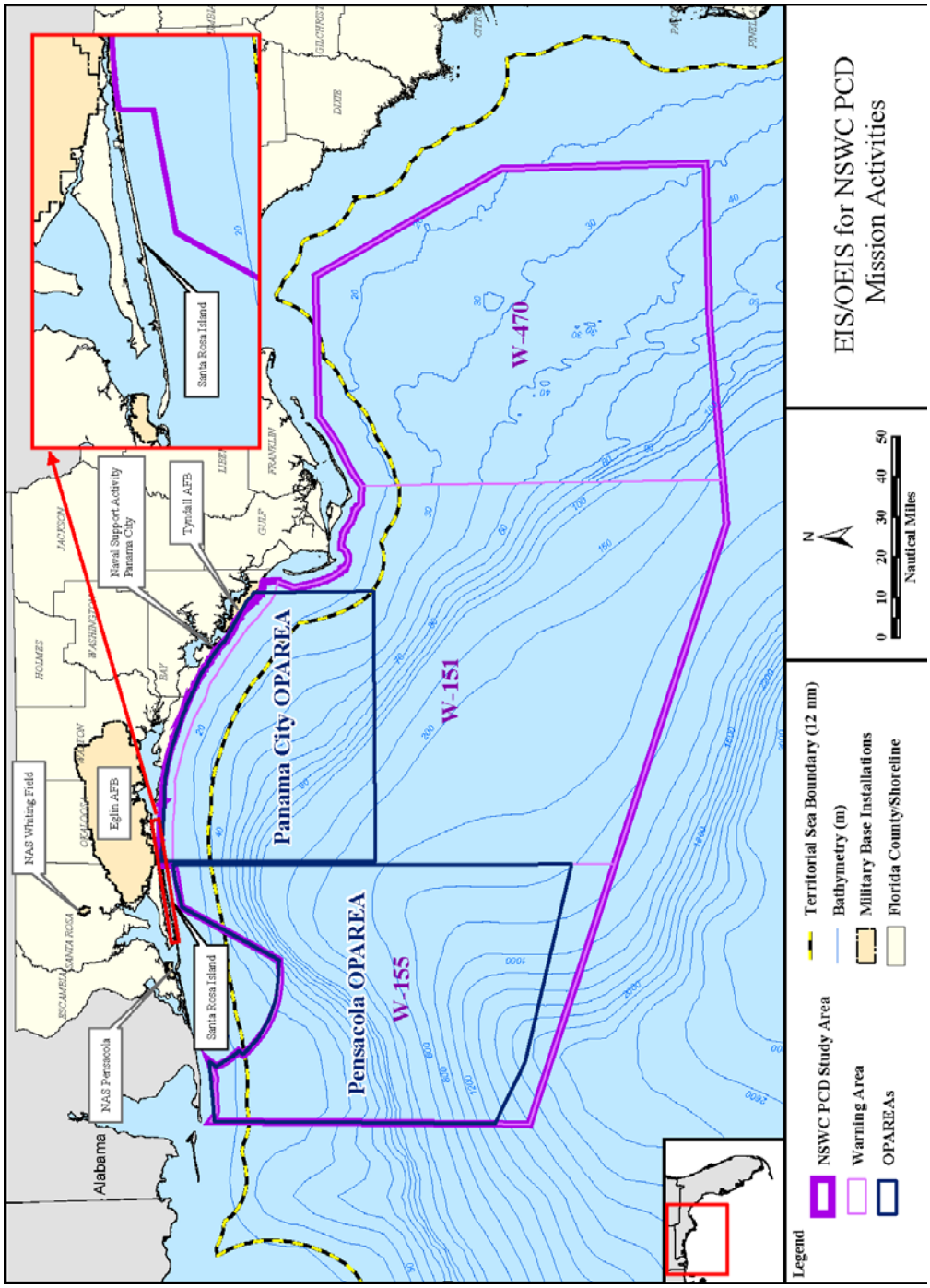

Figure 1. The action area for this consultation (from U.S. Navy 2008a, 2008b).

1.2 Scope of the MMPA Regulations

The Permits Division promulgated regulations that authorize the U.S. Navy to "take" marine mammals only if the "take" occurs within the NSWC PCD Study Area, which includes St. Andrew Bay and the military warning areas (that is, areas within the Gulf of Mexico subject to military operations): W-151 (which includes the Panama City Operating Area), W-155 (which includes the Pensacola Operating Area), and W-470.

The NSWC PCD Study Area includes a Coastal Test Area, a Very Shallow Water Test Area, and Target and Operational Test Fields. The U.S. Navy may conduct RDT&E activities anywhere within the NSWC PCD Study Area from the mean high water line (average high tide mark) out to 222 km (120 nm) offshore.

The MMPA regulations authorize the U.S. Navy to "take" marine mammals only if the "take" occurs incidental to the following activities within the designated amounts of use:

1 The use of the following high frequency active sonar and mid-frequency active sonar or similar sources for U.S. Navy mission activities in territorial waters in the amounts indicated below:

- i AN/SQS-53/56 Kingfisher - up to 15 hours over the course of 5 years (an average of 3 hours per year);
- ii Sub-bottom profiler (2-9 kHz) - up to 105 hours over the course of 5 years (an average of 21 hours per year);
- iii REMUS SAS-LF[1] (center frequency 15 kHz) - up to 60 hours over the course of 5 years (an average of 12 hours per year);
- iv REMUS Modem - up to 125 hours over the course of 5 years (an average of 25 hours per year);
- v Sub-bottom profiler (2-16 kHz) - up to 120 hours over the course of 5 years (an average of 24 hours per year);
- vi AN/SQQ-32 - up to 150 hours over the course of 5 years (an average of 30 hours per year);
- vii REMUS SAS-LF (center frequency 20 kHz) - up to 100 hours over the course of 5 years (an average of 20 hours per year);
- viii SAS-LF - up to 175 hours over the course of 5 years (an average of 35 hours per year);
- ix AN/WLD-1 RMS-ACL - up to 168 hours over the course of 5 years (an average of 33.5 hours per year);

[1] REMUS stands for Remote Environmental Measuring Unit and is an unmanned underwater vehicle; BPAUV is the acronym for Battlespace Preparation Autonomous Underwater Vehicle; TVSS is the acronym for Toroidal Volume Search Sonar; sas is the acronym for Synthetic Aperture Sonar.

x BPAUV Sidescan (center frequency 75 kHz) - up to 125 hours over the course of 5 years (an average of 25 hours per year);

xi TVSS - up to 75 hours over the course of 5 years (an average of 15 hours per year);

xii F84Y - up to 75 hours over the course of 5 years (an average of 15 hours per year);

xiii BPAUV Sidescan (center frequency 102.5 kHz) - up to 125 hours over the course of 5 years (an average of 25 hours per year);

xiv REMUS-SAS-HF - up to 50 hours over the course of 5 years (an average of 10 hours per year);

xv SAS-HF - up to 58 hours over the course of 5 years (an average of 11.5 hours per year);

xvi AN/AQS-20 - up to 2725 hours over the course of 5 years (an average of 545 hours per year);

xvii AN/WLD-11 RMS Navigation - up to 75 hours over the course of 5 years (an average of 15 hours per year); and

xviii BPAUV Sidescan (center frequency 120 kHz) - up to 150 hours over the course of 5 years (an average of 30 hours per year).

(2) The use of the following high frequency active sonar and mid-frequency active sonar or similar sources for U.S. Navy mission activities in non-territorial waters in the amounts indicated below:

i AN/SQS-53/56 Kingfisher - up to 5 hours over the course of 5 years (an average of 1 hour per year);

ii Sub-bottom profiler (2-9 kHz) - up to 5 hours over the course of 5 years (an average of 1 hour per year);

iii REMUS Modem - up to 60 hours over the course of 5 years (an average of 12 hours per year);

iv Sub-bottom profiler (2-16 kHz) - up to 5 hours over the course of 5 years (an average of 1 hour per year);

v AN/SQQ-32 - up to 5 hours over the course of 5 years (an average of 1 hour per year);

vi SAS-LF - up to 75 hours over the course of 5 years (an average of 15 hours per year);

vii AN/WLD-1 RMS-ACL - up to 25 hours over the course of 5 years (an average of 5 hours per year);

viii BPAUV Sidescan (center frequency 75 kHz) - up to 190 hours over the course of 5 years (an average of 38 hours per year);

ix TVSS - up to 83 hours over the course of 5 years (an average of 16.5 hours per year);

x F84Y - up to 75 hours over the course of 5 years (an average of 15 hours per year);

xi REMUS-SAS-HF - up to 125 hours over the course of 5 years (an average of 25 hours per year);

xii SAS-HF - up to 75 hours over the course of 5 years (an average of 15 hours per year);

xiii AN/AQS-20 - up to 75 hours over the course of 5 years (an average of 15 hours per year); and

xiv BPAUV Sidescan (center frequency 120 kHz) - up to 125 hours over the course of 5 years (an average of 25 hours per year).

3. Ordnance operations for U.S. Navy mission activities in territorial waters in the amounts indicated below:

i Range 1 (0-10 lb) - up to 255 detonations over the course of 5 years (an average of 51 detonations per year);

ii Range 2 (11-75 lb) - up to 15 detonations over the course of 5 years (an average of 3 detonations per year); and

iii Line charges - up to 15 detonations over the course of 5 years (an average of 3 detonations per year).

4. Ordnance operations for U.S. Navy mission activities in non-territorial waters in the amounts indicated below:

i Range 3 (76-600 lb) - up to 80 detonations over the course of 5 years (an average of 16 detonations per year).

ii Reserved.

5. Projectile firing operations for U.S. Navy mission activities in non-territorial waters in the amounts indicated below:

i 5 in. Naval gunfire - up to 300 rounds over the course of 5 years (an average of 60 rounds per year);

ii 40 mm rounds - up to 2,400 rounds over the course of 5 years (an average of 480 rounds per year)

iii 30 mm rounds - up to 3,000 rounds over the course of 5 years (an average of 600 rounds per year);

iv 20 mm rounds - up to 14,835 rounds over the course of 5 years (an average of 2,967 rounds per year);

v 76 mm rounds - up to 1,200 rounds over the course of 5 years (an average of 240 rounds per year);

vi 25 mm rounds - up to 2,625 rounds over the course of 5 years (an average of 525 rounds per year); and

vii Small arms - up to 30,000 rounds over the course of 5 years (an average of 6,000 rounds per year).

Notwithstanding the forms of takings contemplated in the proposed regulations and that would be authorized by future Letters of Authorization, the proposed regulations would not authorize persons connected with the activities the regulations cover to:

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

1.2.1 2010 Letter of Authorization

The Permits Division proposes to issue a Letter of Authorization, which would allow the U.S. Navy to "take" marine mammals only if the "take" occurs within the NSWC PCD Study Area, for the following marine mammal species:

a Level B Harassment:

i Sperm whale (Physeter macrocephalus) – 2

ii Risso's dolphin (*Grampus griseus*) - 2

iii Bottlenose dolphin (*Tursiops truncatus*) - 614

iv Atlantic spotted dolphin (*Stenella frontalis*) - 471

v Pantropical spotted dolphin (*S. attenuata*) - 23

vi Striped dolphin (*S. coeruleoalba*) - 5

vii Spinner dolphin (*S. longirostris*) - 23

viii Melon-headed whale (*Peponocephala electra*) - 2

ix Short-finned pilot whale (*Globicephala macrorhynchus*) - 1

x Clymene dolphin (*S. clymene*) - 5

b. Level A Harassment:

i Bottlenose dolphin (*Tursiops truncatus*) - 2

ii Atlantic spotted dolphin (*Stenella frontalis*) - 2;

iii Pantropical spotted dolphin (*S. attenuata*) - 1;

iv Spinner dolphin (*S. longirostris*) - 1.

Sperm whales are the only species of marine mammal on this list that are also listed as endangered or threatened pursuant to the ESA.

1.3 Mitigation Measures Proposed by the U.S. Navy

As required to satisfy the requirements of the Marine Mammal Protection Act of 1972, as amended, the U.S. Navy's proposes to implement measures that would allow their research, development, test, and evaluation activities to have the least practicable adverse impact on marine mammal species or stocks (which includes considerations of personnel safety, practicality of implementation, and impact on the effectiveness of the "military readiness activity"). Those measures are summarized in this section of this Opinion; for a complete description of all of the measures applicable to the proposed exercises, readers should refer to the U.S. Navy's request for a letter of authorization and the Permit Division's regulations:

The following procedures would be implemented to maximize the ability of Navy personnel to recognize instances when marine mammals are in the vicinity.

General Maritime Protective Measures: Personnel Training

- Marine observers would be trained to quickly and effectively communicate within the command structure to facilitate implementation of protective measures if marine species are spotted.

General Maritime Protective Measures: Observer Responsibilities

- At least one marine observer would participate in test events with potential exposures to marine mammals and/or sea turtles by acoustic sources. These test events include mid-frequency sonar, high frequency sonar operating up to 200 kHz, and detonations equal to and greater than 34 kg (75 lb).
- Marine observers would have at least one set of binoculars available for each person to aid in the detection of marine mammals.
- Marine observers would scan the water from the ship to the horizon and be responsible for all observations in their sector. In searching the assigned sector, the marine species observer would always start at the forward part of the sector and search aft (toward the back). To search and scan, the marine species observer would hold the binoculars steady so the horizon is in the top third of the field of vision and direct the eyes just below the horizon. The marine species observer would scan for approximately five seconds in as many small steps as possible across the field seen through the binoculars. They would search the entire sector in approximately five-degree steps, pausing between steps for approximately five seconds to scan the field of view. At the end of the sector search, the glasses would be lowered to allow the eyes to rest for a few seconds, and then the marine species observer would search back across the sector with the naked eye.

- Observers would be responsible for informing the Test Director of any marine mammal or sea turtle that may need to be avoided, as warranted.

OPERATING PROCEDURES. General requirements:

- Test Directors would, as appropriate to the event, make use of marine species detection cues and information to limit interaction with marine species to the maximum extent possible, consistent with the safety of the ship.
- During operations involving mid-frequency active (MFA) sonar, personnel would use all available sensor and optical systems (such as night vision goggles) to aid in the detection of marine mammals.
- Participating Navy aircraft would conduct and maintain, when operationally feasible, required, and safe, surveillance for marine species of concern as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties.
- Marine mammal detections by aircraft would be immediately reported to the Test Director. This action would occur when it is reasonable to conclude that the course of the ship will likely close the distance between the ship and the detected marine mammal.
- Safety zones – For tests that require the use of safety zones, when marine mammals are detected by any means (aircraft, shipboard marine species observer, or acoustically) within 914 m (1,000 yd) of the sonar source, the platform would limit active transmission levels to at least 6 decibels (dB) below normal operating levels.
- Vessels would continue to limit maximum transmission levels by this 6-dB factor until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 914 m (1,000 yd) beyond the location of the last detection.
- Should a marine mammal be detected within or closing to inside 457 m (500 yd) of the sonar source, active sonar transmissions would be limited to at least 10 dB below the equipment's normal operating level. Platforms would continue to limit maximum ping levels by this 10-dB factor until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 914 m (1,000 yd) beyond the location of the last detection.
- Should the marine mammal be detected within or closing to inside 183 m (200 yd) of the sonar source, active sonar transmissions would cease. Sonar would not resume until the animal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 914 m (1,000 yd) beyond the location of the last detection.
- If the need for power-down should arise, as detailed in "Safety Zones" above, Navy staff would follow the requirements as though they were operating at 235 dB—the normal operating level (i.e., the first power-down would be to 229 dB, regardless of the level above 235 dB the sonar was being operated).

- Prior to start up or restart of active sonar, operators would check that the safety zone radius around the sound source is clear of marine mammals.
- Sonar levels (generally) – the Navy would operate sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet RDT&E objectives.
- Helicopters would observe/survey the vicinity of a Naval Surface Warfare Center – Panama City RDT&E activity for 10 minutes before the first deployment of active (dipping) sonar in the water.
- Helicopters would not dip their sonar within 183 m (200 yd) of a marine mammal and would cease pinging if a marine mammal closes within 183 m (200 yd) after pinging has begun.

SPECIAL CONDITIONS APPLICABLE FOR BOW-RIDING DOLPHINS. If, after conducting an initial maneuver to avoid close quarters with dolphins, the officer of the ship concludes that dolphins are deliberately closing in on the ship to ride the vessel's bow wave, no further mitigation actions would be necessary because dolphins are out of the main transmission axis of the active sonar while in the shallow-wave area of the vessel bow.

MONITORING. The Navy is developing an Integrated Comprehensive Monitoring Program (ICMP) for marine species to assess the effects of NSWC PCD RDT&E activities on marine species and investigate population trends in marine species distribution and abundance in locations where NSWC PCD RDT&E activities regularly occurs. The primary goals of the ICMP for NSWC PCD RDT&E activities are:

- To monitor Navy RDT&E exercises for compliance with the terms and conditions of the Endangered Species Act Biological Opinion and MMPA authorization.
- Estimate the number of individuals (primarily marine mammals) exposed to sound levels above current regulatory thresholds.
- Assess the effectiveness of the Navy's marine species mitigation.
- To minimize exposure of protected species (primarily marine mammals) to sound levels from active sonar or sound pressure levels from underwater detonations currently considered to result in harassment.
- To document trends in species distribution and abundance in the NSWC PCD RDT&E.
- To add to the knowledge base on potential behavioral and physiological effects to marine species from active sonar and underwater detonations.
- To assess the practicality and usefulness of a number of mitigation tools and techniques.

This ICMP will evaluate the range of potential monitoring techniques that can be tailored to any Naval Surface Warfare Center – Panama City RDT&E activity and the appropriate species of concern.

PROTECTIVE MEASURES RELATED TO OPERATIONAL AND ENVIRONMENTAL PLANNING AND COORDINATION

- Test areas would not be sited in areas of seagrass.
- The most favorable temporal-spatial (seasonal and geographical) province that satisfies all operational requirements would be utilized.
- Local Notices to Mariners would be issued at least 24 hours ahead of time when areas would be used for testing.
- The Navy would follow established procedures designed to avoid conflicts with mariners, such as avoidance of shipping lanes and artificial reefs, where feasible.
- Consultation with the appropriate agencies would be conducted when avoidance of historic properties in territorial waters is not possible.

PROTECTIVE MEASURES RELATED TO SURFACE OPERATIONS

- Surface vessels would not operate over areas of seagrass. Marine vehicle operators would observe idle speed limits, channel markers, and other aids to navigation to avoid any effects to nearby seagrass.
- Visual surveys would be conducted for all test operations to reduce the potential for vessel collisions with a protected species. If necessary, the ship's course and speed could be adjusted.

PROTECTIVE MEASURES RELATED TO SUBSURFACE OPERATIONS

- No mine-like object (MLO) and versatile exercise mine (VEM) placement or crawler operations would occur within areas of seagrass.
- No MLO and VEM placement or crawler operations would occur within hardbottom areas.
- Activities such as mine placement and crawler operations that cause bottom disturbance would not be conducted in Marine Managed Areas.
- Mine placement and anchoring would not be conducted in areas that could damage hardbottom or seagrass habitats.
- Activities such as mine placement and crawler operations that cause bottom disturbance would not occur over artificial reefs or shipwrecks.

PROTECTIVE MEASURES RELATED TO ELECTROMAGNETIC OPERATIONS

- When operationally feasible, electromagnetic operations and tests would not be conducted within .03 kilometer (approximately .02 nautical mile) of shore during sea turtle nesting and hatching season, which is considered to be 01 May through 30 September.

- Visual surveys would be conducted for all test operations involving electromagnetic field generation.

PROTECTIVE MEASURES RELATED TO LASERS

- Lasers would be operated at or below human unaided eye safety levels.
- Visual surveys would be conducted for all test operations involving laser line scan, light imaging detection, and ranging lasers.
- A test/safety plan must be developed for operations involving laser systems and must include a laser hazard analysis, which includes the distance in which exposure or irradiance falls below the applicable exposure limit (nominal ocular hazard distance), wavelength, energy, optical density of goggles, etc.; a description of the required safety buffer zone and procedures for securing the safety buffer during testing; a description of laser safety features (beam shutters, beam stops, roll/pitch limits, etc.) and other potential laser-related hazards (high voltage, liquid cooling, etc.); and documentation of laser safety training for test personnel.
- The test/safety plan must also indicate that the Range Laser Safety Officer has the authority to shut down the laser test if he/she observes any unsafe conditions related to firing the laser.

PROTECTIVE MEASURES RELATED TO DETONATIONS AND PROJECTILES

- No detonations over 34 kilograms (kg) (75 pounds [lbs]) would be conducted in territorial waters. This does not apply to the line charge detonation, which is not considered to be a single detonation but a series of 2.3 kg (5 lbs) detonations.
- The number of live mine detonations would be minimized and the smallest amount of explosive material possible to achieve test objectives would be used.
- Ammunition casings would be collected when possible. Some of the casings from the rounds would be expected to fall within the test platform. They should be collected when possible and not swept into the water.
- Activities will be coordinated through the Environmental Help Desk to allow potential concentrations of detonations in a particular area over a short time to be identified and avoided.
- No detonations would occur within areas of seagrass or where they could damage seagrass habitat.
- No detonations would occur within hardbottom areas or where they could damage hardbottom habitat.
- Detonations that cause bottom disturbance would not be conducted in Marine Managed Areas.
- Detonations that cause bottom disturbance would not occur over artificial reefs or shipwrecks.

- No detonations would occur in estuarine areas.
- Line charge tests would not be conducted during the nighttime.
- Detonations would not occur if flocks of birds are rafting on the water's surface inside a test area or if flocks of birds are migrating directly above the proposed test site.
- Gulf sturgeon critical habitat occurs from the shoreline to 1.9 km (1 NM) offshore throughout the NSWC PCD Study Area. During the months of October and November, many of these fish move from fresh water into the Gulf of Mexico and may be found in the marine portion of critical habitat. They generally remain in the Gulf of Mexico until March. Therefore, when operationally feasible, surf zone line charge detonations would not be conducted between October and March.
- Visual surveys and aerial surveys would be conducted for all test operations that involve detonation events with large net explosive weight. Any protected species sighted would be avoided. For additional information regarding clearance procedures, refer to Section 5.10.
- If a Gulf sturgeon was sighted close to the line charge detonation point, tests would be postponed until the animal is over 0.8 km (0.5 mi) from the detonation point.
- No surf zone line charge detonations would be conducted within 24 hours of any turtle nest hatching on U.S. Air Force property within 5 km (3 mi) in either direction of the detonation site.
- Mitigations will be determined through the Environmental Review Process review based on test activities including the size of detonations, test platforms, and environmental effects documented in this EIS/OEIS.
- NSWC PCD will follow established Navy safety guidance documents for operations involving live ammunition or explosives, including OPNAVINST 8020.14, *Department Of The Navy Explosives Safety Policy*, *Naval Sea Systems Command Operating Procedures (NAVSEA OP)* 5, Volume 1, *Ammunition and Explosives Ashore, Safety Regulations for Handling, Storing, Production, Renovation, and Shipping*, and Naval Ordnance, Safety, and Security Activity Instruction (*NOSSAINST*) *8023.11A Standard Operating Procedures Development, Implementation, Maintenance for Ammunition and Explosives* (Naval Support Activity Panama City Instruction 2007).
- Departments at Naval Surface Warfare Center – Panama City will develop written standard operating procedures (SOPs), which clearly identify and minimize existing and potential hazards inherent in processing explosive components. These standard procedures provide NSWC PCD personnel with detailed, step-by-step instructions for conducting safe processing of explosive ordnance or components and integrate technical requirements; explosive safety standards; Naval Occupational Safety and Health standards; federal, state, local environmental protection standards; security and physical security directives; and other factors as determined by the activity. Elements of an SOP include a flow chart of step-by-step test procedures, a Hazard Control Brief detailing

hazard control measures, and an Emergency Response and Contingency Plan. NSAPCINST 8023.4A Explosive Safety Policies, Requirements and Procedures, dated 22 January 2007, provides guidance and direction for developing and using SOPs at Naval Surface Warfare Center – Panama City.

- All SOPs will be reviewed and validated by the facility Explosive Safety Office and Ordnance Officer to ensure that they are correct and will result in a safe, effective, and efficient operation.

CLEARANCE PROCEDURES. Visual surveys would be conducted from vessels and/or aircraft, when the Environmental Review Process desk determines that they are required. Aerial surveys would be used for detonations involving large amounts of net explosive weight (NEW), since the impact range could be too large to be effectively surveyed from a surface vessel only. The Environmental Review Process desk will evaluate the proposed type of test activities and determine the appropriate monitoring requirements including pre- and post- monitoring times, number of observers, and any other specifics for the required mitigation activities.

A visual survey would consist of searching the water 360 degrees around the detonation point and out to the Level B behavioral harassment zone for the presence or indicators of protected species. If a protected species is sighted within 914 m (1,000 yd) of the detonation point, all efforts would be made to avoid these sighted species. Since the effectiveness of visual surveys depends not only on observer training and experience, but also on sea state and observer fatigue, operations requiring visual surveys would be carried out only in sea states of 3.5 or lower. Higher winds typically increase wave height and create “white cap” conditions, thus limiting an observer’s ability to locate surfacing marine mammals and sea turtles. The Environmental Review Process personnel would also provide suggestions based on the hours of operation, the type of RDT&E activity, and the level of mitigation requirements to reduce observer fatigue.

When the test platform (surface vessel or aircraft) arrives at the test site, an initial evaluation of environmental suitability would be made. This evaluation would include an assessment of sea state and verification that the area is clear of visually detectable marine mammals, sea turtles, and indicators of their presence. Large *Sargassum* rafts and large concentrations of jellyfish are considered indicators of potential sea turtle presence. Large flocks of birds and large schools of fish are considered indicators of potential marine mammal presence.

1.4 Mitigation Required by NMFS’ Permits Division

When the U.S. Navy conducts the research, development, test, and evaluation activities identified in the relevant regulations, the regulations issued by NMFS’ Permits Division require the U.S. Navy to implement mitigation measures that include (but are not limited to) the following:

(a) Mitigation Measures for HFAS/MFAS Operations

(1) Personnel Training:

(i) All marine observers onboard platforms involved in NSWC PCD RDT&E activities shall complete Marine Species Awareness Training (MSAT).

(ii) Marine observers shall be trained in the most effective means to ensure quick and effective communication within the command structure in order to facilitate implementation of mitigation measures if marine species are spotted.

(2) Marine Observer Responsibilities:

(i) On the bridge of surface vessels, there shall always be at least one to three marine species awareness trained observer(s) on watch whose duties include observing the water surface around the vessel.

(A) For vessels with length under 65 ft (20 m), there shall always be at least one marine observer on watch.

(B) For vessels with length between 65 – 200 ft (20 – 61 m), there shall always be at least two marine observers on watch.

(C) For vessels with length above 200 ft (61 m), there shall always be at least three marine observers on watch.

(ii) Each marine observer shall have at their disposal at least one set of binoculars available to aid in the detection of marine mammals.

(iii) On surface vessels equipped with AN/SQQ-53C/56, pedestal mounted "Big Eye" (20 x 110) binoculars shall be present and in good working order to assist in the detection of marine mammals in the vicinity of the vessel.

(iv) Marine observers shall employ visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook (NAVEDTRA 12968–D) (Navy 2007).

(v) Marine observers shall scan the water from the vessel to the horizon and be responsible for ensuring that all contacts in their sector follow the below protocols:

(A) In searching the assigned sector, the marine observer shall always start at the forward part of the sector and search aft (toward the back).

(B) To search and scan, the marine observer shall hold the binoculars steady so the horizon is in the top third of the field of vision and direct the eyes just below the horizon.

(C) The marine observer shall scan for approximately five seconds in as many small steps as possible across the field seen through the binoculars.

(D) The marine observers shall search the entire sector in approximately five-degree steps, pausing between steps for approximately five seconds to scan the field of view.

(E) At the end of the sector search, the glasses would be lowered to allow the eyes to rest for a few seconds, and then the marine observer shall search back across the sector with the naked eye.

(vi) After sunset and prior to sunrise, marine observers shall employ Night Lookout Techniques in accordance with the Lookout Training Handbook.

(vii) At night, marine observers shall scan the horizon in a series of movements that would allow their eyes to come to periodic rests as they scan the sector. When visually searching at night, marine observers shall look a little to one side and out of the corners of their eyes, paying attention to the things on the outer edges of their field of vision.

(viii) Marine observers shall be responsible for reporting all objects or anomalies sighted in the water (regardless of the distance from the vessel) to the Test Director or the Test Director's designee.

(3) Operating Procedures:

(i) The Test Director or the Test Director's designee shall maintain the logs and records documenting RDT&E activities should they be required for event reconstruction purposes. Logs and records will be kept for a period of 30 days following completion of a RDT&E mission activity.

(ii) A Record of Environmental Consideration shall be included in the Test Plan prior to the test event to further disseminate the personnel testing requirement and general marine mammal mitigation measures.

(iii) Test Directors shall make use of marine species detection cues and information to limit interaction with marine species to the maximum extent possible consistent with safety of the vessel.

(iv) All personnel engaged in passive acoustic sonar operation (including aircraft or surface vessels) shall monitor for marine mammal vocalizations and report the detection of any marine mammal to the Test Director or the Test Director's designee for dissemination and appropriate action.

(v) During HFAS/MFAS mission activities, personnel shall utilize all available sensor and optical systems (such as Night Vision Goggles) to aid in the detection of marine mammals.

(vi) Navy aircraft participating in RDT&E activities at sea shall conduct and maintain surveillance for marine species of concern as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties.

(vii) Marine mammal detections shall be immediately reported to the Test Director or the Test Director's designee for further dissemination to vessels in the vicinity of the marine species as appropriate where it is reasonable to conclude that the course of the vessel will likely result in a closing of the distance to the detected marine mammal.

(viii) Safety Zones—When marine mammals are detected by any means (aircraft, shipboard marine observer, or acoustically) the Navy will ensure that HFAS/MFAS transmission levels are limited to at least 6 dB below normal operating levels if any detected marine mammals are within 1,000 yards (914 m) of the sonar source (the bow).

(A) Vessels shall continue to limit maximum HFAS/MFAS transmission levels by this 6-dB factor until the marine mammal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yards (1,828 m) beyond the location of the last detection.

(B) The Navy shall ensure that HFAS/MFAS transmissions will be limited to at least 10 dB below the equipment's normal operating level if any detected animals are within 500 yards (457 m) of the sonar source. Vessels will continue to limit maximum ping levels by this 10-dB factor until the marine mammal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yards (1,828 m) beyond the location of the last detection.

(C) The Navy shall ensure that HFAS/MFAS transmissions are ceased if any detected marine mammals are within 200 yards (183 m) of the sonar source. HFAS/MFAS will not resume until the marine mammal has been seen to leave the area, has not been detected for 30 minutes, or the vessel has transited more than 2,000 yards (1,828 m) beyond the location of the last detection.

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

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

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

(x) Sonar levels (generally)—Navy shall operate sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet RDT&E objectives.

(b) Mitigation Measures for Ordnance and Projectile Firing

(1) No detonations over 34 kg (75 lb) shall be conducted in territorial waters, except the line charge detonation, which is at 107 m (350 ft).

(2) The number of live mine detonations shall be minimized and the smallest amount of explosive material possible to achieve test objectives will be used.

(3) Activities shall be coordinated through the Environmental Help Desk to allow potential concentrations of detonations in a particular area over a short time to be identified and avoided.

(4) Visual surveys and aerial surveys of the clearance zones specified in 50 CFR §218.183(b)(6)(i)-(iii) shall be conducted in accordance with 50 CFR §218.184(c) for all test operations that involve detonation events with large net explosive weight (NEW). Any protected species sighted will be reported.

(5) Line charge tests shall not be conducted during the nighttime.

(6) Additional mitigation measures shall be determined through the NSWC PCD's Environmental Review Process based on test activities including the size of detonations, test platforms, and environmental effects documented in the Navy's EIS/OEIS. Clearance zones must be determined based on the upper limit of different ranges of net explosive weight (NEW) used in the tests, as listed below:

(i) NEW between 76 – 600 lb: clearance zone is 2,863 m (9,393 ft);

(ii) NEW between 11 – 75 lb: clearance zone is 997 m (2,865 ft); and

(iii) NEW less than 11 lb – clearance zone is 345 m (1,132 ft).

(c) Mitigation Measures for Surface Operations:

(1) While underway, vessels shall have at least one to three marine species awareness trained observers (based on vessel length) with binoculars. As part of their regular duties, marine observers shall watch for and report to the Test Director or Test Director's designee the presence of marine mammals.

(i) For vessels with length under 65 ft (20 m), there shall always be at least one marine observer on watch.

(ii) For vessels with length between 65 – 200 ft (20 – 61 m), there shall always be at least two marine observers on watch.

(iii) For vessels with length above 200 ft (61 m), there shall always be at least three marine observers on watch.

(2) Marine observers shall employ visual search procedures employing a scanning method in accordance with the Lookout Training Handbook (NAVEDTRA 12968-D) (Navy 2007).

(3) While in transit, naval vessels shall be alert at all times, use extreme caution, and proceed at a "safe speed" (the minimum speed at which mission goals or safety will not be compromised) so that the vessel can take proper and effective action to avoid a collision with any marine animal and can be stopped within a distance appropriate to the prevailing circumstances and conditions.

(4) When marine mammals have been sighted in the area, Navy vessels shall increase vigilance and shall implement measures to avoid collisions with marine mammals and avoid activities that might result in close interaction of naval assets and marine mammals. Actions shall include changing speed and/or direction and are dictated by environmental and other conditions (e.g., safety, weather).

(5) Naval vessels shall maneuver to keep at least 500 yd (460 m) away from any observed whale and avoid approaching whales head-on. This requirement does not apply if a vessel's safety is threatened, such as when change of course will create an imminent and serious threat to a person, vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver. Vessels shall take reasonable steps to alert other vessels in the vicinity of the whale.

(6) Where operationally feasible and safe, vessels shall avoid closing to within 200 yd (183 m) of marine mammals other than whales.

MONITORING AND REPORTING. The Permits Division's regulations include the following monitoring and reporting requirements:

(a) The Holder of the Letter of Authorization issued pursuant to 50 CFR §§ 216.106 and 218.186 for activities described in 50 CFR § 218.180(c) is required to cooperate with the NMFS when monitoring the impacts of the activity on marine mammals.

(b) The Holder of the Authorization must notify NMFS immediately (or as soon as clearance procedures allow) if the specified activity identified in 50 CFR § 218.180(c) is thought to have resulted in the mortality or injury of any marine mammals, or in any take of marine mammals not identified or authorized in 50 CFR § 218.181(b).

(c) The Holder of the Letter of Authorization must conduct all monitoring and required reporting under the Letter of Authorization, including abiding by the NSWC PCD Study Area Complex Monitoring Plan, which requires the Navy to implement, at a minimum, the monitoring activities summarized below.

(1) Visual Surveys – Vessel, Aerial and Shore-based: The Holder of the Letter of Authorization shall visually survey a minimum of 2 HFAS/MFAS activities and 2 explosive events per year. If the 53C sonar was being operated, such activity must

be monitored as one of the HFAS/MFAS activities. For explosive events, one of the monitoring measures shall be focused on a multiple detonation event.

(i) In accordance with all safety considerations, observations shall be maximized by working from all available platforms: vessels, aircraft, land and/or in combination.

(ii) Vessel and aerial surveys shall be conducted two days before, during, and one to five days after the NSWC PCD mission activities on commercial vessels and aircraft.

(iii) Visual surveys shall be conducted during Navy mission activities that have been identified to provide the highest likelihood of success.

(iv) The visual survey team shall collect the same data that are collected by Navy marine observers, including but not limited to:

(A) location of sighting;

(B) species (or to the lowest taxa possible);

(C) number of individuals;

(D) number of calves present, if any;

(E) duration of sighting;

(F) behavior of marine animals sighted;

(G) direction of travel;

(H) environmental information associated with sighting event including Beaufort sea state, wave height, swell direction, wind direction, wind speed, glare, percentage of glare, percentage of cloud cover; and

(I) when in relation to Navy exercises did the sighting occur (before, during or after detonations/exercise).

(v) Animal sightings and relative distance from a particular activity site shall be used post survey to estimate the number of marine mammals exposed to different received levels (energy and pressure of discharge based on distance to the source, bathymetry, oceanographic conditions and the type and size of detonation) and their corresponding behavior.

(vi) Any digital photographs that are taken of marine mammals during visual surveys shall be provided to local researchers for their regional research.

(vii) The Holder of the Letter of Authorization shall, when conducting RDT&E activities in the NSWC PCD Study Area, implement the following monitoring methods:

(A) Aerial surveys:

(1) During NSWC PCD sonar related mission activities, an aerial survey team shall fly transects relative to a Navy surface vessel that is conducting the mission activities.

(2) The aerial survey team shall collect both visual sightings and behavioral observations of marine animals.

(3) These transect data shall provide an opportunity to collect data of marine mammals at different received levels and their behavioral responses and movement relative to the Navy vessel's position.

(4) Aerial surveys shall include time with and without test events in order to compare density, geographical distribution and behavioral observations.

(5) Behavioral observation methods shall involve three professionally trained marine mammal observers and a pilot. Two observers shall observe behaviors, one with hand-held binoculars and one with the naked eye.

(6) Detailed behavioral focal observations of cetaceans shall be recorded, including the following variables where possible: species (or to the lowest taxa possible), group size and composition (number of calves, etc.), latitude/longitude, surface and dive durations and times, number and spacing/times of respirations, conspicuous behaviors (e.g., breach, tail slap, etc.), behavioral states, orientation and changes in orientation, estimated group travel speed, inter-individual distances, defecation, social interactions, aircraft speed, aircraft altitude, distance to focal group (using the plane's radar) and any unusual behaviors or apparent reactions.

(B) Vessel Surveys:

(1) Vessel surveys shall be designed to maximize detections of any target species near mission activity event for focal follows.

(2) Systematic transects shall be used to locate marine mammals. In the course of conducting these surveys, the vessel(s) shall deviate from transect protocol to collect behavioral data particularly if a Navy vessel is visible on the horizon or closer.

(3) While the Navy vessels are within view, attempts shall be made to position the dedicated survey vessel in the best possible way to obtain focal follow data in the presence of the Navy mission activities. If Navy vessels are not in view, then the vessel

shall begin a systematic line transect survey within the area to assess marine mammal occurrence and observe behavior.

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

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

(C) Shore-based Surveys:

(1) Shore-based monitors shall observe explosive events that are planned in advance to occur adjacent to nearshore areas where there are elevated coastal structures (e.g. lookout tower at Eglin Air Force Base) or topography, and shall use binoculars or theodolite to augment other visual survey methods.

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

(3) If animals are observed prior to or during an explosion, a focal follow of that individual or group shall be conducted to record behavioral responses.

(2) Passive Acoustic Monitoring (PAM):

(i) The Navy shall use towed or over-the-side passive acoustic monitoring device/hydrophone array when feasible in the NSWC PCD Study Area for PAM.

(ii) The array shall be deployed for each of the days the ship is at sea.

(iii) The array shall be able to detect low frequency vocalizations (less than 1,000 Hz) for baleen whales and relatively high frequency vocalizations (up to 30 kHz) for odontocetes.

(3) Marine Mammal Observers on Navy vessels:

(i) Civilian Marine Mammal Observers (MMOs) aboard Navy vessels shall be used to research the effectiveness of Navy marine observers, as well as for data collection during other monitoring surveys.

(ii) MMOs shall be field-experienced observers that are Navy biologists or contracted observers.

(iii) MMOs shall be placed alongside existing Navy marine observers during a sub-set of RDT&E events.

(iv) MMOs shall inform the Navy marine observer of any marine mammal sighting so that appropriate action may be taken by the chain of command. For less biased data, it is recommended that MMOs schedule their daily observations to duplicate the marine observers' schedule.

(v) MMOs shall monitor for marine mammals from the same height above water as the Navy marine observers (e.g. bridge wings) and as all visual survey teams, and they shall collect the same data collected by Navy marine observers, including but not limited to:

(A) location of sighting;

(B) species;

(C) number of individuals;

(D) number of calves present, if any;

(E) duration of sighting;

(F) behavior of marine animals sighted;

(G) direction of travel;

(H) environmental information associated with sighting event including Beaufort sea state, wave height, swell direction, wind direction, wind speed, glare, percentage of glare, percentage of cloud cover; and

(I) when in relation to Navy RDT&E activities did the sighting occur (before, during or after detonations/exercise).

(d) General Notification of Injured or Dead Marine Mammals - Navy personnel shall ensure that NMFS (regional stranding coordinator) is notified immediately (or as soon as clearance procedures allow) if an injured or dead marine mammal is found during or shortly after, and in the vicinity of, any Navy's RDT&E activities utilizing underwater explosive detonations. The Navy shall provide NMFS with species or description of the animal(s), the condition of the animal(s) (including carcass condition if the animal is dead), location, time of first discovery, observed behaviors (if alive), and photo or video (if available).

(e) Annual NSWC PCD Report – The Navy shall submit a report annually on October 1 describing the RDT&E activities conducted and implementation and results of the NSWC PCD Monitoring Plan (through August 1 of the same year) Monitoring Plan and RDT&E activities. Although additional information will also be gathered, the MMOs collecting marine mammal data pursuant to the NSWC PCD Monitoring Plan shall, at a minimum, provide the same marine mammal observation data listed below.

(1) RDT&E Information:

(i) Date and time test began and ended;

(ii) Location;

(iii) Number and types of active sources used in the test;

(iv) Number and types of vessels, aircraft, etc., participated in the test;

(v) Number and types of underwater detonations;

(vi) Total hours of observation effort (including observation time when sonar was not operating).

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

(viii) Total hours of each active sonar source; and

(ix) Wave height (high, low, and average during the test).

(2) Individual Marine Mammal Sighting Info:

(i) Location of sighting;

(ii) Species;

(iii) Number of individuals;

(iv) Calves observed (y/n);

(v) Initial detection sensor;

(vi) Indication of specific type of platform observation made from;

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

(viii) Wave height (in feet);

(ix) Visibility;

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

(xi) Indication of whether animal is <200 yd, 200-500 yd, 500-1,000 yd, 1,000-2,000 yd, or >2,000 yd from sonar source above;

(xii) Mitigation implementation – Whether operation of sonar sensor was delayed, or sonar was powered or shut down, and how long the delay was;

(xiii) If the active MFAS in use is hull-mounted, true bearing of animal from ship, true direction of ship's travel, and estimation of animal's motion relative to ship (opening, closing, parallel);

(xiv) Observed behavior – Marine observers shall report, in plain language and without trying to categorize in any way, the observed behavior of the

animals (such as animal closing to bow ride, paralleling course/speed, floating on surface and not swimming, etc.); and

(xv) An evaluation of the effectiveness of mitigation measures designed to avoid exposing marine mammals to HFAS/MFAS. This evaluation shall identify the specific observations that support any conclusions the Navy reaches about the effectiveness of the mitigation.

(f) NSWC PCD Comprehensive Report – The Navy shall submit to NMFS a draft report that analyzes and summarizes all of the multi-year marine mammal information gathered during sonar operations and underwater explosive events for which individual reports are required in 50 CFR § 218.184 (d-f). This report will be submitted at the end of the fourth year of the rule (December 2013), covering activities that have occurred through July 1, 2013.

(h) The Navy shall respond to NMFS comments and requests for additional information or clarification on the NSWC PCD Comprehensive Report and the Annual NSWC PCD Report if submitted within 3 months of receipt. The report will be considered final after the Navy has addressed NMFS' comments or provided the requested information, or three months after the submittal of the draft if NMFS does not comment by then.

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

2 Approach to the Assessment

In previous biological opinions NMFS has explained the approach to the assessment of the effects of Federal actions on endangered and threatened species and designated critical habitat. The approach is a four step sequential analyses. The first step analysis identifies those physical, chemical, or biotic aspects of proposed actions that are likely to have individual, interactive, or cumulative direct and indirect effect on the environment (the potential stressors). The second analysis starts by determining whether endangered species, threatened species, or designated critical habitat are likely to occur in the same space and at the same time as these potential stressors. If we conclude that such co-occurrence is likely, we then try to estimate the nature of that co-occurrence (the *exposure analysis*). 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 third step is an examination of the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (this is the *response analysis*). 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 analysis*).

2.1 Potential Stressors

The primary stressors associated with the RDT&E activities at the NSWC PCD Study Area consist of:

1. Sound fields produced by the active sonar systems the U.S. Navy would employ during the research, development, test, and evaluation activities it proposes;
2. Sound fields produced by the underwater detonations the U.S. Navy would employ during the research, development, test, and evaluation activities it proposes;
3. Projectiles associated with firing operations;
4. Disturbance produced by the vessels involved in the research, development, test, and evaluation activities; and
5. The risk of collisions associated with proximity to the vessels involved in the research, development, test, and evaluation activities.

The first step of our analysis evaluates the available evidence to determine the likelihood of listed species or critical habitat being exposed to these stressors. Our analysis assumed that these stressors pose no risk to listed species or critical habitat if these stressors do not co-occur with those species or critical habitat in space or time. 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.

2.2 Exposure Analysis

In this consultation we relied on the results of acoustic models the U.S. Navy used to prepare its National Environmental Policy Act (NEPA) compliance documents and to request permits from NMFS Permits Division. The U.S. Navy's model focuses on a suite of representative provinces based on sound velocity profiles, bathymetries, and bottom types. Within each of these provinces, the U.S. Navy modeled transmission losses in 5 meter increments and used the results to build sound fields (based on maximum sound pressure levels). The U.S. Navy then calculates an "impact volume," which is the volume of water in which an acoustic metric exceeds a specified threshold; in this case, the Navy used one of three acoustic metrics: energy flux density (in a limited band or across a full band), peak pressure, or positive impulse. By multiplying these "impact volumes" by estimates of animal densities in three dimensions (densities distributed by area and depth), the U.S. Navy estimated the expected number of animals that might be exposed to an acoustic metric (energy flux density, peak pressure, or positive impulse) at levels that exceed thresholds that had been specified in advance. Specifically, the U.S. Navy calculated impact volumes for sonar operations (using energy flux density to estimate the probability of

injury), peak pressure, and a Goertner modified positive impulse (for onset of slight lung injury associated with explosions).

To calculate "impact volumes," the U.S. Navy used a "risk continuum" or a curve that the U.S. Navy and NMFS developed that relates the probability of a behavioral response given exposure to a received level that is generally represented by sound pressure level, but included sound exposure level to deal with threshold shifts. The risk continuum, which the U.S. Navy and NMFS' Permits Division adapted from a mathematical model presented in Feller (1968) (see Navy 2009), was estimated using three data sources: (1) data from controlled experiments conducted at the U.S. Navy's Space and Naval Warfare Systems Center in San Diego, California (Finneran et al. 2001; Finneran et al. 2005; Finneran et al. 2003; Finneran and Schlundt. 2004; Schlundt et al. 2000a), (2) data from a reconstruction of an incident in which killer whales were probably exposed to mid-frequency active sonar (Fromme 2004), and (3) a suite of studies of the response of baleen whales to low-frequency sound sources (Nowacek et al. 2004b). The U.S. Navy and NMFS' Permits Division estimated the proportion of a population that would be expected to exhibit behavioral responses that NMFS' would classify as "take" (as that term is defined by the MMPA) by multiplying the different "impact volumes" at particular received levels by the "risk continuum."

Based on our evaluation of the U.S. Navy's model, we are satisfied that the model would tend to overestimate the number of marine mammals that might be exposed, because marine mammals are highly mobile and are likely to use their mobility to avoid stimuli like active sonar, just as they avoid vessel traffic. Consequently, the results of these models would tend to provide the benefit of uncertainty to endangered or threatened species by overestimating their likelihood of being exposed and exhibiting adverse responses given exposure to the RDT&E activities the U.S. Navy plans to conduct in the NSWC PCD Study Area.

2.3 Response Analysis

As discussed in the introduction to this section of this Opinion, once we identified which listed resources were likely to be exposed to active sonar associated with the proposed activities and the nature of that exposure, we examined the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure. Prior to this consultation, we updated the conceptual model that provides the foundation for our response analysis and the first step of our risk analyses. Specifically, we modified the conceptual model based on a more expansive concept of "hearing," a clearer presentation of the relationship between hearing and behavior, and a more explicit presentation of the components of behavioral decisions.

This updated conceptual model begins with acoustic stimuli we focus on in an assessment. In this case, we treat the mid- and high-frequency active sonar and any shock waves associated with underwater detonations associated with the proposed RDT&E activities as separate focal stimuli. The preceding section of our *Approach* described how we estimated the number of animals that

are likely to be exposed to those acoustic stimuli associated with the proposed research, development, test, and evaluation activities and the nature of that exposure.

The stressors that would be associated with the research, development, test, and evaluation activities the U.S. Navy proposes to conduct at the Naval Surface Warfare Center in Panama City, Florida, represent two classes of stressors: *processive stressors*, which require high-level cognitive processing of sensory information, and *systemic stressors*, which usually elicit direct physical or physiological responses and, therefore, do not require high-level cognitive processing of sensory information (Anisman and Merali 1999; Herman and Cullinan 1997). Disturbance from surface vessels and active sonar would be examples of processive stressors while ship strikes and shock waves associated with underwater detonations would be examples of systemic stressors (the sound field produced by an underwater detonation would be a systemic stressor close to the explosion and a processive stressor further away). As a result, exposures resulting from the proposed training exercises are likely to result in two general classes of responses:

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

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

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

This conceptual model departs from our earlier model and models advanced by the U.S. Navy and others by adopting a more expansive concept of "hearing." Other conceptions of the sensory modality that we call "hearing" have treated it as a purely mechanical process that only involves structures in the ear that transduce sound pressure waves into vibrations and vibrations to electro-

chemical impulses. That conception of hearing resulted in assessments that focus solely on active sonar while discounting other acoustic stimuli associated with U.S. Navy research, development, test, and evaluation activities that marine animals might also perceive as relevant. That concept of hearing also led to an almost singular focus on received level as an assessment metric and noise-induced hearing loss as an assessment endpoint.

This conceptual model expands the concept of "hearing" to include a mechanical-cognitive-perceptual processes. That is, our concept of "hearing" includes the mental processes an animal employs when it analyzes acoustic impulses (see Blumstein and Bouskila 1996; Bregman 1990; Hudspeth 1997; Pickles 1982; Yost 2007), which includes the processes animals employ to integrate and segregate sounds and auditory streams and the circumstances under which they are likely to devote attentional resources to an acoustic stimulus. As a result of this shift in focus, we have to consider more than the received level of a particular low- or mid-frequency wave form and its effects on the sensitivity of an animal's ear structure. We also have to distinguish between different auditory scenes; for example, animals will distinguish between sounds from a source that is moving away versus a sound produced by a source that is approaching them, sounds from multiple sources that are all approaching, and sounds from multiple sources that appear to be moving at random, etc.

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

This process of "classifying a stimulus" (Box B2) lends meaning to the stimulus and places the animal in a position to decide whether and how to respond to the stimulus (Blumstein and Bouskila 1996). How an animal classifies a stimulus will determine the set of candidate responses that are appropriate. That is, we assume that animals that classified a stimulus as a "predatory cue" would invoke candidate responses that consisted of anti-predator behavior rather than foraging behavior (Blumstein and Bouskila 1996). We then assume that animals apply one or more behavioral decision rules to the set of candidate responses that are appropriate to the acoustic stimulus as it has been classified (Box B3). Our use of the term "behavioral decision rule" follows Blumstein and Bouskila (1996), McFarland (1982), and Lima and Dill (1990) and is synonymous with the term "behavioral policy" of McNamara and Houston (1986): the process an animal applies to determine which specific behavior it will select from the set of behaviors that are appropriate to the auditory scene, given its physiological and behavioral state when exposed and its experience. Because we would never know the behavioral policy of an

individual, free- ranging animal, we treat this policy as a probability distribution function that matches the vector of candidate behavioral responses.

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

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

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

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

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

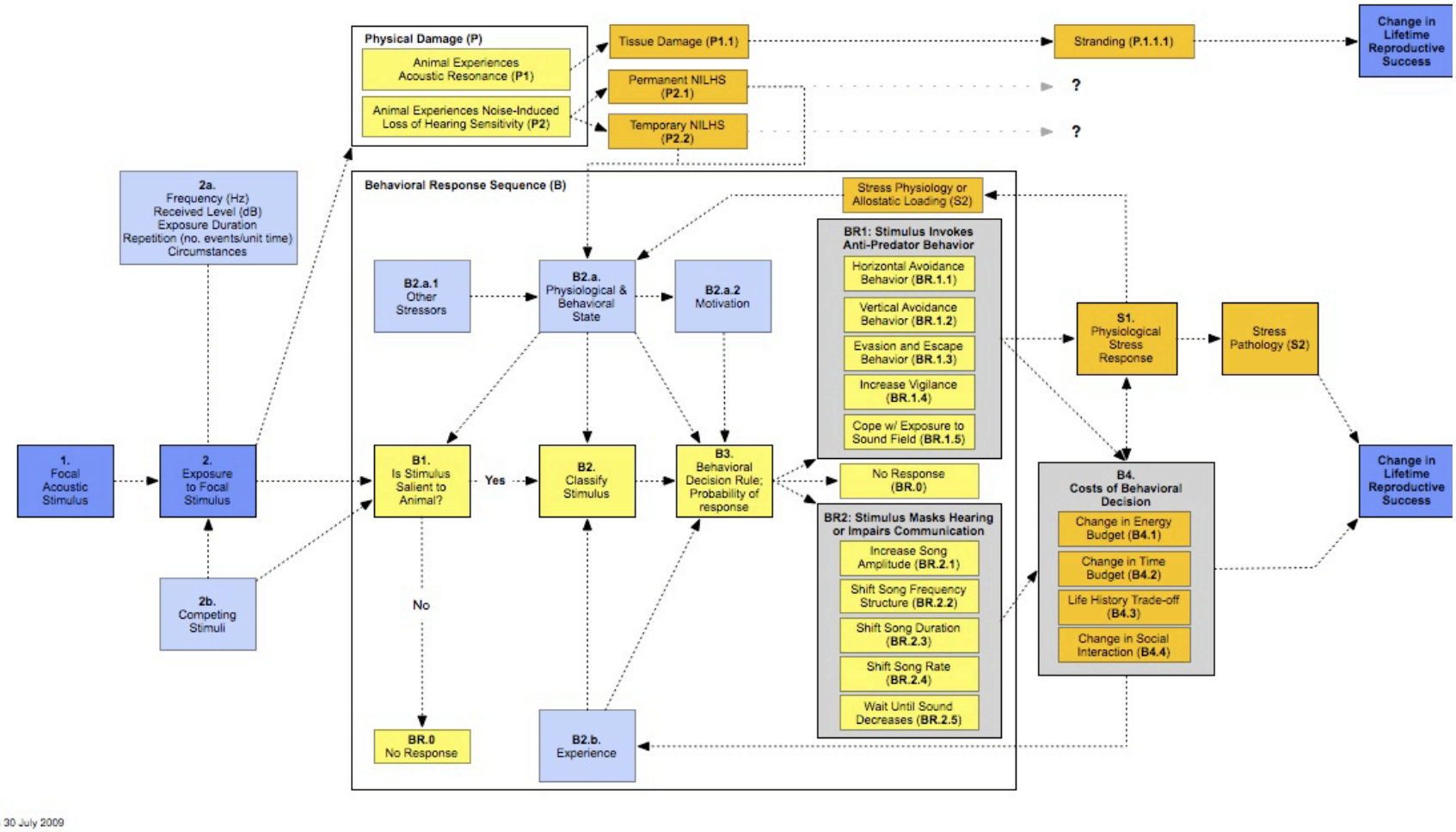

Figure 2. Conceptual model of the potential responses of endangered and threatened species upon being exposed to active sonar and the pathways by which those responses might affect the fitness of individual animals that have been exposed.

mysticetes) and (2) an uninformed prior, which assumed that all responses that had non-zero values were equally probable.

To apply this procedure to our response analyses, we formed the set of candidate responses identified in Figure 2 (see Table 3). Then we identified the number of instances in which animals were reported to have exhibited one or more of those proximate responses based on published studies or studies available as gray literature. For example, (2004a) reported one instance in which North Atlantic right whales exposed to alarm stimuli did not respond to the stimulus and several instances in which right whales exhibited "disturbance" responses. We coded these two responses (no response and disturbance response) separately. We used the resulting posterior probabilities to identify the kind of responses that would be represented by the "take" estimates that were produced by the models the U.S. Navy and the Permits Division used.

Table 3. Grouping of proximate responses (identified in Figure 2) into categories for response analyses.

	Proximate Response	Grouping for Bayesian Analyses
1	No response	No Response
2	Acoustic resonance	Physical Trauma
3	Noise-induced hearing loss (P)	Not used for formal analyses
4	Noise-induced hearing loss (T)	Not used for formal analyses
5	Reduced auditory field (reduced active space)	Not used for formal analyses
6	Signal masking	Not used for formal analyses
7	Increase call amplitude of vocalizations	Vocal Adjustments
8	Shift frequency structure of vocalizations	
9	Shift call duration of vocalizations	
10	Shift call rate of vocalizations	
11	Shift timing of vocalizations	
12	Physiological stress	Not used for formal analyses
13	Avoid sound field	Avoidance Response
14	Avoid received levels in sound field	
15	Abandon area of exercise	Evasive Response
16	Increase vigilance	Not used for formal analyses
17	Exhibit "disturbance" behavior	Behavioral Disturbance
18	Continue current behavior (coping)	No Response
19	Unspecified behavioral responses (adverse)	Unspecified behavioral responses (adverse)
20	Unspecified behavioral responses (not adverse)	Unspecified behavioral responses (not adverse)
21	Behaviors that cannot be classified	Not used for formal analyses

2.4 Risk Analysis

The final steps of our analyses — establishing the risks those responses pose to endangered and threatened species or designated critical habitat — normally begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our

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

We measure risks to listed individuals using the concept of current or expected future reproductive success which, as we described in the preceding sub-section, integrates survival and longevity with current and future reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable response to stressors produced by an Action would reasonably be expected to reduce the individual's current or expected future reproductive success by increasing the individual's likelihood of dying prematurely, having reduced longevity, increasing the age at which individuals become reproductively mature, reducing the age at which individuals stop reproducing, reducing the number of live births individuals produce during any reproductive bout, decreasing the number of times an individual is likely to reproduce over the reproductive lifespan (in animals that reproduce multiple times), or causing an individual's progeny to experience any of these phenomena.

When individual plants or animals would be expected to experience reductions in their current or expected future reproductive success, we would also expect those reductions to also reduce the abundance, reproduction rates, or growth rates (or increase variance in one or more of these rates) of the populations those individuals represent (see Sterns 1992). If we conclude that listed plants or animals are *not* likely to experience reductions in their current or expected future reproductive success, we would conclude our assessment.

If we conclude that listed plants or animals are likely to experience reductions in their current or expected future reproductive success, we would integrate those individual risks to determine if the number of individuals that experience reduced fitness (or the magnitude of any reductions) is likely to be sufficient to reduce the viability of the populations those individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about a population's probability of becoming demographically, ecologically, or genetically extinct in 10, 25, 50, or 100 years). For this step of our analyses, we would rely on the population's base condition (established in the *Environmental Baseline* and *Status of Listed Resources* sections of this Opinion) as our point of reference.

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

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

2.3 Evidence Available for the Consultation

To conduct these analyses, we considered all lines of evidence available through published and unpublished sources that represent evidence of adverse consequences or the absence of such consequences. Over the past decade, a considerable body of scientific information has become available on anthropogenic sound and its effects on marine mammals and other marine life. Many investigators have studied the potential responses of marine mammals and other marine organisms to human-generated sounds in marine environments or have integrated and synthesized the results of these studies (for example, Bowles et al. 1994; Croll et al. 2001; Croll et al. 1999; Frankel and Clark 1998; Gisiner 1998; Norris 1994; Southall et al. 2007; Tyack 2007; Tyack and Clark. 2000; Wright et al. 2007).

To supplement that body of knowledge, we conducted electronic literature searches using the *Web of Science*, and Cambridge Abstract's *Aquatic Sciences and Fisheries Abstracts* (ASFA) database services. The *First Search* databases provide access to general biological literature, master's theses, and doctoral dissertations back to 1980; ASFA provides access to journal articles, magazine articles, and conference proceedings back to 1964. Our searches specifically focus on the *ArticleFirst*, *BasicBiosis*, *Dissertation Abstracts*, *Proceedings* and *ECO* databases, which index the major journals dealing with issues of ecological risk (for example, the journals *Environmental Toxicology and Chemistry*, *Human and Ecological Risk Assessment*), marine mammals (*Journal of Mammalogy*, *Canadian Journal of Zoology*, *Journal of Zoology*, *Marine Mammal Science*), sea turtles (*Copeia*, *Herpetologia*, *Journal of Herpetology*), ecology (*Ambio*, *Bioscience*, *Journal of Animal Ecology*, *Journal of Applied Ecology*, *Journal of the Marine Biological Association of the UK*, *Marine Pollution Bulletin*, *Oikos*), bioacoustics (*Bioacoustics*, *Journal of the Acoustical Society of America*), and animal behavior (*Advances in the Study of Behavior*, *Animal Behavior*, *Behavior*, *Behavioral Ecology and Sociobiology*, *Ethology*). We manually searched issues of the *Journal of Cetacean Research and Management* and *Reports of the International Whaling Commission*.

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

as well as "behavior"), stranding, unusual mortality event. To collect data for our exposure analyses, we used the keyword: encounter rate paired with marine mammal, cetacean, and whale.

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

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

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

We ranked the results of these searches based on the quality of their study design, sample sizes, level of scrutiny prior to and during publication, and study results. We ranked carefully-designed field experiments (for example, experiments that control variables, such as other sources of sound in an area, that might produce the same behavioral responses) higher than field experiments that were not designed to control those variables. We ranked carefully-designed field experiments higher than computer simulations. Studies that were based on large sample

sizes with small variances were generally ranked higher than studies with small sample sizes or large variances.

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

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

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

The U.S. Council on Environmental Quality defined "cumulative effects" (which we refer to as "cumulative impacts" to distinguish between NEPA and ESA uses of the same term) as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions" (40 CFR §1508.7).

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

In practice we address "cumulative impacts" by focusing on individual organisms, which integrate the environments they occupy or interact with indirectly over the course of their lives. In our assessments, we think in terms of the biotic or ecological "costs" of exposing endangered and threatened individuals to a single stressor, a sequence of single stressors, or a suite of stressors (or "stress regime"). At the level of individual organisms, these "costs" consist of incremental reductions in the current or expected future reproductive success of the individuals that result from exposing those individuals to one or more stressors. The "costs" of those exposures might be immediately significant for an organism's reproductive success (for example, when an individual dies or loses one of its young) or the "costs" might become significant only

over time. The costs of synergistic interactions between two stressors or a sequence of stressors would be expected to be higher than the "costs" incurred without the synergism; the "costs" of antagonistic interactions would be expected to be lower than the "costs" incurred without the antagonism.

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

2.5 Action Area

The action area for this Opinion encompasses the coastal waters at the U.S. Naval Surface Warfare Center, Panama City, Florida, including waters within and adjacent to the Pensacola and Panama City Operating Areas, warning areas W-155, W-151- and W-470 (see Figure 1). We assume that any activities that are likely to occur landward of the mean higher high water line — including activities that may affect threatened or endangered species of sea turtle landward of the mean higher high water line — are addressed in separate section 7 consultations with the U.S. Fish and Wildlife Service.

3 Status of Listed Resources

NMFS has determined that the following species and critical habitat designations may occur in the action area for this consultation:

Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
North Atlantic right whale	*Eubalaena glacialis*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Green sea turtle	*Chelonia mydas*	Threatened
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Loggerhead sea turtle	*Caretta caretta*	Threatened
Gulf sturgeon	*Acipenser oxyrinchus desotoi*	Threatened

In 1996, loggerhead sea turtles were listed as threatened throughout their range (61 FR 17). Since that time, a biological review team (BRT) has identified and proposed the listing of several distinct populations segments (DPSs) of loggerhead sea turtles for protection under the ESA (75 FR 12598). For the loggerhead sea turtle proposed DPSs, NMFS conducted the effects analysis based on the proposed DPS determinations. As such, this Opinion also serves as a conference opinion for the loggerhead sea turtles.

In addition to these species, critical habitat that has been designated for gulf sturgeon also occurs in the action area. In 2003, NMFS and the U.S. Fish and Wildlife Service jointly designated critical habitat for gulf sturgeon that encompasses 14 geographic areas that were based on the location of spawning rivers and adjacent estuaries from Florida and Louisiana.

3.1 Species and Critical Habitat Not Considered Further in this Opinion

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

3.1.1 Blue Whale

There have only been a few reliable reports of blue whales from the Gulf of Mexico and these have been of animals that had stranded in 1924 and 1940 (Würsig et al. 2000). They are assumed to occur only accidentally in the Gulf of Mexico, so we assume that the probability of exposing these whales to one or more of the stressors is sufficiently small to be discountable. Therefore, we assume that blue whales are not likely to be adversely affected by the activities the U.S. Navy plans to conduct in waters on and adjacent to Naval Surface Warfare Center – Panama City, Florida.

3.1.2 Fin Whale

Fin whales have been reported more frequently than blue whales in the Gulf of Mexico, although many of these reports are probably of Bryde's whales, which are more common in the Gulf. Like blue whales, fin whales are assumed to occur only accidentally in the Gulf of Mexico, so we assume that the probability of exposing these whales to one or more of the stressors associated with the proposed action is sufficiently small to be discountable. Therefore, we assume that fin whales are not likely to be adversely affected by the activities the U.S. Navy plans to conduct in waters on and adjacent to Naval Surface Warfare Center – Panama City, Florida.

3.1.3 Humpback Whale

Humpback whales have been reported from the southern tip of Florida, where they were hunted, but they are uncommon in the Gulf of Mexico proper. Over the past few decades, small groups of humpback whales have been reported off the west coast of Florida, Alabama, the delta of the Mississippi River, and Texas (Galveston); in 1983, a humpback whale stranded on the coast of Levy County, Florida. In addition, vocalizations of humpback whales have also been recorded from within the Gulf of Mexico. However, humpback whales that occur in the Gulf of Mexico are assumed to have been inexperienced juveniles that strayed from the normal geographic distribution of these whales in the Caribbean Sea. Because the Action Area for this consultation lies outside of the normal geographic distribution of humpback whales, we assume that the probability of exposing these whales to one or more of the stressors associated with the proposed action is sufficiently small to be discountable. Therefore, we assume that humpback whales are not likely to be adversely affected by the activities the U.S. Navy plans to conduct in waters on and adjacent to Naval Surface Warfare Center – Panama City, Florida.

3.1.4 North Atlantic Right Whale

The Atlantic coast of Florida is considered the southern limit of the North Atlantic right whale's range along North America, so there have only been a few reports of North Atlantic right whales from the Gulf of Mexico: in 1965, two right whales were observed off Sarasota, Florida and a third right whale appeared to have stranded near Freeport, Texas. The evidence suggests that North Atlantic right whales have very small probabilities of occurring in the Gulf of Mexico at all and, as a result, are not likely to be exposed to any of the stressors associated with the proposed action. Therefore, we assume that North Atlantic right whales are not likely to be adversely affected by the activities the U.S. Navy plans to conduct in waters on and adjacent to Naval Surface Warfare Center – Panama City, Florida.

3.1.5 Sei Whale

Sei whales have been reported with about the same frequency as fin whales in the Gulf of Mexico, although there are still only five reliable records of sei whales from the Gulf. Like blue and fin whales, sei whales are assumed to occur only accidentally in the Gulf of Mexico, so we assume that the probability of exposing these whales to one or more of the stressors associated with the proposed action is sufficiently small to be discountable. Therefore, we assume that sei whales are not likely to be adversely affected by the activities the U.S. Navy plans to conduct in waters on and adjacent to Naval Surface Warfare Center – Panama City, Florida.

3.1.6 Gulf Sturgeon

Gulf sturgeon historically occurred in most of the major river systems of the Gulf of Mexico from the Mississippi River east to the Suwannee River in Florida. In marine waters, gulf sturgeon occur from the central and eastern Gulf of Mexico south to Charlotte Harbor. Gulf sturgeon have been captured in commercial and recreational fisheries off of Louisiana, in the Mississippi Sound and Biloxi Bay, Pensacola Bay, Apalachicola Bay, Tampa Bay and Charlotte Harbor and have been reported from the Rio Grande River on the west to Florida Bay, although

these areas are not part of their regular occurrence (Reynolds 1993-1994; Wooley and Crateau 1985).

In Florida, Gulf sturgeon occur in the Appalachicola, Escambia, Blackwater, Choctawhatchee, Ochlockonee, Suwanee, and Yellow Rivers. Because most of the underwater detonations and firing exercises the U.S. Navy plans to conduct would occur further from shore than most gulf sturgeon occur, gulf sturgeon are not likely to be exposed to shock waves or sound fields associated with those activities.

However, given their geographic distribution and migratory habit, gulf sturgeon are likely to occur in the areas that might be ensonified by the high- or mid-frequency active sonar associated with the RDT&E activities the U.S. Navy plans to conduct in the NSWC PCD Study Area. We do not have specific information on hearing in gulf sturgeon. Meyer and Popper (unpublished) (Popper 2005) recorded auditory evoked potentials to pure tone stimuli of varying frequency and intensity in lake sturgeon and reported that lake sturgeon detect pure tones from 100 to 2000 Hz, with best sensitivity from 100 to 400 Hz. They also compared these sturgeon data with comparable data for oscar (*Astronotus ocellatus*) and goldfish (*Carassius auratus*) and reported that the auditory brainstem responses for the lake sturgeon are more similar to the goldfish (which is considered a hearing specialist that can hear up to 5000 Hz) than to the oscar (which is a non-specialist that can only detect sound up to 400 Hz); these authors, however, felt additional data were necessary before lake sturgeon could be considered specialized for hearing. Lovell (2005) also studied sound reception in and the hearing abilities of paddlefish (*Polyodon spathula*) and lake sturgeon (*Acipenser fulvescens*). They concluded that both species were responsive to sounds ranging in frequency from 100 to 500 Hz with lowest hearing thresholds from frequencies in bandwidths between 200 and 300 Hz and higher thresholds at 100 and 500 Hz. Because of their hearing sensitivity, we would not expect gulf sturgeon to respond to high- or mid-frequency active sonar and are not likely to be adversely affected by the sonar activities the U.S. Navy plans to conduct in waters on and adjacent to Naval Surface Warfare Center – Panama City, Florida.

During the months of October and November, many gulf sturgeon move from fresh water into the Gulf of Mexico and may be found in the marine portion of the critical habitat that has been designated for this species. They generally remain in these waters until March. To avoid exposing these fish to detonations associated with line charges, the U.S. Navy proposes to avoid conducting surf zone line charge detonations between October and March when it is feasible to do so. The U.S. Navy also plans to visually survey areas in which they plan to conduct detonations; if a gulf sturgeon was sighted by a survey, detonations would be postponed until the animal is over 0.8 km (0.5 mi) from the intended detonation point. Because the U.S. Navy plans to employ measures to insure that gulf sturgeon are not likely to be exposed to detonations they plan to conduct at the Naval Surface Warfare Center, we would not expect gulf sturgeon to be adversely affected by the detonations the U.S. Navy plans to conduct in waters on and adjacent to Naval Surface Warfare Center – Panama City, Florida.

CRITICAL HABITAT FOR GULF STURGEON. Critical habitat that has been designated for gulf sturgeon occurs in the action area for this consultation. In 2003, NMFS and the U.S. Fish and Wildlife Service jointly designated critical habitat for gulf sturgeon that encompasses 14 geographic areas that were based on the location of spawning rivers and adjacent estuaries from Florida and Louisiana. Of these 14 units, the coastal waters that have been designated as critical habitat that extends from Money Bayou on the east (specifically from the point where longitude 85°17.0′W intersects with the shore near Money Bayou between Cape San Blas and Indian Peninsula) and continues west to about 1 nautical mile of Pensacola Pass (specifically from the point where the line of longitude 87°20.0′W intersects the shore) and extending 1 nautical mile from mean higher water (68 FR 13370).

Although the RDT&E activities the U.S. Navy plans to conduct in the NSWC PCD Study Area overlaps with this critical habitat, those activities are not likely to reduce the quantity, quality, or availability of the physical, chemical, or biotic resources (food, prey, cover, etc.) that make the designated area valuable for the survival and recovery of gulf sturgeon. Specifically, none of the physical or biological features that were used to identify the critical habitat appear to be sensitive to active sonar or sound fields associated with underwater detonations and those sound fields were not identified as phenomena that might cause gulf sturgeon to avoid the designated area. Therefore, we conclude that the research, development, test, and evaluation activities the U.S. Navy plans to conduct at the Naval Surface Warfare Center, Panama City, Florida is not likely to adversely affect critical habitat that has been designated for gulf sturgeon.

3.2 Climate Change

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

The Intergovernmental Panel on Climate Change (IPCC) estimated that average global land and sea surface temperature has increased by 0.6°C (±0.2) since the mid-1800s, with most of the change occurring since 1976. This temperature increase is greater than what would be expected given the range of natural climatic variability recorded over the past 1,000 years (Crowley 2000). The IPCC reviewed computer simulations of the effect of greenhouse gas emissions on observed climate variations that have been recorded in the past and evaluated the influence of natural phenomena such as solar and volcanic activity. Based on their review, the IPCC concluded that natural phenomena are insufficient to explain the increasing trend in land and sea surface temperature, and that most of the warming observed over the last 50 years is likely to be attributable to human activities(IPCC 2001a; IPCC 2001b). Climatic models estimate that global

temperatures would increase between 1.4 to 5.8°C from 1990 to 2100 if humans do nothing to reduce greenhouse gas emissions (IPCC 2001b). These projections identify a suite of changes in global climate conditions that are relevant to the future status and trend of endangered and threatened species (Table 3).

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

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

Table 4. Phenomena associated with projections of global climate change including levels of confidence associated with projections. [1]

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

[1] *(adapted from Campbell-Lendrum and Woodruff 2006; IPCC 2001a)*

The Antarctic Peninsula, which is the northern extension of the Antarctic continent, contains the richest areas of krill in the Southern Ocean. The extent of sea ice cover around this Peninsula has the highest degree of variability relative to other areas within the distribution of krill. Relatively small changes in climate conditions are likely to exert a strong influence on the seasonal pack-ice zone in the Peninsula area, which is likely to affect densities of krill in this region. Because krill are important prey for baleen whales or form a critical component of the food chains on which baleen whales depend, increasing the variability of krill densities or causing those densities to decline dramatically is likely to have an adverse effect on populations of baleen whales in the Southern Ocean. Reid and Croxall (2001) analyzed a 23-year time series of the reproductive performance of predators that depend on krill for prey — Antarctic fur seals (*Arctocephalus gazella*), gentoo penguins (*Pygoscelis papua*), macaroni penguins (*Eudyptes chrysolophus*), and black-browed albatrosses (*Thalassarche melanophrys*) — at South Georgia Island and concluded that these populations experienced increases in the 1980s followed by significant declines in the 1990s accompanied by an increase in the frequency of years with reduced reproductive success. The authors concluded that macaroni penguins and black-browed albatrosses had declined by as much as 50 percent in the 1990s, although incidental mortalities in long-line fisheries probably contributed to the decline of the albatross. These authors concluded, however, that these declines result, at least in part, from changes in the structure of the krill population, particularly reduced recruitment into older age classes, which lowers the number of predators this prey species can sustain. The authors concluded that the biomass of krill within the largest size class was sufficient to support predator demand in the 1980s but not in the 1990s.

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

Climate-mediated changes in the distribution and abundance of keystone prey species like krill and climate-mediated changes in the distribution of cephalopod populations worldwide is likely to affect marine mammal populations as they re-distribute throughout the world's oceans in search of prey. Blue whales, as predators that specialize in eating krill, seem likely to change their distribution in response to changes in the distribution of krill (for example, see Payne et al. 1990; Payne et al. 1986; Weinrich et al. 2001); if they did not change their distribution or could not find the biomass of krill necessary to sustain their population numbers, their populations seem likely to experience declines similar to those observed in other krill predators, which would

cause dramatic declines in their population sizes or would increase the year-to-year variation in population size; either of these outcomes would dramatically increase the extinction probabilities of these whales.

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

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

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

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

Changes in global climatic patterns are also projected to have a profound effect on the coastlines of every continent by increasing sea levels and increasing the intensity, if not the frequency, of

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

3.3 Species of Concern in this Biological Opinion

The rest of this section of our Opinion consists of narratives for each of the threatened and endangered species that occur in the action area and that may be adversely affected by the RDT&E activities the U.S. Navy plans to conduct in the NSWC PCD Study Area, from January 2011 through January 2012. In each narrative, we present a summary of information on the distribution and population structure of each species to provide a foundation for the exposure analyses that appear later in this Opinion. Then we summarize information on the threats to the species and the species' status given those threats to provide points of reference for the jeopardy determinations we make later in this Opinion. That is, we rely on a species' status and trend to determine whether or not an action's direct or indirect effects are likely to increase the species' probability of becoming extinct.

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

More detailed background information on the status of these species and critical habitat can be found in a number of published documents including a status report on large whales prepared by Perry et al. (1999a) and recovery plans for sea turtles (Neuhauser 1991; NMFS 1991; NMFS 1998a; NMFS 1998b; NMFS and USFWS 1991a; NMFS and USFWS 1991b; NMFS and USFWS 1998a; NMFS and USFWS 1998b; NMFS and USFWS 1998c; NMFS and USFWS 1998d; NMFS and USFWS 1998e; NMFS and USFWS 1998f; USFWS 1991). Richardson et al. (1995a) and Tyack (2000) provide detailed analyses of the functional aspects of cetacean communication and their responses to active sonar. Finally, Croll et al. (1999), NRC (2000;

2003a; 2005a), and Richardson and Wursig (1995) provide information on the potential and probable effects of active sonar on the marine animals considered in this Opinion.

3.3.1 Sperm Whale

Sperm whales (*Physeter macrocephalus*) are the largest of the odontocetes (toothed whales) and the most sexually dimorphic cetaceans, with males considerably larger than females. Adult females may grow to lengths of 36 feet (11 m) and weigh 15 tons (13607 kg). Adult males reach about 52 feet (16 m) and may weigh as much as 45 tons (40823 kg).

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

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

Distribution

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

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

In the eastern Atlantic Ocean, mature male sperm whales have been recorded as far north as Spitsbergen (Oien 1990). Recent observations of sperm whales and stranding events involving sperm whales from the eastern North Atlantic suggest that solitary and paired mature male sperm whales predominantly occur in waters off Iceland, the Faroe Islands, and the Norwegian Sea (Christensen et al. 1992; Gunnlaugsson and Sigurjonsson 1990; Oien 1990). Vanselow and Ricklefs (2005) estimated that 20 percent of sperm whale strandings around the North Sea over the last 400 years can be correlated to solar driven geomagnetic anomalies.

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

Population Structure

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

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

Threats to the Species

NATURAL THREATS. Sperm whales are hunted by killer whales (*Orcinus orca*), false killer whales (*Pseudorca crassidens*), and short-finned pilot whales (*Globicephala melas*; (Arnbom et al. 1987; Palacios and Mate. 1996; Rice 1989; Weller et al. 1996). Sperm whales have been observed with bleeding wounds on their heads and tail flukes after attacks by these species (Arnbom et al. 1987; Dufault and Whitehead 1995).

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

ANTHROPOGENIC THREATS. Three human activities are known to threaten sperm whales: whaling, entanglement in fishing gear, and shipping. Historically, whaling represented the greatest threat and was ultimately responsible for listing sperm whales as an endangered species. Sperm whales were hunted all over the world during the 1800s, largely for its spermaceti oil and ambergris.

Harvesting of sperm whales subsided by 1880 when petroleum replaced the need for sperm whale oil (Whitehead 2003).

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

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

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

Sperm whales are also killed by ship strikes. In May 1994 a sperm whale that had been struck by a ship was observed south of Nova Scotia (Reeves and Whitehead 1997) and in May 2000 a merchant ship reported a strike in Block Canyon (NMFS, unpublished data), which is a major pathway for sperm whales entering southern New England continental shelf waters in pursuit of migrating squid (CETAP 1982; Scott and Sadove 1997).

Oil spills into the whale habitat also poses a threat. Skin contact or inhalation exposure are risks for large whales and would probably only have sub-lethal effects. Long-term impacts are also possible through take-up of oil components through the food chain and likely "biomagnification" of the contaminants in large marine mammals (NMFS 2010d).

Status

Sperm whales were listed as endangered under the ESA in 1973. Sperm whales have been protected from commercial harvest by the International Whaling Commission since 1981, although the Japanese continued to harvest sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). They are also protected by the Convention on International Trade in Endangered Species of Wild Flora and Fauna and the MMPA. Critical habitat has not been designated for sperm whales.

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

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

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

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

abundance of sperm whales in Hawai'i was 7,082 sperm whales (coefficient of variation = 0.30) based on ship-board surveys conducted in 2002.

Mark and recapture data from sperm whales led Whitehead and his co-workers to conclude that sperm whale numbers off the Galapagos Islands decreased by about 20% a year between 1985 and 1995 (Whitehead et al. 1997). In 1985 Whitehead et al. (1997) estimated there were about 4,000 female and immature sperm whales, whereas in 1995 they estimated that there were only a few hundred. They suggested that sperm whales migrated to waters off the Central and South American mainland to feed in productive waters of the Humboldt Current, which had been depopulated of sperm whales as a result of intensive whaling.

A mark recapture analysis using photo-identification images in the Gulf of Mexico resulted in a population estimate of 281 with 95% confidence intervals of 202-434 (Jochens et al. 2008). This is in general agreement with, though a little lower than, the population sizes indicated by visual surveys.

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

A draft Recovery Plan written in 2006 was finalized in December 2010 (NMFS 2010c).

Diving and Social Behavior

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

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

Vocalizations and Hearing

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

The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate (Carder and Ridgway. 1990). These data suggest that neonatal sperm whales respond to sounds from 2.5-60 kHz. Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Sperm whales have moved out of areas after the start of air gun seismic testing (Davis et al. 1995). Seismic air guns produce loud, broadband, impulsive noise (source levels are on the order of 250 dB) with “shots” every 15 seconds, 240 shots per hour, 24 hours per day during active tests. Because they spend large amounts of time at depth and use low frequency sound sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). Furthermore, because of their apparent role as important predators of mesopelagic squid and fish, changing the abundance of sperm whales should affect the distribution and abundance of other marine species.

3.3.2 Green Sea Turtle

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

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

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

The nesting season varies depending on location. In the southeastern U.S., females generally nest between June and September, while peak nesting occurs in June and July. During the nesting season, females nest at approximately two week intervals, laying an average of five clutches. In Florida, green turtle nests contain an average of 135 eggs, which will incubate for approximately 2 months before hatching.

Distribution

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

Green turtles appear to prefer waters that usually remain around 20EC in the coldest month. During warm spells (e.g., El Niño), green turtles may be found considerably north of their normal distribution. Stinson (1984) found green turtles most frequently in U.S. coastal waters with temperatures exceeding 18°C.

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

Population Structure

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

Primary nesting aggregations of green turtles (i.e. sites with greater than 500 nesting females per year) include: Ascension Island (south Atlantic Ocean), Australia, Brazil, Comoros Islands,

Costa Rica, Ecuador (Galapagos Archipelago), Equatorial Guinea (Bioko Island), Guinea-Bissau (Bijagos Archipelago), Iles Eparses - (Tromelin Island, Europa Island), Indonesia, Malaysia, Myanmar, Oman, Philippines, Saudi Arabia, Seychelles Islands, Suriname, and United States (Florida; NMFS and USFWS 1998c; Seminoff et al. 2002).

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

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

Threats to the Species

NATURAL THREATS. The various habitat types green sea turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural threats. The beaches on which green sea turtles nest and the nests themselves are threatened by hurricanes and tropical storms as well as the storm surges, sand accretion, and rainfall that are associated with hurricanes. Hatchlings are hunted by predators like herons, gulls, dogfish, and sharks. Larger green sea turtles, including adults, are also killed by sharks and other large, marine predators.

Green turtles in the northwest Hawai'ian Islands are afflicted with a tumor disease, fibropapilloma, which is of an unknown etiology and often fatal, as well as spirochidiasis, both of which are the major causes of strandings of this species. The presence of fibropapillomatosis among stranded turtles has increased significantly over the past 17 years, ranging from 47-69 percent during the past decade (Murakawa et al. 2000). Preliminary evidence suggests an association between the distribution of fibropapillomatosis in the Hawai'ian Islands and the distribution of toxic benthic dinoflagellates (*Prorocentrum* spp.) known to produce a tumor promoter, okadaic acid (Landsberg et al. 1999).

ANTHROPOGENIC THREATS. Three human activities are known to threaten green sea turtles: overharvests of individual animals, incidental capture in commercial fisheries, and human development of coastlines. Historically, the primary cause of the global decline of green sea

turtles populations were the number of eggs and adults captured and killed on nesting beaches in combination with the number of juveniles and adults captured and killed in coastal feeding areas. Some population of green sea turtles still lose large number of eggs, juveniles, and adults to subsistence hunters, local communities that have a tradition of harvesting sea turtles, and poachers in search of turtle eggs and meat.

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

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

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

Green sea turtles are also threatened by domestic or domesticated animals which prey on their nests; artificial lighting that disorients adult female and hatchling sea turtles, which can dramatically increase the mortality rates of hatchling sea turtles; beach replenishment; ingestion and entanglement in marine debris; and environmental contaminants.

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

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

External Effects: Oil and other chemicals on skin and body may result in skin and eye irritation, burns to mucous membranes of eyes and mouth, and increased susceptibility to infection.

Internal Effects: Inhalation of volatile organics from oil or dispersants may result in respiratory irritation, tissue injury, and pneumonia. Ingestion of oil or dispersants may result in gastrointestinal inflammation, ulcers, bleeding, diarrhea, and maldigestion. Absorption of inhaled and ingested chemicals may damage organs such as the liver or kidney, result in anemia and immune suppression, or lead to reproductive failure or death.

Status

Green sea turtles are listed as threatened under the ESA, except for breeding populations found in Florida and the Pacific coast of Mexico, which are listed as endangered. Causes for this decline include harvest of eggs, subadults and adults, incidental capture by fisheries, loss of habitat, and disease.

While some nesting populations of green sea turtles appear to be stable or increasing in the Atlantic Ocean (e.g. Bujigos Archipelago (Guinea-Bissau), Ascension Island, Tortuguero (Costa Rica), Yucatan Peninsula (Mexico), and Florida), declines of over 50% have been documented in the eastern (Bioko Island, Equatorial Guinea) and western Atlantic (Aves Island, Venezuela). Nesting populations in Turkey (Mediterranean Sea) have declined between 42% and 88% since the late 1970s. Population trend variations also appear in the Indian Ocean. Declines greater than 50% have been documented at Sharma (Republic of Yemen) and Assumption and Aldabra (Seychelles), while no changes have occurred at Karan Island (Saudi Arabia) or at Ras al Hadd (Oman). The number of females nesting annually in the Indian Ocean has increased at the Comoros Islands, Tromelin and maybe Europa Island (Iles Esparses; Seminoff 2004).

Green turtles are thought to be declining throughout the Pacific Ocean, with the exception of Hawai'i, as a direct consequence of a historical combination of overexploitation and habitat loss (Eckert 1993; Seminoff 2004). They are also thought to be declining in the Atlantic Ocean. However, like several of the species we have already discussed, the information available on the status and trend of green sea turtles do not allow us to make definitive statement about the global extinction risks facing these sea turtles or risks facing particular populations (nesting aggregations) of these turtles. With the limited data available on green sea turtles, we do not know whether green sea turtles exist at population sizes large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself) or if green sea turtles are threatened more by exogenous

threats such as anthropogenic activities (entanglement, habitat loss, overharvests, etc.) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate). Nevertheless, with the exception of the Hawai'ian nesting aggregations, we assume that green sea turtles are threatened or endangered because of both anthropogenic and natural threats as well as changes in their population dynamics.

A recovery plan for the U.S Population of Atlantic Green Turtles was written in 1991 (NMFS and USFWS 1991a). A recovery plan for the U.S. Pacific Populations of the Green Turtle was written in 1998 (NMFS and USFWS 1998c).

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

*Vocalizations and Hearing*The information on green sea turtle hearing is very limited. Ridgway et al. (1969) studied the auditory evoked potentials of three green sea turtles (in air and through mechanical stimulation of the ear) and concluded that their maximum sensitivity occurred from 300 to 400 Hz with rapid declines for tones at lower and higher frequencies. They reported an upper limit for cochlear potentials without injury of 2000 Hz and a practical limit of about 1000 Hz. This is similar to estimates for loggerhead sea turtles, which had most sensitive hearing between 250 and 1000 Hz, with rapid decline above 1000 Hz (Bartol et al. 1999).

In a study of the auditory brainstem responses of subadult green sea turtles, Ketten and Bartol (2005) reported responses to frequencies between 100 and 500 Hz; with highest sensitivity between 200 and 400 Hz. They reported that two juvenile green turtles had hearing sensitivities that were slightly broader in range: they responded to sounds at frequencies from 100 to 800 Hz, with highest hearing sensitivities from 600 to 700 Hz.

These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

3.3.3 Hawksbill Sea Turtle

The hawksbill turtle is small to medium-sized compared to other sea turtle species. Adults weigh 100-150 lbs (45 to 68 kg) on average, but can grow as large as 200 lbs (91 kg). Hatchlings weigh about 0.5 oz (14 g).

The carapace (top shell) of an adult ranges from 25 to 35 inches (63 to 90 cm) in length and has a "tortoiseshell" coloring, ranging from dark to golden brown, with streaks of orange, red, and/or black. The shells of hatchlings are 1-2 inches (about 42 mm) long and are mostly brown and somewhat heart-shaped. The plastron (bottom shell) is clear yellow. The rear edge of the carapace is almost always serrated, except in older adults, and has overlapping "scutes".

The hawksbill turtle's head is elongated and tapers to a point, with a beak-like mouth that gives the species its name. The shape of the mouth allows the hawksbill turtle to reach into holes and crevices of coral reefs to find sponges, their primary food source as adults, and other invertebrates. Hawksbill turtles are unique among sea turtles in that they have two pairs of prefrontal scales on the top of the head and each of the flippers usually has two claws.

Male hawksbills mature when they are about 27 inches (69 cm) long. Females mature at about 31 inches (78 cm). The ages at which turtles reach these lengths are unknown.

Female hawksbills return to their natal beaches every 2-3 years to nest at night approximately every 14-16 days during the nesting season. A female hawksbill generally lays 3-5 nests per season, which contain an average of 130 eggs. Hawksbill turtles usually nest high up on the beach under or in the beach/dune vegetation on both calm and turbulent beaches. They commonly nest on pocket beaches, with little or no sand.

Distribution

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

In the continental U.S., hawksbill sea turtles have been reported in every state on the coast of the Gulf of Mexico and along the coast of the Atlantic Ocean from Florida to Massachusetts, except for Connecticut; however, sightings of hawksbill sea turtles north of Florida are rare. The only states where hawksbill sea turtles occur with any regularity are Florida (particularly in the Florida Keys and the reefs off Palm Beach County on Florida’s Atlantic coast, where the warm waters of the Gulf Stream pass close to shore) and Texas. In both of these states, most sightings are of post-hatchlings and juveniles that are believed to have originated from nesting beaches in Mexico.

Hawksbill sea turtles have stranded along almost the entire Atlantic coast of the United States, although most stranding records occur south of Cape Canaveral, Florida, particularly in Palm Beach, Broward and Miami-Dade counties (Florida Sea Turtle Stranding and Salvage database). During their pelagic-stage, hawksbills disperse from the Gulf of Mexico and southern Florida in the Gulfstream Current, which would carry them offshore of Georgia and the Carolinas. As evidence of this, a pelagic-stage hawksbill was captured 37 nautical miles east of Sapelo Island,

Georgia in May 1994 (Parker 2005). There are also records of hawksbill sea turtles stranding on the coast of Georgia (Odell et al. 2008), being captured in pound nets off Savannah, and being captured in summer flounder trawls (Epperly et al. 1995), gillnets (Epperly et al. 1995), and power plants off Georgia and the Carolinas. There are also records of hawksbill sea turtles being captured in pound nets off Savannah, and being captured in summer flounder trawls, gillnets, and power plants off Georgia and the Carolinas (Epperly et al. 1995).

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

Hawksbill sea turtles occupy different habitats depending on their life history stage. After entering the sea, hawksbill sea turtles occupy pelagic waters and occupy weed lines that accumulate at convergence points. When they grow to about 20-25 cm carapace length, hawksbill sea turtles reenter coastal waters where they inhabit and forage in coral reefs as juveniles, subadults and adults. Hawksbill sea turtles also occur around rocky outcrops and high energy shoals, where sponges grow and provide forage, and they are known to inhabit mangrove-fringed bays and estuaries, particularly along the eastern shore of continents where coral reefs are absent.

Population Structure

Hawksbill sea turtles, like other sea turtles, are divided into regional groupings that represent major oceans or seas: the Atlantic Ocean, Pacific Ocean, Indian Ocean, Caribbean Sea and Mediterranean Sea. In these regions, the population structure of hawksbill turtles is usually based on the distribution of their nesting aggregations.

Threats to the Species

NATURAL THREATS. The various habitat types hawksbill sea turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural threats. The beaches on which hawksbill sea turtles nest and the nests themselves are threatened by hurricanes and tropical storms as well as the storm surges, sand accretion, and rainfall that are associated with hurricanes. Hatchlings are hunted by predators like herons, gulls, dogfish, and sharks. Adult hawksbill sea turtles are also killed by sharks and other large, marine predators.

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

For centuries, hawksbill sea turtles have been captured for their shells, which have commercial value, rather than food (the meat of hawksbill sea turtles is considered to have a bad taste and can be toxic to humans) ((NMFS and USFWS 1993; NMFS and USFWS 1998d). Until recently, tens of thousands of hawksbills were captured and killed each year to meet demand for jewelry, ornamentation, and whole stuffed turtles (Milliken and Tokunga 1987 cited in Eckert 1993). In 1988, Japan's imports from Jamaica, Haiti and Cuba represented some 13,383 hawksbills: it is extremely unlikely that this volume could have originated solely from local waters (Greenpeace 1989 cited in Eckert 1993).

Although Japan banned the importation of turtle shell in 1994, domestic harvests of eggs and turtles continue in the United States, its territories, and dependencies, particularly in the Caribbean and Pacific Island territories. Large numbers of nesting and foraging hawksbill sea turtles are captured and killed for trade in Micronesia, the Mexican Pacific coast, southeast Asia and Indonesia ((NMFS and USFWS 1993; NMFS and USFWS 1998d). In addition to the demand for the hawksbill's shell, there is a demand for other products including leather, oil, perfume, and cosmetics. Before the U.S. certified Japan under the Pelly Amendment, Japan had been importing about 20 metric tons of hawksbill shell per year, representing approximately 19,000 turtles.

The second most important threat to hawksbill sea turtles is the loss of nesting habitat caused by the expansion of resident human populations in coastal areas of the world and increased destruction or modification of coastal ecosystems to support tourism. Hawksbill sea turtles are also captured and killed in commercial fisheries. Along the Atlantic coast of the U.S., NMFS estimated that about 650 hawksbill sea turtles are captured in shrimp trawl fisheries each year in the Gulf of Mexico, with most of those sea turtles dying as a result of their capture. Each year, about 35 hawksbill sea turtles are captured in Atlantic pelagic longline fisheries. Although most of these turtles are released alive, these fisheries are expected to kill about 50 hawksbill sea turtles each year; the health effects of being captured on the sea turtles that survive remain unknown.

Like green sea turtles, hawksbill sea turtles are threatened by domestic or domesticated animals that prey on their nests; artificial lighting that disorients adult female and hatchling sea turtles, which can dramatically increase the mortality rates of hatchling sea turtles; beach replenishment; ingestion and entanglement in marine debris; and environmental contaminants.

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

Additionally, sea turtles may experience oiling impacts on nesting beaches when they come ashore to lay their eggs, and their eggs may be exposed during incubation potentially resulting in increased egg mortality and/or possibly developmental defects in hatchlings. Hatchlings

emerging from their nests may encounter oil on the beach and in the water as they begin their lives at sea.

External Effects: Oil and other chemicals on skin and body may result in skin and eye irritation, burns to mucous membranes of eyes and mouth, and increased susceptibility to infection.

Internal Effects: Inhalation of volatile organics from oil or dispersants may result in respiratory irritation, tissue injury, and pneumonia. Ingestion of oil or dispersants may result in gastrointestinal inflammation, ulcers, bleeding, diarrhea, and maldigestion. Absorption of inhaled and ingested chemicals may damage organs such as the liver or kidney, result in anemia and immune suppression, or lead to reproductive failure or death.

Status

Hawksbill sea turtles were listed as endangered under the ESA in 1970. Under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, hawksbill sea turtles are identified as "most endangered."

Hawksbill sea turtles are solitary nesters, which makes it difficult to estimate the size of their populations. There are no global estimates of the number of hawksbill sea turtles, but a minimum of 15,000 to 25,000 females are thought to nest annually in more than 60 geopolitical entities (Groombridge and Luxmoore 1989). Moderate populations appear to persist around the Solomon Islands, northern Australia, Palau, Persian Gule islands, Oman, and parts of the Seychelles. In a more recent review, Groombridge and Luxmoore (1989) list Papua New Guinea, Queensland, and Western Australia as likely to host 500-1,000 nesting females per year, while Indonesia and the Seychelles may support >1,000 nesting females. The largest known nesting colony in the world is located on Milman Island, Queensland, Australia where Loop (1995) tagged 365 hawksbills nesting within an 11 week period. With the exception of Mexico, and possibly Cuba, nearly all Wider Caribbean countries are estimated to receive <100 nesting females per year.

Of the 65 geopolitical units on which hawksbill sea turtles nest and where hawksbill nesting densities can be estimated, 38 geopolitical units have hawksbill populations that are suspected or known to be declining. Another 18 geopolitical units have experienced well-substantiated declines (NMFS and USFWS 1995). The largest remaining nesting concentrations occur on remote oceanic islands off Australia (Torres Strait) and the Indian Ocean (Seychelles).

Hawksbill sea turtles, like green sea turtles, are thought to be declining globally as a direct consequence of a historical combination of overexploitation and habitat loss. However, like several of the species we have already discussed, the information available on the status and trend of hawksbill sea turtles do not allow us to make definitive statements about the global extinction risks facing these sea turtles or the risks facing particular populations (nesting aggregations) of these turtles. However, the limited data available suggests that several hawksbill sea turtles populations exist at sizes small enough to be classified as "small" populations (that is, populations that exhibit population dynamics that increase the extinction probabilities of the species or several of its populations) while others are large enough to avoid these problems.

Exogenous threats such as overharvests and entanglement in fishing gear only increase their probabilities of becoming extinct in the foreseeable future.

Diving and Social Behavior

The duration of foraging dives in hawksbill sea turtles commonly depends on the size of the turtle: larger turtles dive deeper and longer. At a study site also in the northern Caribbean, foraging dives were made only during the day and dive durations ranged from 19-26 minutes in duration at depths of 8-10 m. At night, resting dives ranged from 35-47 minutes in duration (vanDam and Diez 1997).

Vocalizations and Hearing

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

These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Peterson 1966).

3.3.4 Kemp's Ridley Sea Turtle

Adult Kemp's ridley turtles, considered the smallest marine turtle in the world, weigh on average around 100 pounds (45 kg) with a carapace (top shell) measuring between 24-28 inches (60-70 cm) in length. The almost circular carapace has a grayish green color while the plastron (bottom shell) is pale yellowish to cream in color. The carapace is often as wide as it is long and contains 5 pairs of costal "scutes". Each of the front flippers has one claw while the back flippers may have one or two.

Similar to olive ridley turtles, Kemp's ridley turtles display one of the most unique synchronized nesting habits in the natural world. Large groups of Kemp's ridley turtles gather off a particular nesting beach near Rancho Nuevo, Mexico, in the state of Tamaulipas. This wave upon wave of females coming ashore and nesting is known as an "arribada," which means "arrival" in Spanish.

There are many theories on what triggers an arribada, including offshore winds, lunar cycles, and the release of pheromones by females. Scientists have yet to conclusively determine the cues for ridley arribadas. Arribada nesting is a behavior found only in the genus Lepidochelys.

Female Kemp's ridley turtles nest from May to July, laying two to three clutches of approximately 100 eggs, which incubate for 50-60 days. After incubation, hatchlings emerge weighing about half an ounce (14 g) and measuring about 1.5 inches (3.8 cm).

Distribution

Adult Kemp's ridley turtles are restricted to the Gulf of Mexico in shallow near shore waters, although adult-sized individuals sometimes are found on the eastern seaboard of the United States. Females rarely leave the Gulf of Mexico and adult males do not migrate. Juveniles feed along the east coast of the United States up to the waters off Cape Cod, Massachusetts (NMFS and USFWS 2007a). A small number of individuals reach European waters and the Mediterranean (NMFS and USFWS 2007a; Pritchard and Marquez 1973).

Juvenile Kemp's ridley sea turtles are the second most abundant sea turtle in the mid-Atlantic region from New England, New York, and the Chesapeake Bay, south to coastal areas off North Carolina. Juvenile Kemp's ridley sea turtles migrate into the region during May and June and forage for crabs in submerged aquatic vegetation (Musick and Limpus 1997). In the fall, they migrate south along the coast, forming one of the densest concentrations of Kemp's ridley sea turtles outside of the Gulf of Mexico (Musick and Limpus 1997).

Population Structure

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

Almost 95 percent of all Kemp's ridley sea turtle nesting occurs on the beaches of Rancho Nuevo, Tepehuajes, and Barra del Tordo in the State of Tamaulipas, Mexico. Nesting also occurs in Veracruz, Mexico, and Texas, U.S., but on a much smaller scale. Occasional nesting has been documented in North Carolina, South Carolina, and the Gulf and Atlantic coasts of Florida. As a general matter, Kemp's ridley sea turtles are treated as a single population.

Threats to the Species

NATURAL THREATS. Kemp's ridley sea turtles are exposed to a wide variety of threats during every stage of their lives. Eggs and hatchlings on nesting beaches are preyed upon by coyotes, raccoons, coatis, skunks, ghost crabs, ants, and to lesser degrees hawks, vultures, grackles, and caracaras (Dodd Jr. 1988). Those hatchlings that reach the ocean are preyed upon by gulls, terns, sharks, and predatory fish (Dodd Jr. 1988). Sharks and other large marine predators prey on large juvenile Kemp's ridley sea turtles.

Because of their restricted geographic distribution, the concentration of most nesting activity at one beach, and the frequency of hurricanes in the Gulf of Mexico, hurricanes represent a

substantial threat to Kemp's ridley sea turtles. For example, in 1988 Hurricane Gilbert struck the primary nesting beach, destroyed many of the nests, and altered the structure of the nesting beach.

ANTHROPOGENIC THREATS. Several human activities contributed to the endangerment of Kemp's ridley sea turtles: harvests of eggs on nesting beaches, incidental capture in fisheries, loss of foraging habitat, and marine pollution. In 1947, 40,000 female Kemp's ridley sea turtles were observed nesting on the beaches at Rancho Nuevo on a single day (Carr 1963; Hildebrand 1963).

Kemp's ridley sea turtles have been captured and killed by fishing gear in several Federal and state fisheries throughout their range. They have been captured in gear used in lobster fisheries and monkfish fisheries off the northeastern United States, pound net fisheries off eastern Long Island, the mid-Atlantic, and Chesapeake Bay; fisheries for squid, mackerel, butterfish, bluefish, summer flounder, Atlantic herring, weakfish, and the sargassum fishery. The most significant fishery-related threat to Kemp's ridley sea turtles has been the number of sea turtles that have been captured and killed in the shrimp trawl fisheries in the Gulf of Mexico.

Kemp's ridley sea turtles have also been captured and killed as a result of entrainment in power plans along the coast of the United States and coastal dredging.

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

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

External Effects: Oil and other chemicals on skin and body may result in skin and eye irritation, burns to mucous membranes of eyes and mouth, and increased susceptibility to infection.

Internal Effects: Inhalation of volatile organics from oil or dispersants may result in respiratory irritation, tissue injury, and pneumonia. Ingestion of oil or dispersants may result in gastrointestinal inflammation, ulcers, bleeding, diarrhea, and maldigestion. Absorption of inhaled and ingested chemicals may damage organs such as the liver or kidney, result in anemia and immune suppression, or lead to reproductive failure or death.

RECOVERY ACTIONS. Kemp's ridley sea turtles have benefited from a concentrated recovery effort that began in the mid-1960s when the government of Mexico established a program to protect eggs on the beach of Rancho Nuevo. In 1977, a Mexican presidential decree included the Rancho Nuevo Nesting Beach Natural Reserve as part of a system of reserves for sea turtles. In 1978, an

experiment to "head start" Kemp's ridley sea turtles was implemented as part of a larger effort to recover the species. From 1978 to 1991, under a cooperative beach patrol effort involving both the U.S. and Mexico, the number of released hatchlings was increased to a yearly average of 54,676 individuals. In 1990 a complete ban on taking any species of sea turtle was established by the Government of Mexico.

Status

Kemp's ridley sea turtles were listed as endangered on 2 December 1970 (35 FR 18320). There is no designated critical habitat for the Kemp's ridley sea turtle.

In 1947, 40,000 female Kemp's ridley sea turtles were observed nesting on the beaches at Rancho Nuevo on a single day (Carr 1963; Hildebrand 1963). By the early 1970s, the estimate of mature female Kemp's ridley turtles had been reduced to 2,500-5,000 individuals. Between the years of 1978 and 1991 only 200 Kemp's ridley turtles nested annually. Today the Kemp's ridley population appears to be in the early stages of recovery. Since the mid-1980s, the number of nests observed at Rancho Nuevo and nearby beaches has increased 14-16% per year (Heppell et al. 2005), allowing cautious optimism that the population is on its way to recovery. The total annual number of nests recorded at Rancho Nuevo and adjacent camps has exceeded 10,000 in recent years (NMFS et al. 2010). For Texas, from 2002-2009, a total of 771 Kemp's ridley nests have been documented on the Texas coast (NMFS et al. 2010). This is more than nine times greater than the 81 nests recorded over the previous 54 years from 1948-2001(Shaver 2005), indicating an increasing nesting population in Texas. From 2005 through 2009, the number of nests from all monitored beaches indicate approximately 5,500 females are nesting each season in the Gulf of Mexico.

The Turtle Expert Working Group (TEWG 2000) estimated that the population size of Kemp's ridley sea turtles grew at an average rate of l1.3 percent per year (95% C.I. slope = 0.096-0.130) between 1985 and 1998. Over the same time interval, hatchling production increased at a slightly slower rate (9.5% per year).

Vocalizations and Hearing

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

These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

3.3.5 Leatherback Sea Turtle

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

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

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

Distribution

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

Leatherback sea turtles are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Eckert and Eckert 1988; Eckert 1999; Morreale et al. 1994). In a single year, a leatherback may swim more than 10,000 kilometers (Eckert 1998). In the North Atlantic Ocean, leatherback turtles regularly occur in deep waters (>328 ft), and an aerial survey study in the north Atlantic sighted leatherback

turtles in water depths ranging from 3 to 13,618 ft, with a median sighting depth of 131.6 ft (CETAP 1982). This same study found leatherbacks in waters ranging from 7 to 27.2°C. In the Pacific Ocean, leatherback turtles have the most extensive range of any living reptile and have been reported in all pelagic waters of the Pacific between 71°N and 47°S latitude and in all other major pelagic ocean habitats (NMFS and USFWS 1998a). Leatherback turtles lead a completely pelagic existence, foraging widely in temperate waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. Males are rarely observed near nesting areas, and it has been hypothesized that leatherback sea turtles probably mate outside of tropical waters, before females swim to their nesting beaches (Eckert and Eckert 1988).

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

Population Structure

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

Threats to the Species

NATURAL THREATS. The various habitat types leatherback sea turtles occupy throughout their lives exposes these sea turtles to a wide variety of natural threats. The beaches on which leatherback sea turtles nest and the nests themselves are threatened by hurricanes and tropical storms as well as the storm surges, sand accretion, and rainfall that are associated with hurricanes. Hatchlings are hunted by predators like herons, gulls, dogfish, and sharks. Larger leatherback sea turtles, including adults, are also killed by sharks and other large, marine predators.

ANTHROPOGENIC THREATS. Leatherback sea turtles are endangered by several human activities, including fisheries interactions, entanglement in fishing gear (e.g., gillnets, longlines, lobster pots, weirs), direct harvest, egg collection, the destruction and degradation of nesting and coastal habitat, boat collisions, and ingestion of marine debris (NMFS and USFWS 1998e).

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

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

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

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

Leatherback sea turtles are known to drown in fish nets set in coastal waters of Sao Tome, West Africa (Tomás et al. 2000). Gillnets are one of the suspected causes for the decline in the leatherback turtle population in French Guiana (Chevalier et al. 1999), and gillnets targeting green and hawksbill turtles in the waters of coastal Nicaragua also incidentally catch leatherback turtles (Lagueux 1998). Observers on shrimp trawlers operating in the northeastern region of

Venezuela documented the capture of six leatherbacks from 13,600 trawls (Marcano and Alió-M 2000). An estimated 1,000 mature female leatherback turtles are caught annually off of Trinidad and Tobago with mortality estimated to be between 50-95% (Eckert et al. 2007). However, many of the turtles do not die as a result of drowning, but rather because the fishermen butcher them in order to get them out of their nets. There are known to be many sizeable populations of leatherbacks nesting in West Africa, possibly as many as 20,000 females nesting annually (Fretey 2001). In Ghana, nearly two thirds of the leatherback turtles that come up to nest on the beach are killed by local fishermen.

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

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

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

External Effects: Oil and other chemicals on skin and body may result in skin and eye irritation, burns to mucous membranes of eyes and mouth, and increased susceptibility to infection.

Internal Effects: Inhalation of volatile organics from oil or dispersants may result in respiratory irritation, tissue injury, and pneumonia. Ingestion of oil or dispersants may result in gastrointestinal inflammation, ulcers, bleeding, diarrhea, and maldigestion. Absorption of inhaled and ingested chemicals may damage organs such as the liver or kidney, result in anemia and immune suppression, or lead to reproductive failure or death.

Status

The leatherback turtles are listed as endangered under the ESA throughout the species' global range. Increases in the number of nesting females have been noted at some sites in the Atlantic Ocean, but these are far outweighed by local extinctions, especially of island populations, and the demise of populations throughout the Pacific, such as in Malaysia and Mexico. Spotila et al. (1996) estimated the global population of female leatherback turtles to be only 34,500

(confidence limits: 26,200 to 42,900) nesting females; however, the eastern Pacific population has continued to decline since that estimate, leading some researchers to conclude that the leatherback is now on the verge of extinction in the Pacific Ocean (e.g., Spotila et al. 1996; Spotila et al. 2000).

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

In the Atlantic and Caribbean, the largest nesting assemblages of leatherbacks are found in the U.S. Virgin Islands, Puerto Rico, and Florida. Since the early 1980s, nesting data has been collected at these locations. Populations in the eastern Atlantic (*i.e.* off Africa) and Caribbean appear to be stable; however, information regarding the status of the entire leatherback population in the Atlantic is lacking and it is certain that some nesting populations (*e.g.*, St. John and St. Thomas, U.S. Virgin Islands) have been extirpated (NMFS AND USFWS 1995). Data collected in southeast Florida clearly indicate increasing numbers of nests for the past twenty years (9.1-11.5% increase), although it is critical to note that there was also an increase in the survey area in Florida over time (NMFS 2001). However, the largest leatherback rookery in the western North Atlantic remains along the northern coast of South America in French Guiana and Suriname. Recent information suggests that Western Atlantic populations declined from 18,800 nesting females in 1996 (Spotila et al. 1996) to 15,000 nesting females by 2000 (Spotila, personal communication *cited in* NMFS 2001). The nesting population of leatherback turtles in the Suriname-French Guiana trans-boundary region has been declining since 1992 (Chevalier et al. 1999). Poaching and fishing gear interactions are believed to be the major contributors to the decline of leatherbacks in the area.

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

While Spotila et al.(1996) indicated that turtles may have been shifting their nesting from French Guiana to Suriname due to beach erosion, analyses show that the overall area trend in number of nests has been negative since 1987 at a rate of 15.0 -17.3 % per year (NMFS 2001). If turtles are

not nesting elsewhere, it appears that the Western Atlantic portion of the population is being subjected to mortality beyond sustainable levels, resulting in a continued decline in numbers of nesting females.

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

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

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

In the Pacific Ocean, leatherback sea turtles are critically endangered as a direct consequence of a historical combination of overexploitation and habitat loss. The information available suggests that leatherback sea turtles have high probabilities of becoming extinct in the Pacific Ocean unless they are protected from the combined threats of entanglements in fishing gear, overharvests, and loss of their nesting habitat. The limited data available suggests that

leatherback sea turtles exist at population sizes small enough to be classified as "small" populations (that is, populations that exhibit population dynamics that increase the extinction probabilities of the species or several of its populations) as evidenced by biases in the male to female ratios in the Pacific. The status of leatherback sea turtles in the Atlantic Ocean remains uncertain.

Diving and Social Behavior

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

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

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

Vocalizations and Hearing

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

These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

3.3.6 Loggerhead Sea Turtle

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

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

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

Distribution

Loggerheads are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. Major nesting grounds are generally located in temperate and subtropical regions, with scattered nesting in the tropics in the Atlantic, Pacific and Indian Oceans and the Mediterranean Sea (NMFS and USFWS 1998e). The majority of loggerhead nesting is at the western rims of the Atlantic and Indian Oceans. Nesting aggregations occur in the eastern Atlantic at Cape Verde, Greece, Libya, Turkey and along the West African Coast. The western Atlantic and Caribbean hosts nesting aggregations along the U.S. east coast from Virginia through the Florida peninsula, the Dry Tortugas and Northern Gulf of Mexico, the Bahamas, the Yucatan Peninsula, Central America and the Caribbean and into South America. Within the Indian Ocean, nesting aggregations occur at Oman, Yemen, Sri Lanka and Madagascar and South Africa. Pacific Ocean nesting sites include western and eastern Australia and Japan.

Adult loggerheads are known to make considerable migrations from nesting beaches to foraging grounds (TEWG 2009); and evidence indicates turtles entering the benthic environment

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

Population Structure

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

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

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

Threats to the Species

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

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

When they are in coastal or marine waters, loggerhead turtles are affected by a completely different set of human activities that include discharges of toxic chemicals and other pollutants into the marine ecosystem; underwater explosions; hopper dredging, offshore artificial lighting; entrainment or impingement in power plants; entanglement in marine debris; ingestion of marine debris; boat collisions; poaching, and interactions with commercial fisheries. Of these, interactions with fisheries represent a primary threat because of the number of individuals that are captured and killed in fishing gear each year (Table 5).

Loggerhead sea turtles are also captured and killed in commercial fisheries. In the Pacific Ocean, between 2,600 and 6,000 loggerhead sea turtles are estimated to have been captured and killed in longline fisheries in 2000 (Lewison et al. 2004). Shallow-set Hawai'i based longline fisheries are estimated to have captured and killed several hundred loggerhead sea turtles before they were closed in 2001. When they were re-opened in 2004, with substantial modifications to protect sea turtles, these fisheries were estimated to have captured and killed about fewer than 5 loggerhead sea turtles each year. Between 2004 and 2008, shallow-set fisheries based out of Hawai'i are estimated to have captured about 45 loggerhead sea turtles, killing about 10 of these sea turtles. A recent biological opinion on these fisheries expected this rate of interaction and deaths to continue into the foreseeable future (NMFS 2008B). Loggerhead sea turtles have also been and are expected to continue to be captured and killed in the deep-set longline fisheries based out of Hawai'i and American Samoa.

Shrimp trawl fisheries account for the highest number of loggerhead sea turtles that are captured and killed, but they are also captured and killed in trawls, traps and pots, longlines, and dredges. Along the Atlantic coast of the U.S., NMFS estimated that almost 163,000 loggerhead sea turtles are captured in shrimp trawl fisheries each year in the Gulf of Mexico, with 3,948 of those sea turtles dying as a result of their capture. Each year, several hundred loggerhead sea turtles are also captured in herring fisheries; mackerel, squid, and butterfish fisheries; monkfish fisheries; pound net fisheries, summer flounder and scup fisheries; Atlantic pelagic longline fisheries; and gillnet fisheries in Pamlico Sound. Although most of these turtles are released alive, these fisheries capture about 2,000 loggerhead sea turtles each year, killing almost 700; the effects of capture-related stress on the current or expected future reproductive success of sea turtles remains unknown.

In the pelagic environment, loggerhead sea turtles are exposed to a series of longline fisheries that include the U.S. Atlantic tuna and swordfish longline fisheries, an Azorean longline fleet, a Spanish longline fleet, and various fleets in the Mediterranean Sea (Aguilar et al. 1995; Bolten et al. 2002). In the benthic environment in waters off the coastal U.S., loggerheads are exposed to a suite of fisheries in federal and state waters including trawl, purse seine, hook and line, gillnet, pound net, longline, dredge, and trap fisheries.

Like all of the other sea turtles we have discussed, loggerhead sea turtles are threatened by domestic or domesticated animals that prey on their nests; artificial lighting that disorients adult female and hatchling sea turtles, which can dramatically increase the mortality rates of hatchling sea turtles; beach replenishment; ingestion and entanglement in marine debris; and environmental contaminants.

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

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

External Effects: Oil and other chemicals on skin and body may result in skin and eye irritation, burns to mucous membranes of eyes and mouth, and increased susceptibility to infection.

Internal Effects: Inhalation of volatile organics from oil or dispersants may result in respiratory irritation, tissue injury, and pneumonia. Ingestion of oil or dispersants may result in gastrointestinal inflammation, ulcers, bleeding, diarrhea, and maldigestion. Absorption of inhaled

and ingested chemicals may damage organs such as the liver or kidney, result in anemia and immune suppression, or lead to reproductive failure or death.

Status

Loggerhead sea turtles are currently listed as threatened under the ESA throughout its global range. In 2010 NMFS and FWS published a proposed rule to list several distinct population segments (DPS) of loggerhead sea turtles (75 FR 12598, March 16, 2010). Two DPSs are proposed for the Pacific Ocean, three in the Indian Ocean, and four in the Atlantic Ocean/Mediterranean Sea (See Table 5.).

Table 5. Proposed Loggerhead Sea Turtle Distinct Population Segments.

Population Segment	Historic Range	Population Boundaries	Proposed Status
Mediterranean Sea	Mediterranean Sea Basin	Mediterranean Sea east of 5°36' W. Long.	Endangered
North Indian Ocean	North Indian Ocean Basin	North Indian Ocean north of the equator and south of 30° N. Lat.	Endangered
North Pacific Ocean	North Pacific Ocean Basin	North Pacific north of the equator and south of 60° N. Lat.	Endangered
Northeast Atlantic Ocean	Northeast Atlantic Ocean Basin	Northeast Atlantic Ocean north of the equator, south of 60° N. Lat, east of 40° W. Long, and west of 5°36' W. Long	Endangered
Northwest Atlantic Ocean	Northwest Atlantic Ocean Basin	Northwest Atlantic Ocean north of the equator, south of 60° N. Lat, and west of 40° W. Long	Endangered
South Atlantic Ocean	South Atlantic Ocean	South Atlantic Ocean south of the equator, north of 60° S. Lat, west of 20° E. Long, and east of 67° W. Long	Threatened
South Pacific Ocean	South Pacific Ocean Basin	South Pacific south of the equator, north of 60° S. Lat, west of 67° W. Long, and east of 139° E. Long.	Endangered
Southeast Indo-Pacific Ocean	Southeast Indian Ocean Basin; South Pacific Ocean Basin as far east as 139° E Long	Southeast Indian Ocean south of the equator, north of 60° S. Lat, and east of 80° E. Long; South Pacific Ocean south of the equator, north of 60° S. Lat, and west of 139° E. Long	Endangered
Southwest Indian Ocean	Southwest Indian Ocean Basin	Southwest Indian Ocean north of the equator, south of 30° N. Lat, west of 20° E. Long, and east of 80° E. Long	Threatened

All loggerheads inhabiting the North Pacific Ocean are derived primarily, if not entirely, from Japanese beaches (although low level nesting may occur in areas around the South China Sea). Along the Japanese coast, nine major nesting beaches (greater than 100 nests per season) and six "submajor'' beaches (10– 100 nests per season) were identified. Using information collected

from these nine beaches (Kamezaki et al. 2003) found a substantial decline (50–90 percent) in the size of the annual loggerhead nesting population over the last half of the 20th century. Also, nest count data for the last two decades suggests that the North Pacific population is "small" and lacks a robust gene pool when compared to the larger northwest Atlantic and north Indian Ocean loggerhead populations. Small populations are more susceptible to demographic variability which increases their probability of extinction. Available evidence indicates that due to loss of adult and juvenile mortalities from fishery bycatch and, to a lesser degree the loss of nesting habitat, the North Pacific loggerhead population is declining.

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

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

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

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

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

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

(1) Northern U.S. (Florida/Georgia border to southern Virginia). The Northern U.S. subpopulation is the second largest unit within the Northwest Atlantic population and has been declining significantly at 1.3 percent annually since 1983 (NMFS and USFWS 2008);

(2) Peninsular Florida (Florida/Georgia border south through Pinellas County, excluding the islands west of Key West, Florida). The most significant declining trend has been documented for the Peninsular Florida subpopulation, where nesting declined 26 percent over the 20-year period from 1989–2008, and declined 41 percent over the period 1998–2008 (NMFS and USFWS 2008; Witherington et al. 2009). This subpopulation represents approximately 87 percent of all nesting effort in the Northwest Atlantic Ocean DPS (Ehrhart et al. 2003);

(3) Dry Tortugas (islands west of Key West, Florida). Data are currently not adequate to assess trends in the annual number of nests for this subpopulation;

(4) Northern Gulf of Mexico (Franklin County, Florida, west through Texas). Data are currently not adequate to assess trends in the annual number of nests for this subpopulation; and

(5) Greater Caribbean (Mexico through French Guiana, the Bahamas, Lesser and Greater Antilles). This is the third largest subpopulation within the Northwest Atlantic population, with the majority of nesting at Quintana Roo, Mexico. TEWG (2009) reported a greater than 5 percent annual decline in loggerhead nesting from 1995–2006 at Quintana Roo.

In the northeastern Atlantic, the Cape Verde Islands support the only large nesting population of loggerheads in the region (Fretey 2001). Nesting occurs at some level on most of the islands in the archipelago with the largest nesting numbers reported from Boa Vista Island where 833 and 1,917 nests were reported in 2001 and 2002, respectively, and between 1998 and 2002 the local project had tagged 2,856 females (Cruz et al. 2007). More recently, in 2005, about 3,121 females were reported (López-Jurado et al. 2003). Elsewhere in the northeastern Atlantic, loggerhead nesting is non-existent or occurs at very low levels. Population trends could not be determined for the Cape Verde population because of limited data; however, evidence of directed killing of nesting females suggests that this nesting population is under severe pressure and likely significantly reduced from historic levels. Available evidence indicates that this population is declining due to ongoing mortality of mature females and eggs, low hatchling and emergence success and mortality of juveniles and adults from fishery bycatch.

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

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

Diving and Social Behavior

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

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

Vocalizations and Hearing

The information on loggerhead turtle hearing is very limited. Bartol et al. (1999) studied the auditory evoked potential of loggerhead sea turtles that had been captured in pound nets in tributaries to the Chesapeake Bay in Maryland and Virginia and concluded that loggerhead sea turtles had most sensitive hearing between 250 and 1000 Hz, with rapid decline above 1000 Hz (Bartol et al. 1999). This is similar to the results produced by Ridgway et al. (1969) who studied the auditory evoked potentials of three green sea turtles (in air and through mechanical stimulation of the ear). They concluded that the maximum sensitivity of green sea turtles occurred from 300 to 400 Hz with rapid declines for tones at lower and higher frequencies. They reported an upper limit for cochlear potentials without injury of 2000 Hz and a practical limit of about 1000 Hz.

These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

4 Environmental Baseline

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

A number of human activities have contributed to the current status of sperm whales and sea turtles in the Action Area. In addition to being a biologically important area, the Action Area has a history of established economic activities and continues to be used for oil, gas, and mineral development; maritime vessel traffic; and recreational and commercial fisheries. These and other activities may affect listed species in the Action Area. The following information summarizes the principal natural and human phenomena in the Panama City area of the northern Gulf of Mexico that are believed to potentially affect the survival and recovery of these species in the wild.

4.1 Natural Mortality

For the Environmental Baseline, we assume that the same sources of natural mortality for each species within the action area are similar to those sources across the range of the species, as identified in the Status of Listed Resources section. These include natural mortality resulting from parasites, predation and exposure to biotoxins. For example, the giant spirurid nematode (*Crassicauda boopis*) has been attributed to congestive kidney failure and death in some large whale species (Lambertsen 1986). However, the rates at which natural mortality occur in cetaceans, especially large whale species, are largely unknown. Other natural events, such as fluctuations in sea surface temperatures and severe weather affecting prey availability, may also contribute to large whale and sea turtle natural mortality.

4.2 Climate Change

Global climate patterns have a natural year-to-year variability; however, a global warming trend has become apparent based on observations of average air and sea surface temperatures, losses of ice and snow and rising average sea level. This warming trend has varying effects on ecosystems at the regional climate level such as that which affects the Gulf of Mexico. Observational evidence from all continents and most oceans shows that many ecosystems are being affected by regional climate changes due to global climate change, particularly temperature increases (IPCC 2007).

Twilley et al. (2001) used two climate scenarios with each predicting warmer temperatures (3° F to 7° F throughout the Gulf in summer and 5° F in the eastern Gulf and as much as 10° F in the western Gulf in the winter). Although global climate change models have predicted an increase in sea-level of 8 to 20 inches along the Gulf Coast over the next 100 years, regional characteristics including the Gulf's flat topography, regional land subsidence, extensive shoreline development, and vulnerability to major storms suggests a more dramatic sea-level increase of

15 inches along most of the Gulf Coast to as much as 44 inches along the Louisiana/Mississippi Delta (Twilley et al. 2001). Since 2001, the Intergovernmental Panel on Climate Change (IPCC 2007) has estimated that sea surface temperatures are warming at a much faster rate than earlier predicted. The 100 year linear warming trend from 1901-2000 was 0.6°C (0.4 to 0.8°C) as compared to the trend from 1906-2005 of 0.74°C (0.56 to 0.92°C). Based on the more recent trend analyses the climate scenarios presented by Twilley et al. (2001) may be underestimates.

Changes in air and sea surface temperatures affect the marine environment in several ways. Variations in sea surface temperature can affect an ecological community's composition and structure, alter migration and breeding patterns of fauna and flora and change the frequency and intensity of extreme weather events. Over the long term, increases in sea surface temperature also can reduce the amount of nutrients supplied to surface waters from the deep sea leading to declines in fish populations, and, therefore, declines in those species whose diets are dominated by fish.

Climatic variability is thought to possibly result in populations of cetaceans relocating from areas they currently use in response to changes in oceanic conditions (MacLeod 2009; MacLeod et al. 2005), or sea turtles expanding their range as temperature-dependent distribution limits change (McMahon and Hays 2006). Pike et al. (2006) concluded that warming sea surface temperatures may lead to potential fitness consequences in sea turtles resulting from altered seasonality and duration of nesting. Sea turtles will also be affected by loss of historic nesting habitat by elevated sea levels and skewed sex ratios as warming temperatures may lead to the production of female only clutches (Newson et al. 2009). Genetic analyses and behavioral data suggest that populations with temperature-dependent sex determination may be unable to evolve rapidly enough to counteract the negative fitness consequences of rapid global temperature change (Hays 2008 as cited in Newson et al. 2009). However, Hayes et al. (2010) suggests that because of the increased frequency of male loggerhead breeding (based on visits to breeding sites) versus female breeding, the ability of males to breed with many females and the ability of females to store sperm and fertilize many clutches, any skewed sex ratios due to climate change can be compensated for and population effects may be ameliorated. Changes in prey composition (e.g., jellyfish) and diminished prey availability are also possible; however, gaps in information on the movements and distribution of marine species, as well as insufficient historical information, complicate any potential conclusions regarding the effects of climate change (Kintisch 2006). As prey reach their temperature tolerance limits in a warming environment, however, they will either relocate to more favorable conditions, habituate or as individual fitness consequences increase, population consequences may be inevitable.

4.3 Severe Weather

Climate change is expected to affect the intensity of hurricanes through increasing sea surface temperatures, a key factor that influences hurricane formation and behavior (EPA 2010b). The intensity of tropical storms in the Atlantic Ocean, Caribbean, and Gulf of Mexico has risen noticeably over the past 20 years and six of the 10 most active hurricane seasons have occurred

since the mid-1990s (EPA 2010b). On average one third of the named Atlantic storms eventually pass through the Gulf of Mexico. Severe storms such as hurricanes exhibit high winds and a storm surge that can cause extensive habitat degradation (e.g., erosion); as well as mixing of the water column in shallower depths, which can release nutrients and prompt short-lived algal blooms (Valiela et al. 1998).

Predictions of impacts from these storms are especially difficult, and little is known on the effects of hurricanes on listed species in the action area. Valiela et al. (1998) reported that damage to aquatic animals from hurricanes appeared to be minimal. For sea turtles, effects of hurricanes are reported to include destruction of nesting beaches and nests due to inundation or exposure, resulting in transient disturbance of nesting, loss of eggs laid before storms, and inability of hatchlings to reach the surf (Milton et al. 1994; Ross 2005). However, Ross (2005) reported that in one study adult fecundity, nesting periodicity, and nest site location were not changed and adult mortality was negligible following a hurricane in the Indian Ocean. The effects of recent hurricanes in the Gulf of Mexico on sea turtle population numbers and trends are not yet known although (Milton et al. 1994) reported high levels of sea turtles killed and nests lost due to Hurricane Andrew in 1992.

4.4 Habitat Degradation

Habitat degradation can occur due to a number of activities that directly or indirectly impact the action area for this consultation. These activities include water pollution/contaminants, oil and gas activities, ocean noise, and marine dredging and construction as discussed below.

The northern Gulf of Mexico is heavily influenced by freshwater input, nutrient and pesticide run-off and other pollutants from the Mississippi-Atchafalaya River Basin. Parts or all of 31 states plus two Canadian provinces drain into the Mississippi River, totaling 41% of the contiguous United States and 14% of North America (Brown et al. 2005). The massive influx of nutrients can result in substantial algal blooms that consume available oxygen in the water column, leading to hypoxic or anoxic conditions. Since their discovery in the 1970s hypoxic or "dead zones" have increased in area, duration and frequency throughout the oceans. The largest man-induced dead zone in the U.S. and second in the world only to the Dead Sea occurs in the Northern Gulf of Mexico. This dead zone is distributed across the Louisiana shelf west of the Mississippi River and onto the upper Texas coast, from near shore to as much as 125 km (nm) offshore, and in water depths up to 60 m (Rabalais et al. 2007). Hypoxic conditions have been found in all months of the year, but are most persistent and severe in summer (Turner et al. 2005) (Rabalais et al. 2007). These conditions are correlated with reduced abundance of benthic and demersal organisms, reduced species richness and reduced biomass, and have also been attributed to abandonment of habitat and massive die-offs of organisms that cannot escape to sufficiently oxygenated waters.

4.5 Water Pollution

Coastal runoff and river discharges carry large volumes of petrochemical and other contaminants from agricultural activities, cities and industries into the Gulf of Mexico. The coastal waters of

the Gulf of Mexico have more sites with high contaminant concentrations than other areas of the coastal United States, due to the large number of waste discharge point sources. Although these contaminant concentrations do not likely affect the more pelagic waters of the action area, the species of turtles analyzed in these Opinions travel between nearshore and offshore habitats and may be exposed to and accumulate these contaminants during their life cycles.

An extensive review of environmental contaminants in turtles has been conducted by Meyers-Schöne and Walton (1994); however, most of this information relates to freshwater species. High concentrations of chlorobiphenyls and organochlorine pesticides in the eggs of the freshwater snapping turtle, *Chelydra serpentina*, have been correlated with population effects such as decreased hatching success, increased hatchling deformities and disorientation (Bishop et al. 1994).

Very little is known about baseline levels and physiological effects of environmental contaminants on marine turtle populations (Bishop et al. 1991). There are a few isolated studies on organic contaminants and trace metal accumulation in green and leatherback sea turtles (Aguirre et al. 1994; Davenport et al. 1990). Mckenzie et al. (1999) measured concentrations of chlorobiphenyls and organochlorine pesticides in marine turtle tissues collected from the Mediterranean (Cyprus, Greece) and European Atlantic waters (Scotland) between 1994 and 1996. Omnivorous logger-head turtles had the highest organochlorine contaminant concentrations in all the tissues sampled, including those from green and leatherback turtles. It is thought that dietary preferences were likely to be the main differentiating factor among species. Decreasing lipid contaminant burdens with turtle size were observed in green turtles, most likely attributable to a change in diet with age. Sakai et al. (1995) found the presence of metal residues occurring in loggerhead turtle organs and eggs. More recently, Storelli et al. (1998) analyzed tissues from twelve loggerhead sea turtles stranded along the Adriatic Sea (Italy) and found that characteristically, mercury accumulates in sea turtle livers while cadmium accumulates in their kidneys, as has been reported for other marine organisms like dolphins, seals and porpoises by Law et al. (1991). Keller et al. (2006) found that chronic exposure of sea turtles to organochlorine contaminants (such as PCBs and pesticides) may modulate the immune response in these animals by suppressing innate immunity and enhancing certain lymphocyte activity. Polycyclic aromatic hydrocarbons (PAHs) have been documented to affect embryo development in other turtle species (Van Meter et al. 2006). More research is needed on the short- and long-term health and fecundity effects of chlorobiphenyl, organochlorine, and heavy metal accumulation in sea turtles.

The impacts on these activities are difficult to measure. 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 PAHs) and immunosuppression (De Swart et al. 1996; Ross et al. 1995). Organochlorines are chemicals that tend to bioaccumulate through the food chain, thereby increasing the potential of indirect exposure to a marine mammal via its food source. During pregnancy and nursing,

some of these contaminants can be passed from the mother to developing offspring. Contaminants like organochlorines do not tend to accumulate in significant amounts in invertebrates, but do accumulate in fish and fish-eating animals. Thus, contaminant levels in piscivorous odontocetes have been reported to be one to two orders of magnitude higher compared to planktivorous mysticetes (O'Hara et al. 1999; Oshea and Brownell 1994).

4.6 Oil and Gas Activities

While oil and gas is produced within state waters in the Gulf of Mexico, oil and gas production in offshore areas provide about 30 percent of the total crude oil and 13 percent of the total natural gas produced in the United States. Most of the oil and gas production is confined to the western and central portions of the Northern Gulf. Gulf Coast refiners represent about 43 percent of U.S. refining capacity, and are reliant on tanker shipments for a majority of their crude supply, and both tanker and barge shipments for moving significant volumes of petroleum products (EIA 2010). Oil and gas operations within the Action Area include a number of activities: seismic exploration, drilling and rig removals, vessel traffic and the risk of oil spills.

Oil and gas activities have been increasing in the Gulf of Mexico sparking an increase in deepwater rig activity to supplement decreasing production in other U.S. oil and gas fields (see Table 6). Oil and gas activities already occur in areas inhabited by nesting and foraging sea turtles, however, as oil and gas activities move further offshore into deeper waters, there is an increasing opportunity for overlap between these activities and sperm whales.

Table 6. Oil and gas statistics by water depth as of December 6, 2010 from the U.S. Bureau of Ocean Energy Management, Regulation, and Enforcement 2010.

Water Depth in Meters	Active Leases	Approved Applications to Drill	Active Platforms
0 to 200	2,140	33,710	3,333
201 to 400	138	1,105	21
401 to 800	324	834	10
801 to 1,000	408	506	7
1,001 and above	3,413	1,637	26

Between 1993 and 2007, Federal offshore oil and gas companies throughout the U.S. produced 7.49 billion barrels of oil (crude oil and condensate) and spilled about 47,800 barrels (crude & refined petroleum spills of 1 barrel or greater) (about 1 barrel of petroleum spilled for every 156,000 barrels produced (MMS 2009). Recent numbers of barrels of oil spilled within the Action Area will surpass the 1993 to 2007 nation-wide numbers due to the more recent accidental spills.

Substantial damage to offshore oil platforms in the Gulf occurred as a result of hurricanes Katrina and Rita in August and September of 2005. No major oil spills from offshore platforms were reported although minor sheening was reported (MMS 2006). While considered relatively

rare events, oil spills when they occur can result in acute effects of short duration and limited impact, or they may have long-term population- or ecosystem-level impacts depending on the timing and duration of the spill and the numbers and types of organisms affected (NRC 2003b).

On April 20, 2010, an explosion and fire occurred on the offshore drilling rig Deepwater Horizon, which had been drilling an exploratory well in approximately 5,000 feet of water in the Mississippi Canyon Block 252 about 50 miles (80.5 km) off the Louisiana coast. Before the well was capped on July 15, 2010, scientific teams estimate that approximately 5 million barrels of oil is estimated to have leaked from the oil well (DHJICC 2010a) with about 804, 877 barrels of oil and 1,774.5 million cubic feet of gas recovered from the well. Oil spill response activities continue to occur in the Northern Gulf of Mexico. As of August 10, 2010, the Deepwater Horizon Joint Incident Command Center (DHJICC 2010b) reported:

- Approximately 3,600 vessels are currently responding on site, including skimmers, tugs, barges, and recovery vessels to assist in containment and cleanup efforts—in addition to dozens of aircraft, remotely operated vehicles, and multiple mobile offshore drilling units;
- More than 34.7 million gallons of an oil-water mix have been recovered;
- Approximately 1,84 million gallons of total dispersant have been applied (1.07 million on the surface and 771,000 sub-sea);
- On August 10, 2010, approximately 115 miles of Gulf Coast shoreline is currently experiencing moderate to heavy oil impact (about 104 miles in Louisiana, 9 miles in Mississippi and 2 miles in Florida. Another 244 miles in Louisiana, 90 miles in Mississippi, 63 miles in Alabama and 115 miles in Florida are experiencing light to trace oil impacts. These numbers do not take into account the total miles of shoreline impacted to date; and
- Approximately 39, 885 square miles of Federal waters within the Gulf of Mexico remain closed to fishing due to the possibility of contamination representing about 17 percent of Federal waters.

In addition (NMFS 2010f) reports a number of small cetaceans and sea turtles have been oiled and have succumbed to floating oil in the Action Area (Table 7.). One dead, floating sperm whale was also observed, but the carcass could not be recovered.

In addition to the rescue of live turtles and collection of dead turtles, a number of sea turtle nests and hatchlings from the northern Gulf of Mexico have been relocated to Florida (271 loggerhead, 4 kemp's ridley, and 3 green sea turtle nests and 14,235 loggerhead, 125 kemp's ridley and 316 green sea turtle hatchlings)(NMFS 2010f).

Table 7. Total animals known to be affected by the Deepwater Horizon oil spill as of December, 6, 2010. Data from NMFS website accessed December 6, 2010.

	Live		Dead			Total	Rehabilitated Animals			
	Visibly Oiled	Not Visibly Oiled	Visibly Oiled	Not Visibly Oiled	Pending		Collected	Retained	Died	Released
Dolphins	2	7	4	95	0	108	95	2	4	3
Whales	0	0	0	0	1	1	0	0	0	0
Turtles	456	79	19	319	272	1,145	1,102	37	10	26
Total	**458**	**86**	**23**	**414**	**273**	**1,254**	**1,197**	**39**	**14**	**29**

Crude oil is a complex mixture of organic compounds, including polycyclic aromatic hydrocarbons. Polycyclic aromatic hydrocarbons can bioaccumulate in the food chain depending on the metabolic rate of the organism. In many oil spills, evaporation is the most important process in terms of amount of oil remaining in the water column over time. Oxygen concentrations, nutrients, water temperature, salinity, the physical properties of the oil and the energy level of the environment all play a role in biodegradation rates of oil in water (NRC 2003b; NRC 2005c). A light crude oil such as that spilled from the Deepwater Horizon well can lose up to 75 percent of its initial volume within a few days.

Sperm whales and sea turtles in the action area expend the vast majority of their time underwater but they require contact with the sea surface to breath. At the surface these animals could experience inhalation of toxic fumes from floating oil leading to brain lesions, stress, and disorientation. Transfer of hydrocarbons through the food chain is initiated by single-cell organisms, such as phytoplankton, which are exposed to hydrocarbons primarily through attachment to organic-rich particles, including plankton and detritus and which are ingested by higher trophic levels (i.e., filter feeders, fish, and mammals). The extent of hydrocarbon levels within an organism is controlled by the breakdown rate of the hydrocarbons in the organism after ingestion (NRC 2003b).

The effects of exposure to oil spills on sperm whales and sea turtles in the action area remain unknown, however, we assume that effects described for these species elsewhere would apply within the Gulf of Mexico as well. Geraci (1990) found no conclusive evidence that oil contamination has led to sperm whale mortality, and no adverse effects recorded with any certainty. Some observations indicate possible modification of swimming speed and direction or reduced surface time in oiled waters, but no obvious ill effects were noted (Geraci 1990). For sea turtles, oil spills and the presence of tar in the water can have serious effects on individuals, as sea turtles of all life stages are highly sensitive to chemical contaminations such as oil (NRC 2003b). Oil on the skin and shell of a marine turtle can affect respiration, salt gland functions, digestive and immune systems, and blood chemistry (NRC 2003b). Oil exposure can increase egg mortality and lead to developmental defects, as well as cause direct mortality in hatchlings, juveniles, and adults (NRC 2003b). The ingestion of tar pellets is also a concern for these species. Although major oil spills are relatively rare events, chronic exposure to low levels of oil

may impair a turtle's overall level of fitness and reduce its ability to withstand other stresses in the environment (NOS 2010; NRC 2003b). However, the level of sea turtle exposure to, and thus the effects of, oil spilled in the action area remain largely unknown. Given the numbers of animals affected by the oil spill and that oil was still flowing from the well during the sea turtle nesting season we can only assume that the numbers in Table 6 above are underestimates of the true numbers affected. Natural and other anthropogenic phenomena can hinder recovery of species injured by oil spills (NOS 2010) although our ability to distinguish effects from oil spills versus other factors are difficult and lessens over time.

Dispersants were used on the water's surface as well as at depth during the spill and in limited quantities after the well was capped (200 gallons). Dispersants are comprised of three main components: surfactants, solvents, and additives, and are used to disperse oil on the water's surface into smaller droplets that then sink into the water column. Dispersants are applied to decrease exposure levels of contaminated surface waters to marine life and shorelines but as a consequence can increase the exposure of intertidal and benthic communities to the oil/dispersant mixtures. As some dispersants can degrade into estrogenic compounds, the potential for endocrine disruption in fish is also a concern (Jobling et al. as cited in EPA 2010a).

Amid concerns regarding toxicity and endocrine effects of dispersants, the U.S. Environmental Protection Agency (EPA) conducted a series of tests to determine the toxicity of individual dispersants, whether less toxic alternative dispersants were available for use and whether endocrine disruption was possible from dispersant use (EPA 2010a; EPA 2010c). Test organisms were endemic to the Gulf of Mexico—mysid shrimp (*Americamysis bahia*) and the inland silverside, (*Menidia beryllina*) a small estuarine fish. The tests were conducted on mixtures of Louisiana Sweet Crude Oil and eight dispersant products approved for use by EPA including Corexit 9500A which was used for the Deepwater Horizon spill.

These results confirm that the dispersant used in response to the oil spill in the Gulf, Corexit 9500A, is not distinguishable from other dispersants tested based on the acute toxicity tests for the test species (EPA 2010c). For both the shrimp and the fish species tested all of the dispersants alone were less toxic than the dispersant/oil mixture. These findings agree with information collected by Fingas (Fingas 2008) from literature reviews of oil spill dispersants. Oil alone was found to be more toxic to mysid shrimp than the eight dispersants when tested alone. Oil alone and the dispersant/oil mixture both had similar toxicity to mysid shrimp in all but one alternative dispersant tested. None of the tests for endocrine disruption indicated that dispersants displayed biologically significant endocrine disrupting activity via the pathways tested. EPA (EPA 2010a) reports, however, that there were other routes through which chemicals can cause endocrine disruption, as well as other types of toxicity that were not tested. Tests were not conducted for marine mammals and sea turtles and the effects of the dispersant used are unknown.

In addition to the above mentioned tests, surface water samples collected on August 31, and September 1-2, 2010, along the Gulf coast did not reveal elevated levels of chemicals usually

found in oil or dispersant chemical levels above EPA reporting limits. Sediment samples collected along the Gulf coast on August 25 and 30, and September 1-2, 2010, did not reveal elevated levels of chemicals usually found in oil and sediment samples collected along the Gulf coast on August 30, 2010, did not detect levels of dispersant chemicals above the EPA reporting limit. This information suggests that dispersant use can decrease environmental impact to shorelines and organisms within the water column, however, the long term effects on aquatic life and their ecosystems are largely unknown, particularly as oil/dispersants continue to oil Gulf coast shorelines. Reports of underwater plumes of oil/dispersant mixes suggest that other areas of the Gulf could be affected as oil droplets within the plumes continue to disperse and settle into the sediment.

4.7 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. 1995a).

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 2005b; Richardson et al. 1995b). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003a). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute to sound into the ocean (NRC 2003a). 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 2003a). As of September 13, 2010, approximately 3,600 vessels, including skimmers, tugs, barges, and recovery vessels as well as aircraft are currently assisting in containment and cleanup efforts from the Deepwater Horizon spill. Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995a). 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; Krieger and Wing 1984), but the long-term effects, if any, are unclear or not detectable. Carretta (2001) and Jasny et al. (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate.

Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans (Simmonds and Hutchinson 1996). The Navy estimated that the 60,000 vessels of the world's merchant fleet annually emit low frequency sound into the world's oceans for the equivalent of 21.9 million days, assuming that 80 percent of the merchant ships are at sea at any one time (Navy 2010a). The radiated noise spectrum of merchant ships ranges from 20 to 500 Hz and peaks at approximately 60 Hz. The NRC (NRC 2003a) estimated that the background ocean noise level at 100 Hz has been increasing by about 1.5 dB per decade since the advent of propeller-driven ships. At lower frequencies, the dominant source of this noise is the cumulative effect of ships that are too far away to be heard individually, but because of their great number, contribute substantially to the average noise background.

4.8 U.S. Military Training Activities

The U.S. Navy has conducted and continues to conduct a variety of activities within the Action Area. These activities include air-to-air, air-to-surface, and surface-to-surface and subsurface fleet-training and air force exercises as well as RTD&E activities.

U.S. Air Force conducts training in the Eglin Gulf Test Range in the eastern Gulf of Mexico offshore of Santa Rosa Island eight times annually. These activities were evaluated under the ESA with the conclusion that the U.S. Air Force activities would not result in the take of any listed species and formal consultation is no longer required for the Air Force's proposed action (NMFS 2010e).

NMFS issued a programmatic biological opinion on November 22, 2010, for U.S. Navy activities and MMPA regulations governing the incidental take of Navy activities over a 5-year period for RDT&E activities in the Gulf of Mexico. That biological opinion concluded that activities at the NSWC PCD range were likely to adversely affect listed sperm whales as well as green, hawksbill, Kemp's ridley, leatherback and loggerhead sea turtles, but were not likely to jeopardize the continued existence of any of those species. The programmatic opinion did not exempt take of any listed species.

NMFS issued another biological opinion also on November 22, 2010, for the issuance of MMPA Letters of Authorization for RDT&E activities in the Gulf of Mexico for 2011-2012 activities and concluded that the Navy's activities were likely to adversely affect listed sperm whales as well as green, hawksbill, Kemp's ridley, leatherback and loggerhead sea turtles, but were not likely to jeopardize the continued existence of any of those species. That biological opinion estimated that two sperm whales, two leatherback sea turtles, two loggerhead sea turtles and three hardshell sea turtles of any species of green, hawksbill, Kemp's ridley or loggerhead sea turtle would experience behavioral changes that would qualify as "harassment" as a result of exposure to air operations, surface operations, subsurface operations, sonar operations, electromagnetic operations, laser operations, ordnance operations, and projectile firing over a 1-year period.

On January 16, 2008, NMFS issued a five year programmatic biological opinion on the U.S. Navy's active sonar training (Atlantic Fleet Active Sonar Training) within operational areas

along the U.S. Atlantic seaboard. This biological opinion concluded that the proposed activities are likely to adversely affect but are not likely to jeopardize the continued existence of blue whales, fin whales, humpback whales, North Atlantic right whales, sei whales, sperm whales, green sea turtles, hawksbill sea turtles, leatherback sea turtles, and loggerhead sea turtles.

This Opinion also concluded that the active sonar training activities along the Atlantic Coast of the United States and in the Gulf of Mexico are not likely to result in the destruction or adverse modification of critical habitat that has been designated for endangered or threatened species in the action area.

Two subsequent biological opinions have been issued related to the Atlantic Fleet Active Sonar Training (AFAST) with associated estimates of incidental take of listed species for 2009-2010 (dated January 21, 2009) (NMFS 2009a) and 2010-2011 (dated January 21, 2010) (NMFS 2010a). Each of these Opinions concluded that the Navy's yearly activities were not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of designated critical habitat.

The programmatic opinion did not exempt any take of listed species. The 2010 biological opinion estimated the number of instances in which whales may be exposed to U.S. Navy active sonar training activities along the Atlantic coast and Gulf of Mexico: 881 instances for blue whales; 970 instances for fin whales; 4,622 instances for humpback whales; 733 instances for north Atlantic right whales; 1,163 instances for sei whales; and 10,734 instances for sperm whales. The whales are expected to change their behavioral patterns in response to the Navy's activities. Neither Opinion anticipated the take of sea turtles.

4.9 Deep Water Ambient Noise

Urick (1983) provided a discussion of the ambient noise spectrum expected in the deep ocean. Shipping, seismic activity, and weather are primary causes of deep-water ambient noise. Noise levels between 20 and 500 Hz appear to be dominated by distant shipping noise that usually exceeds wind-related noise. Above 300 Hz, the level of wind-related noise might exceed shipping noise. Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500 to 50,000 Hz. The frequency spectrum and level of ambient noise can be predicted fairly accurately for most deep-water areas based primarily on known shipping traffic density and wind state (wind speed, Beaufort wind force, or sea state) (Urick 1983). For frequencies between 100 and 500 Hz, Urick (1983) has estimated the average deep water ambient noise spectra to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas.

4.10 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.

4.11 Entrapment and Entanglement in Commercial Fishing Gear

Several commercial fisheries operate in the Action Area for this consultation. The fisheries that have the most significant demographic effect on sea turtles are the shrimp trawl fisheries that occur in the Gulf of Mexico (from the Gulf coast of Florida to Texas). Although participants in these fisheries are required to use Turtle Exclusion Devices, which are estimated to reduce the number of sea turtles trawlers capture by as much as 97 percent, each year these fisheries are expected to capture about 185,000 sea turtles and kill about 5,000 of the turtles captured. Loggerhead sea turtles account for most of this total: each of these fisheries are expected to capture about 163,000 loggerhead sea turtles, killing almost 4,000 of them. These are followed by green sea turtles: about 18,700 green sea turtles are expected to be captured each year with more than 500 of them dying as a result of their capture (NMFS 2002).

Portions of the Atlantic pelagic fisheries for swordfish, tuna, shark, and billfish also operate in the Action Area and capture and kill the second highest numbers of sea turtles along the Atlantic coast. These fisheries, which operate in the Gulf of Mexico (as well as off the coasts of South Carolina and Georgia; waters off Florida and southernmost Georgia are closed to the longline component of these fisheries), include purse seine fisheries for tuna, harpoon fisheries for tuna and swordfish, commercial and recreational rod and reel fisheries, gillnet fisheries for shark, driftnet fisheries, pelagic longline fisheries, and bottom longline fisheries.

Between 1986 and 1995, this fishery captured and killed 1 north Atlantic right whale, 2 humpback whales, and two sperm whales. Between 1992 and 1998, the longline components of these fisheries are estimated to have captured more than 10,000 sea turtles (4,585 leatherback sea turtles and 5,280 loggerhead sea turtles), killing 168 of these sea turtles in the process (the latter estimate does not include sea turtles that might have died after being released) (Johnson et al. 1999; Yeung 1999). Since then, all components of these fisheries are estimated to capture about 1,350 sea turtles each year, killing 345 sea turtles in the process.

In addition, sea turtles are captured and killed in several other Federal fisheries that operate along the Atlantic coast and Gulf of Mexico (see Table 3), although most of these fisheries capture and kill fewer sea turtles than the fisheries discussed in the preceding narratives. Of all the factors that influenced NMFS' decision to list sea turtles as threatened or endangered, the most significant sources of injury or mortality of juvenile, subadult, and adult sea turtles are those associated with commercial fishing.

The fisheries discussed in this section are expected to continue into the foreseeable future at levels of effort that are roughly equivalent to current levels. As a result, we expect the number of sea turtles that are captured and killed in these fisheries to continue for the foreseeable future. These estimates mean that, every five years, more than 800,000 loggerhead sea turtles would be captured in these fisheries, with more than 23,000 of them dying as a result; about 19,000 leatherback sea turtles would be captured, with about 1,500 of them dying as a result; about

95,000 green sea turtles would be captured, with about 2,900 of them dying; and about 3,200 hawksbill sea turtles would be captured and die.

4.12 Ecotourism

In the Gulf of Mexico, ecotourism activities such as whale watching do not appear to affect listed species within the action area. Tours to see nearshore non-listed marine mammal species, such as dolphins, have occurred for several years and exhibit increasing trends (Würsig et al. 2000). Sperm whales, however, occur further offshore and would require larger vessels to transport people to view them (Würsig et al. 2000). Ecotourism related to sea turtles is not known to occur within the action area.

4.13 Conservation and Management Efforts

A number of conservation and management efforts have a positive effect on listed species in the action area. Recovery plans under the ESA help guide the protection and conservation of listed species, and final plans are in place for green, hawksbill, Kemp's ridley, loggerhead, and leatherback sea turtles; additionally, a final recovery plan was recently issued for the sperm whale. NMFS implements conservation and management activities for these species through its Regional offices and Science Centers in cooperation with states, conservation groups, the public, and other federal agencies. For example, an ESA section 6 agreement with the state of Florida has facilitated funding for the Florida Fish and Wildlife Conservation Commission in support of its research, management, and outreach related to sea turtles; this includes activities within the action area.

There has also been recent extensive work on the movements and habitat use of sperm whales in the northern Gulf of Mexico, such as the studies conducted by the Sperm Whale Acoustic Monitoring Program (SWAMP) and the Sperm Whale Seismic Study (SWSS). These studies include habitat cruises, physical oceanographic analyses, and long term satellite tag deployments. Several satellite tags have operated for over 12 months and indicate movements generally along the shelf break (700-1,000 m depth) throughout the Gulf, with some animals (more frequently males) using deeper oceanic waters (Jochens et al. 2008; Jochens et al. 2006; Jochens and Biggs. 2004). Some data from satellite tag deployments also report large-scale movements of individual sperm whales out of the Gulf of Mexico (Jochens et al. 2008). The ongoing studies continue to provide detailed information on the habitat preferences and population structure of Gulf of Mexico sperm whales.

4.14 Integration of Environmental Baseline

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.

Several of the activities described in this *Environmental Baseline* have had significant and adverse consequences for nesting aggregations of sea turtles that occur in the Action Area. In particular, the commercial fisheries that have been described have captured substantial numbers of green, hawksbill, leatherback, and loggerhead sea turtles each year.

Although only small percentages of these sea turtles are estimated to have died as a result of their capture, the actual number of sea turtles that are estimated to have died in these fisheries each year for the past 5 to 10 years (or longer) still amounts to about 6,000 sea turtles each year. When we add the percentage of sea turtles that have suffered injuries or handling stress sufficient to have caused them to delay the age at which they reach maturity or the frequency at which they return to nesting beaches, the consequences of these fisheries on nesting aggregations of sea turtles would be greater than we have estimated.

Given that we are certain that nest counts of species like loggerhead sea turtles have been declining and are currently declining, these additional mortalities seem likely to increase the rate at which nesting aggregations of this species are declining. Even if these mortalities did not increase the rate at which these nesting aggregations are declining, merely continuing the rate at which they are currently declining would be sufficient to increase the probability of nest counts in these nesting aggregations to decline to zero. Because we know that populations of sea turtles cannot increase over time if the number of nest counts decline, the mortalities associated with these fisheries are likely to increase probability of these populations of sea turtles becoming extinct in the wild.

Historically, commercial whaling had occurred in the action area and had caused all of the large whales to decline to the point where the whales faced risks of extinction that were high enough to list them as endangered species. Since the end of commercial whaling, the primary threat to these species has been eliminated. However, all of the whale species have not recovered from those historic declines and scientists cannot determine if those initial declines continue to influence current populations of most large whale species. The relationship between the historic declines and stressors in the marine environment that may keep sperm whales populations depressed are unknown. Relationships between potential stressors in the marine environments and the responses of these species that may keep their populations depressed are unknown.

Recent attention has focused on the emergence of a wide number of anthropogenic sound sources in the action area and their role as a pollutant in the marine environment. Relationships between specific sound sources, or anthropogenic sound generally, and the responses of marine mammals to those sources are still subject to extensive scientific research and public inquiry but no clear patterns have emerged. As a result, the potential consequences of these activities on threatened and endangered marine mammals remain uncertain.

Listed resources, when exposed to individual stressors or a combination of stressors that are associated with a specific action may suffer insignificant or minor consequences when considered in isolation, but may suffer significant adverse consequences when stressors are

added to other stressors, operate synergistically in combination with other stressors, or magnify or multiply the effects of other stressors.

The effects of everyday events, natural and anthropogenic stressors on an individual's ability to survive and reproduce will depend on the individual's condition when exposed to these challenges. Disease, nutritional stress, body burdens of toxic chemicals, age and reproductive state, etc., can "accumulate" to have substantial consequences for an organism exposed to a stressor. That is, exposing animals to individual stressors associated with a specific action given the animal's prior condition (reproductive condition, their state of health, and their prior experience) can have additive, synergistic, magnifying, and multiplicative effect and produce significant, adverse consequences that would not occur if the animal's prior condition had been different.

To date, about 1,200 sea turtles have been collected as a result of the Deepwater Horizon oil spill. Thousands of hatchlings have been relocated to Florida waters to insure they do not encounter oil. One dead sperm whale was observed but the cause of death could not be determined. Although reports from U.S. Environmental Protection Agency indicate that shorelines and sediment levels of oil and dispersant are within acceptable limits, it is unclear whether subsurface oil/dispersant plumes remain in the Gulf. The long-term additive, synergistic, magnifying, or multiplicative effect of spilled oil and dispersants and other natural and anthropogenic stressors within the Action Area remain to be determined.

5 Effects of the Proposed Action

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

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 injures or has the significant potential

to injure a marine mammal or marine mammal stock in the wild; or any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered" (Public Law 106-136, 2004). The latter portion of these definitions (that is, "...causing disruption of behavioral patterns including…migration, breathing, nursing, breeding, feeding, or sheltering") is almost identical to the U.S. Fish and Wildlife Service's regulatory definition of harass.

For this Opinion, we define "harassment" similarly: "an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents." We are particularly concerned about changes in animal behavior that is likely to result in animals that fail to feed, fail to breed successfully, or fail to complete their life history because those changes may have adverse consequences for populations of those species.

5.1 Potential Stressors

The U.S. Navy has conducted RDT&E activities in the NSWC PCD Study Area (the Action Area) for decades and the potential stressors listed in the following paragraphs have been associated with those earlier activities. As a result, it is more accurate to say that the U.S. Navy's proposes to continue RDT&E activities in the Action Area and the Permits Division proposes to authorize the "take" of marine mammals associated with those RDT&E activities. By extension, the potential stressors associated with the Navy's proposal are stressors that have occurred previously in the Action Area as well. The potential stressors are:

1. The risk of disturbance or collisions associated with proximity to the vessels involved in the RDT&E activities.
2. Sound fields produced by the high- and mid-frequency active sonar systems the U.S. Navy would employ during the RDT&E activities;
3. Shock waves and sound fields produced by the underwater detonations the U.S. Navy would employ during the RD&E activities; and
4. Projectiles associated with firing operations.

Each potential stressor is discussed in greater detail below, followed, by the results of our exposure analyses, which are designed to determine whether endangered or threatened individuals or designated critical habitats are likely to be exposed to one or more of these potential stressors, along with the results of our response analyses. Because direct or indirect exposure to a stressor is a necessary condition for an effect, if endangered or threatened individuals are not likely to be exposed to a potential stressor, that "potential stressor" is not likely to be an actual stressor so we would drop it from further discussion. The effects analyses conclude with an Integration and Synthesis section which contains the results of our risk analyses.

5.1.1 Surface Vessel Traffic

The RDT&E activities the U.S. Navy proposes to conduct in the NSWC PCD Study Area, involve about 7,220 hours of activity from surface vessels (see Table 1). Vessel traffic associated with the proposed training exercises actually represents a suite of stressors or stress regimes that pose several potential hazards to endangered and threatened species along the Gulf of Mexico. First, the size and speed of these surface vessels pose some probability of collisions between marine mammals and sea turtles. Second, this amount of traffic represents an acute or chronic source of disturbance to marine animals along the Gulf of Mexico, although it is not clear what environmental cue marine animals might respond to: the sounds of waters being displaced by the ships, the sounds of the ships' engines, or a combination of environmental cues surface vessels produce while they transit.

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

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

Disturbance. Studies of interactions between surface vessels and marine mammals have demonstrated that surface vessels represent a source of acute and chronic disturbance for marine mammals (Au and Perryman 1982; Bain et al. 2006; Bauer 1986; Bejder et al. 1999; Bejder et al. 2006a; Bejder et al. 2006b; Bryant et al. 1984; Corkeron 1995; Erbe 2000; Felix 2001; Goodwin and Cotton 2004; Hewitt 1985; Lemon et al. 2008; Lemon et al. 2006; Lusseau 2000; Lusseau 2003; Lusseau 2006; Lusseau and Bejder. 2007; Magalhaes et al. 2002; Ng and Leung 2003; Nowacek et al. 2001; Richter et al. 2006; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005; Watkins 1986a; Williams and Ashe 2007; Williams and Ashe. 2006a; Williams and Ashe. 2006b; Williams et al. 2002; Wursig et al. 1998). Specifically, in some circumstances, marine mammals respond to vessels with the same behavioral repertoire and tactics they employ when they encounter predators.

These studies establish that free-ranging cetaceans engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical

presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Goodwin and Cotton. 2004; Lusseau 2006). Several authors, however, suggest that the noise generated by the vessels is probably an important contributing factor to the responses of cetaceans to the vessels (Blane and Jaakson. 1994; Evans et al. 1992; Evans et al. 1994), so we may not be able to treat the effects of vessel traffic as independent of engine and other sounds associated with the vessels.

For surface vessels, the set of variables that help determine whether marine mammals are likely to be disturbed include:

1. *The number of vessels*. The behavioral repertoire marine mammals have used to avoid interactions with surface vessels appears to depend on the number of vessels in their perceptual field (the area within which animals detect acoustic, visual, or other cues) and the animal's assessment of the risks associated with those vessels (the primary index of risk is probably vessel proximity relative to the animal's flight initiation distance). Below a threshold number of vessels (which probably varies from one species to another, although groups of marine mammals probably share sets of patterns), studies have shown that whales will attempt to avoid an interaction using horizontal avoidance behavior. Above that threshold, studies have shown that marine mammals will tend to avoid interactions using vertical avoidance behavior, although some marine mammals will combine horizontal avoidance behavior with vertical avoidance behavior (David 2002; Kruse 1991; Lusseau 2003; Nowacek et al. 2001; Stensland and Berggren. 2007; Williams and Ashe 2007) (see Response Analyses for further discussion);

2. *The distance between vessel and marine mammals* when the animal perceives that an approach has started and during the course of the interaction;

3. *The vessel's speed and vector*;

4. *The predictability of the vessel's path*. That is, whether the vessel stays on a single path or makes continuous course changes;

6. *Any noise associated with the vessel* (particularly engine noise) and the rate at which the engine noise increases (which the animal may treat as evidence of the vessel's speed);

7. *The type of vessel* (displacement versus running on plane), which marine mammals may interpret as evidence of a vessel's maneuverability. Because of the number of vessel hours involved in the proposed RDT&E activities, the speed of those vessels, their use of course changes as a tactical measure, and sounds associated with their engines and displacement of water along their bowline, the available evidence leads us to expect marine mammals to treat Navy vessels as potential stressors, although their perception of these activities would differ substantially from their perception of major training exercises (for example, COMPTUEX, JTFEX, IAC, and SEASWITI) the U.S. Navy conducts along the Atlantic coast.

Much of the increase in ambient noise levels in the oceans over the last 50 years has been attributed to increased shipping, primarily due to the increase in the number and tonnage of ships

throughout the world, as well as the growth and increasing interconnection of the global economy and trade between distant nations (NRC 2003a). Commercial fishing vessels, cruise ships, transport boats, recreational boats, and aircraft, all contribute sound into the ocean (NRC 2003a).

Military vessels underway or involved in naval operations or exercises, also introduce anthropogenic noise into the marine environment.

5.1.2 High-frequency Active Sonar

Most of the active sonar the U.S. Navy proposes to employ during research, development, test, and evaluation in the NSWC PCD Study Area would consist of high-frequency active sonar (1,277 hours versus 77 hours of mid-frequency active sonar; see Table 2.). The high-frequency active sonar systems the U.S. Navy proposes to employ in the NSWC PCD Study Area include towed mine detection sonar (AN/SQQ-32), mine- and object-detection sonar, and navigation sonar (see Table 8.). Center frequencies for these systems range from 20 to 300 kHz with sound pressure levels ranging from 118 dB to 232 dB.

Table 8. Representative active sonar systems the U.S. Navy employs at Naval Surface Warfare Center – Panama City.

Sonar	Description	Frequency Class	In Territorial Waters	Beyond Territorial Waters
AN/SQS-53/56 Kingfisher	Surface ship object detection and navigation sonar (a mode of the AN/SQS-53/56).	Mid-frequency	3	1
AN/SQQ-32	Towed mine detection sonar on surface ships	High frequency	30	1
AN/WLD-1 RMS-ACL	The acoustic communications sonar of the ship-launched Remote Mine-hunting System unmanned underwater vehicle	High frequency	15	0
AN/AQS-20	Helicopter-towed deep-water mine detection sonar	High frequency	545	15
AN/WLD-11 RMS Navigation	Navigation sonar used on the ship-launched Remote Mine-hunting System unmanned underwater vehicle	High frequency	15	0
Sub-bottom profiler (2 to 9 kHz)	A towed body projecting sonar into the seafloor for substrate survey. The center frequency for this system is 4.5 kHz.	Mid-frequency	21	1
Sub-bottom profiler (2 to 16 kHz)	A towed body projecting sonar into the seafloor for substrate survey. The center frequency for this system is 9 kHz.	Mid-frequency	24	1
REMUS SAS-LF	Remote Environmental Measuring Unit (REMUS) used to detect objects with navigation sonar. The center frequency for this system is 15 kHz.	Mid-frequency	12	0
REMUS-SAS-LF	Object detection and navigation sonar on an unmanned underwater vehicle. The center frequency for this system is 25 kHz.	High frequency	20	0
REMUS-SAS-HF	Object detection and navigation sonar on an unmanned underwater vehicle	High frequency	10	25
REMUS Modem	Acoustic communications modem on the REMUS vehicle	Mid-frequency	25	12
SAS-LF	Object detection and navigation sonar. The center frequency for this system is 20 kHz.	High frequency	16.5	10
SAS-HF	Object detection and navigation sonar.	High frequency	11.5	15
BPAUV (sidescan) - 75 kHz	Battlespace Preparation Autonomous Underwater Vehicle sonar, an AUV used for mine detection	High frequency	25	38
BPAUV (sidescan) - 102.5 kHz		High frequency	25	0
BPAUV (sidescan) - 120 kHz		High frequency	30	25
Toroidal Volume Search Sonar (TVSS)	An experimental bottom moored system using toroidal beam-forming	High frequency	15	16.5
F84Y	Tower-mounted parametric sonar used to simulate mine-like objects	High frequency	15	15

5.1.3 Mid-frequency Active Sonar

A small percentage of the active sonar the U.S. Navy proposes to employ during RDT&E activities in the NSWC PCD Study Area would consist of mid-frequency active sonar (see Table 2.). The mid-frequency systems are primarily the AN/SQS-53/56 "Kingfisher" system that is employed for anti-submarine warfare. The "Kingfisher" mode is a modification that provides a surface ship with the ability to detect mine-like objects, and sub-bottom profilers that are used to survey the sea-floor.

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. The duration, rise times, and wave form of sonar transmissions the U.S. Navy would employ during research, development, test, and evaluation are classified; however, the AN/SQS-53/56 "Kingfisher" system has a center frequency of 3.5 kHz, source levels of 235 dB, and pulse lengths of 0.1 second. This sonar system creates acoustic fields that are omnidirectional in azimuth, although AN/SQS-53 also can create beams covering 120° azimuthal sectors that can be swept from side to side during transits (D'Spain et al. 2006). Waveforms of both sonar systems are frequency modulated with continuous waves (D'Spain et al. 2006). We would not expect endangered marine mammals to be exposed to this sonar system, although sea turtles that occur in the ports are likely to be exposed to active sonar from this system.

5.1.4 Ordnance and Line Charges

The U.S. Navy proposes to employ explosive ordnance in the NSWC PCD Study Area (see Table 1), with up to 51 detonations of ordnance weighing between 0.45 and 4.5 kilograms per year and 3 detonations of ordnance weighing between 5 and 34 kilograms per year in territorial waters and 15 detonations of ordnance between 34 and 272 kilograms per year beyond territorial waters. These tests may occur from the surf zone out to the outer perimeter of the NSWC PCD Study Area.

The cumulative effect of a series of explosives can often be estimated by simple addition of the effects of the individual detonations if the detonations are spaced widely in time and space, which would provide marine animals sufficient time to move out of an area affected by an explosion. As a result, we assume that the populations of animals that are exposed to in-water explosions would represent different animals each time.

5.1.5 Projectile Firing

The U.S. Navy proposes to fire 5 in, 20 mm, 40 mm, 76 mm, 25 mm, and small arms ammunitions in the Naval Surface Warfare Center (Table 1). All projectile firing will occur over non-territorial waters.

5.2 Exposure Analysis

As discussed in the *Approach to the Assessment* section of this Opinion, our exposure analyses are designed to determine whether listed resources are likely to co-occur with the direct and indirect beneficial and adverse effects of actions and the nature of that co-occurrence. In this step

of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to one or more of the stressors produced by or associated with an Action and the populations or subpopulations those individuals represent.

As discussed in the *Approach to the Assessment* section of this Opinion, the U.S. Navy, NMFS, and most other entities (for example, oil and gas industries for drilling platforms, geophysics organizations that conduct seismic surveys, etc.) rely on computer models, simulations, or some kind of mathematical algorithm to estimate the number of animals that might be exposed to a sound source. Like all models, these approaches are based on assumptions and are sensitive to those assumptions. Based on our evaluation of assumptions the U.S. Navy incorporates in its models, those models would tend to over-estimate the number of marine mammals that might be exposed to one or more of the research, development, test, and evaluation activities the U.S. Navy proposes to conduct in the NSWC PCD Study Area, from January 2011 through January 2012 because (1) those models assume that marine mammals would not try to avoid being exposed to the sound field associated with active sonar or would not try to avoid continued exposure to the sound field; (2) those models assume that mean densities of marine mammals within any square kilometer area of the study area would be constant over time (that is, the models assume that the probability of marine mammals occurring in any square kilometer area over any time interval is 1.0, when, in fact, the probability would be much smaller than 1.0; this difference would tend to overestimate the number of animals in the action area during shorter time intervals).

5.2.1 Exposure to Vessel Traffic

We did not estimate the number of endangered or threatened species that might be exposed to vessel traffic independent of the number of individuals that might be exposed to active sonar associated with those exercises primarily because data that might have supported such analyses were not available. As a result, we considered the potential risks of vessel traffic on endangered or threatened individuals as part of our analyses of the number of individuals that might be exposed to hull-mounted active sonar and the ship on which the sonar in mounted. Nevertheless, because RDT&E activities involve fewer vessels, have shorter duration, and are much more localized than other naval training activities, fewer endangered and threatened species would be exposed to vessel traffic during RDT&E activities than would be exposed to other naval training activities in the Action Area.

5.2.2 Exposure to Active Sonar

The available empirical information does not allow us to independently estimate the number of marine mammals that might be exposed to high- or mid-frequency active sonar during the RDT&E activities proposed in the NSWC PCD Study Area, from January 2011 through January 2012. The narratives that follow present the results of the U.S. Navy and NMFS' Permits Division model to estimate the number of marine mammals that might be "taken" (as that term is defined pursuant to the MMPA),during active sonar research, development, test, and evaluation activities. The Permits Division proposes to authorize this level of take in each annual LOA.

MITIGATION MEASURES TO MINIMIZE THE LIKELIHOOD OF EXPOSURE TO MID-FREQUENCY ACTIVE SONAR. The Navy proposes to implement a suite of mitigation measures to prevent marine mammals from being exposed to mid-frequency active sonar at high received levels. As discussed in the *Description of the Proposed Action*, these measures are centered on safety zones that trigger reductions in maximum transmission levels depending on the proximity of one or more marine mammals to surface vessels that might be transmitting active sonar or preparing to transmit.

Other measures the U.S. Navy proposes to implement rely primarily on Navy marine species observers, helicopter pilots, and other Navy assets detecting marine mammals visually so that the Navy can take the appropriate action. To the degree that the Navy detects marine mammals visually, these safety zones might reduce the number of marine mammals that are exposed to mid-frequency active sonar or the intensity of their exposure. However, the effectiveness of visual monitoring is greatest in daylight hours, and declines at night and during poor weather conditions (JNCC 2004). In line transect surveys, the range of effective visual sighting (the distance from the ship's track or the *effective strip width*) varies with an animal's size, group size, reliability of conspicuous behaviors (blows), pattern of surfacing behavior, and positions of the observers (which includes the observer's height above the water surface). For most large baleen whales, effective strip width can be about 3 km (1.6 nm) up through Beaufort 6 (Buckland and Borchers. 1993). For harbor porpoises the effective strip width is about 250 m (273 yd), because they are much smaller and less demonstrative on the surface than baleen whales (Palka 1996).

The percentage of marine animals Navy personnel would not detect, either because they would pass unseen below the surface or because they would not be seen at or near the ocean surface, is difficult to determine. However, for minke whales, Schweder et al. (1992) estimated that visual survey crews did not detect about half of the animals in a strip width. Palka (1996) and Barlow (1988) estimated that visual survey teams did not detect about 25 percent of the harbor porpoises in a strip width. The available information leads us to conclude that the combinations of safety zones triggered by visual observations would still allow most marine mammals and sea turtles to be exposed to mid-frequency active sonar transmissions because most marine animals will not be detected at the ocean's surface.

5.2.3 Exposure Estimates

Previously, the U.S. Navy updated the approach it used to estimate the number of marine mammals that might be exposed to active sonar during RDT&E activities in the NSWC PCD Study Area from January 2011 through January 2012. What follows is a brief summary of the Navy's current approach, for more details, refer to Appendix M of the U.S. Navy's Draft EIS/OEIS (Navy 2009).

The U.S. Navy's updated approach focuses on a suite of representative provinces based on sound velocity profiles, bathymetries, and bottom types. Within each of these provinces, the U.S. Navy modeled transmission losses in 5 meter increments and used the results to build sound fields

(based on maximum sound pressure levels). The U.S. Navy then calculates an impact volume, which is the volume of water in which an acoustic metric exceeds a specified threshold; in this case, the possible metrics are energy flux density (in a limited band or across a full band), peak pressure, or positive impulse. By multiplying impact volumes with estimates of animal densities in three dimensions (densities distributed by area and depth), the U.S. Navy estimated the expected number of animals that might be exposed to an acoustic metric (energy flux density, peak pressure, or positive impulse) at levels that exceed specified thresholds. Specifically, the U.S. Navy calculated impact volumes for sonar operations (using energy flux density to estimate the probability of injury), peak pressure, and a Goertner modified positive impulse (for onset of slight lung injury associated with explosions).

To calculate impact volumes, the U.S. Navy used a "risk continuum" (a curve that related the probability of a behavioral response given exposure to a received level that is generally represented by sound pressure level, but included sound exposure level to deal with threshold shifts) that the U.S. Navy and NMFS developed to this area then multiplied that area by a vector that represented the densities of the different species of marine animals that are expected to occur on the Naval Surface Warfare. The risk continuum, which the U.S. Navy adapted from a mathematical model developed by Feller (1968) (Navy 2009), was estimated using three data sources: data from controlled experiments conducted at the U.S. Navy's Space and Naval Warfare Systems Center in San Diego, California (Finneran 2003; Finneran et al. 2001; Finneran et al. 2005; Finneran and Schlundt. 2004; Schlundt et al. 2000a), data from a reconstruction of an incident in which killer whales were probably exposed to mid-frequency active sonar (Fromme 2004), and a suite of studies of the response of baleen whales to low-frequency sound sources (Nowacek et al. 2004a).

This approach to estimating the number of endangered and threatened marine mammals that might be "taken" as a result of being exposed to active sonar produced the following results:

SPERM WHALES. Based on the U.S. Navy's exposure models, over the 12-month period between January 2011 and January 2012, we would expect 2 instances in which sperm whales might be exposed to active sonar during RDT&E activities the U.S. Navy proposes to conduct in the NSWC PCD Study Area and experience behavioral changes that would be sufficient to constitute "take" (as that term is defined for the purposes of the MMPA) as a result of that exposure.

We would also expect another instance in which one sperm whale might be exposed to sound pressure waves associated with underwater detonations and experience behavioral changes that would be sufficient to constitute "take" (as that term is defined for the purposes of the MMPA) as a result of that exposure.

Because of the protocols that the U.S. Navy plans to employ before explosive detonations, the short temporal duration of the shock wave produced by detonations and projectiles, and the relatively small geographic area in which shock waves would be expected to occur, we would not expect sperm whales to co-occur with shock waves associated with underwater detonations

or projectiles produced by the activities the U.S. Navy plans to conduct in the NSWC PCD Study Area. As a result, we would not expect sperm whales to be exposed to these shock waves.

The sperm whales that are likely to be exposed to these stressors would be individuals from the Gulf of Mexico population, which appears to be a grouping that is geographically and ecologically distinct from the sperm whales that occur in the North Atlantic Ocean. They might represent any age or gender.

SEA TURTLES. Based on the U.S. Navy's exposure models, unspecified hardshell sea turtles (green, hawksbill, Kemp's ridley, or loggerhead sea turtles) are likely to be exposed to underwater detonations and detonations associated with line charges as a result of the RDT&E activities the U.S. Navy proposes to conduct in the NSWC PCD Study Area, but sea turtles are not likely to be exposed to high- or mid-frequency active sonar as a result of those activities. Specifically, over the 12-month period between January 2011 and January 2012, we would expect 1 instance in which unspecified hardshell sea turtles might be exposed to sound pressure waves associated with underwater detonations in territorial waters and a second instance in which unspecified hardshell sea turtles might be exposed to underwater detonations in non-territorial waters and experience temporary, noise-induced losses of hearing sensitivity (temporary threshold shifts) as a result of that exposure. In a third instance, unspecified hardshell sea turtles might be exposed to detonations associated with line charges in territorial waters and experience temporary, noise-induced losses of hearing sensitivity as a result of that exposure.

In addition, over the 12-month period between January 2011 and January 2012, we would expect 1 instance in which leatherback sea turtles might be exposed to sound pressure waves associated with underwater detonations in territorial waters and a second instance in which leatherback sea turtles might be exposed to underwater detonations in non-territorial waters and experience temporary, noise-induced losses of hearing sensitivity (temporary threshold shifts) as a result of that exposure. Because of the protocols the U.S. Navy plans to employ before detonations associated with line charges, the short temporal duration of the shock wave produced by those detonations, and the relatively small geographic area in which shock waves would be expected to occur, we would not expect leatherback sea turtles to co-occur with shock waves associated with underwater detonations or projectiles produced by the activities the U.S. Navy plans to conduct in the NSWC PCD Study Area. As a result, we would not expect leatherback sea turtles to be exposed to these shock waves.

We would also expect one (1) instance in which loggerhead sea turtles might be exposed to sound pressure waves associated with underwater detonations in territorial waters and a second instance in which loggerhead sea turtles might be exposed to underwater detonations in non-territorial waters and experience temporary, noise-induced losses of hearing sensitivity (temporary threshold shifts) as a result of that exposure. In a third instance, one loggerhead sea turtle might be exposed to detonations associated with line charges in territorial waters and experience temporary, noise-induced losses of hearing sensitivity as a result of that exposure. Because the U.S. Navy does not plan to detonate line charges in the surf zone within 5 km (3 mi)

of a turtle nesting site within 24 hours of any turtle nest hatching on U.S. Air Force property, we assume that sea turtles exposed to detonations associated with line charges would either be eggs in nests or a hatchling that has entered the water.

Finally, over the 12-month period between January 2011 and January 2012, we would expect 1 instance in which one leatherback sea turtle and 1 instance in which one loggerhead sea turtle might be exposed to detonations associated with 5-inch projectiles and experience temporary, noise-induced losses of hearing sensitivity (temporary threshold shifts) as a result of that exposure.

5.3 Response Analyses

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

It is important to begin these analyses by stating that, to the best of our knowledge, with the exception of the limited data from the U.S.S. *Shoup* incident in Puget Sound, no data are available from actual exposures of endangered or threatened marine mammals to mid-frequency active sonar transmissions produced by U.S. Navy vessels so we do not know if the responses of marine mammals to other mid-frequency active sources are representative of their responses to the waveforms the U.S. Navy actually employs. We are aware of the studies of the behavioral responses of cetaceans exposed to mid-frequency active sonar that are being conducted at the U.S. Navy's instrumented training range in the Bahamas (the AUTEC range) and the recent field work completed off southern California (SoCal-10); however, those studies are still ongoing and no published, peer-reviewed data from them are available at the time of this writing. We are also aware of and have cited initial data available from controlled exposure experiments that are being conducted on free-ranging herring and killer whales by the Norwegian Defense Ministry (Kvadsheim et al. 2007). We we will incorporate additional information from those studies as information becomes available.

Without empirical information on the actual responses of endangered and threatened species to mid-frequency active sonar, we reviewed the best scientific and commercial data available to assess the probable responses of endangered and threatened species to mid-frequency active sonar. In the narratives that follow this introduction, we summarize the best scientific and commercial data on the responses of marine animals to mid-frequency active sonar. Then we use that information to make inferences about the probable responses of the endangered and threatened we are considering in this Opinion.

5.3.1 Potential Responses of Listed Species to Vessel Traffic

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Lusseau 2006). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson. 1994; Evans et al. 1992; Evans et al. 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

As we discussed previously, based on the suite of studies of cetacean behavior to vessel approaches (Au and Perryman 1982; Bain et al. 2006; Bauer 1986; Bejder et al. 1999; Bejder et al. 2006a; Bejder et al. 2006b; Bryant et al. 1984; Corkeron 1995; Erbe 2000; Felix 2001; Goodwin and Cotton 2004; Hewitt 1985; Lemon et al. 2008; Lemon et al. 2006; Lusseau 2000; Lusseau 2003; Lusseau 2006; Lusseau and Bejder. 2007; Magalhaes et al. 2002; Ng and Leung 2003; Nowacek et al. 2001; Richter et al. 2006; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005; Watkins 1986b; Williams and Ashe 2007; Williams and Ashe. 2006a; Williams and Ashe. 2006b; Williams et al. 2002; Wursig et al. 1998), the set of variables that help determine whether marine mammals are likely to be disturbed by surface vessels include:

1. *number of vessels*. The behavioral repertoire marine mammals have used to avoid interactions with surface vessels appears to depend on the number of vessels in their perceptual field (the area within which animals detect acoustic, visual, or other cues) and the animal's assessment of the risks associated with those vessels (the primary index of risk is probably vessel proximity relative to the animal's flight initiation distance).

Below a threshold number of vessels (which probably varies from one species to another, although groups of marine mammals probably share sets of patterns), studies have shown that whales will attempt to avoid an interaction using horizontal avoidance behavior[2]. Above that threshold, studies have shown that marine mammals will tend to avoid interactions using vertical avoidance behavior, although some marine mammals will combine horizontal avoidance behavior with vertical avoidance behavior (Bryant et al. 1984; David 2002; Kruse 1991; Lusseau 2003; Nowacek et al. 2001; Stensland and Berggren. 2007; Williams and Ashe 2007);

2. *the distance between vessel and marine mammals* when the animal perceives that an approach has started and during the course of the interaction (Au and Perryman 1982; David 2002; Hewitt 1985; Kruse 1991);

3. *the vessel's speed and vector* (David 2002);

[2] As discussed in the *Approach to the Assessment* section of this Opinion, we distinguish between "avoidance," "evasion," and "escape" using the distinctions proposed by Weihs and Webb (1984): "avoidance" is a shift in position by prey before a potential predator begins an attack; "evasion" is a response by potential prey to a perceived attack from a potential predator; and "escape" is the most acute form of evasive behavior.

4. *the predictability of the vessel's path*. That is, cetaceans are more likely to respond to approaching vessels when vessels stay on a single or predictable path (Acevedo 1991; Angradi et al. 1993; Browning and Harland. 1999; Lusseau 2003; Lusseau 2006; Williams and Ashe. 2006a; Williams et al. 2002) than when it engages in frequent course changes (Evans et al. 1994; Lusseau 2006; Williams et al. 2002);

6. *noise associated with the vessel* (particularly engine noise) and the rate at which the engine noise increases (which the animal may treat as evidence of the vessel's speed; (David 2002); Lusseau 2003; Lusseau 2006);

7. *the type of vessel* (displacement versus planing), which marine mammals may interpret as evidence of a vessel's maneuverability (Goodwin and Cotton 2004);

8. *the behavioral state* of the marine mammals (David 2002); Lusseau 2003; Lusseau 2006; Wursig et al. 1998). For example, Würsig et al. (Wursig et al. 1998) concluded that whales were more likely to engage in avoidance responses when the whales were "milling" or "resting" than during other behavioral states.

Most of the investigations cited earlier reported that animals tended to reduce their visibility at the water's surface and move horizontally away from the source of disturbance or adopt erratic swimming strategies (Corkeron 1995; Lusseau 2003; Lusseau 2004; Lusseau 2005; Nowacek et al. 2001; Van Parijs and Corkeron 2001; Williams et al. 2002). In the process, their dive times increased, vocalizations and jumping were reduced (with the exception of beaked whales), individuals in groups moved closer together, swimming speeds increased, and their direction of travel took them away from the source of disturbance (Baker and Herman 1989; Edds and Macfarlane 1987; Evans et al. 1992; Lutkebohle 1997; Nowacek 1999). Some individuals also dove and remained motionless, waiting until the vessel moved past their location. Most animals finding themselves in confined spaces, such as shallow bays, during vessel approaches tended to move towards more open, deeper waters (Kruse 1991; Stewart et al. 1982). We assume that this movement would give them greater opportunities to avoid or evade vessels as conditions warranted.

Although most of these studies focused on small cetaceans (for example, bottlenose dolphins, spinner dolphins, spotted dolphins, harbor porpoises, beluga whales, and killer whales), studies of large whales have reported similar results for fin and sperm whales (David 2002; Notarbartolo Di Sciara et al. 2002). Baker et al. (1983) reported that humpbacks in Hawai'i responded to vessels at distances of 2 to 4 km. Richardson et al. (1995a) reported that bowhead whales (*Balaena mysticetus*) swam in the opposite direction of approaching seismic vessels at distances between 1 and 4 km and engage in evasive behavior at distances under 1 km. Fin whales also responded to vessels at a distances of about 1 km (Edds and Macfarlane 1987).

Some cetaceans detect the approach of vessels at substantial distances. Finley et al. (1990) reported that beluga whales seemed aware of approaching vessels at distances of 85 km and began to avoid the approach at distances of 45-60 km. Au and Perryman (1982) studied the

behavioral responses of eight schools of spotted and spinner dolphins (*Stenella attenuata* and *S. longirostris*) to an approaching ship (the NOAA vessel *Surveyor*: 91.4 meters, steam-powered turbine, moving at speeds between 11 and 13 knots) in the eastern Pacific Ocean (10°15 N lat., 109°10 W long.). They monitored the response of the dolphin schools to the vessel from a Bell 204 helicopter flying a track line ahead of the ship at an altitude of 366 – 549 meters (they also monitored the effect of the helicopter on dolphin movements and concluded that it had no observable effect on the behavior of the dolphin schools). All of the schools continuously adjusted their direction of swimming by small increments to continuously increase the distance between the school and the ship over time. The animals in the eight schools began to flee from the ship at distances ranging from 0.9 to 6.9 nm. When the ship turned toward a school, the individuals in the school increased their swimming speeds (for example, from 2.8 to 8.4 knots) and engaged in sharp changes in direction.

Hewitt (1985) reported that five of 15 schools of dolphin responded to the approach of one of two ships used in his study and none of four schools of dolphin responded to the approach of the second ship (the first ship was the NOAA vessel *David Jordan Starr*; the second ship was the *Surveyor*). Spotted dolphin and spinner dolphins responded at distances between 0.5 to 2.5 nm and maintained distances of 0.5 to 2.0 nm from the ship while striped dolphins allows much closer approaches. Lemon et al. (2006) reported that bottlenose dolphin began to avoid approaching vessels at distances of about 100 m.

Würsig et al. (1998) studied the behavior of cetaceans in the northern Gulf of Mexico in response to survey vessels and aircraft. They reported that *Kogia* species and beaked whales (ziphiids) showed the strongest avoidance reactions to approaching ships (avoidance reactions in 11 of 13 approaches) while spinner dolphins, Atlantic spotted dolphins, bottlenose dolphins, false killer whales, and killer whales either did not respond or approached the ship (most commonly to ride the bow). Four of 15 sperm whales avoided the ship while the remainder appeared to ignore its approach.

Because of the number of vessels involved in U.S. Navy RDT&E activities, their speed, their use of course changes as a tactical measure, and sounds associated with their engines and displacement of water along their bowline, the available evidence leads us to expect marine mammals to treat Navy vessels as potential stressors. Animals that perceive an approaching potential predator, predatory stimulus, or disturbance stimulus have four behavioral options (see Blumstein 2003; Nonacs and Dill 1990):

a. ignore the disturbance stimulus entirely and continue behaving as if a risk of predation did not exist;

b. alter their behavior in ways that minimize their perceived risk of predation, which generally involves fleeing immediately;

c. change their behavior proportional to increases in their perceived risk of predation which requires them to monitor the behavior of the predator or predatory stimulus while they continue their current activity, or

d. take proportionally greater risks of predation in situations in which they perceive a high gain and proportionally lower risks where gain is lower, which also requires them to monitor the behavior of the predator or disturbance stimulus while they continue their current activity.

The latter two options are energetically costly and reduce benefits associated with the animal's current behavioral state. As a result, animals that detect a predator or predatory stimulus at a greater distance are more likely to flee at a greater distance (see Blumstein 2003; Holmes et al. 1993). Some investigators have argued that short-term avoidance reactions can lead to longer term impacts such as causing marine mammals to avoid an area (Lusseau 2005; Salden 1988a) or alter a population's behavioral budget (Lusseau 2004) which could have biologically significant consequences on the energetic budget and reproductive output of individuals and their populations.

Of the endangered and threatened species that occur along in the Gulf of Mexico, the endangered and threatened sea turtles are most likely to ignore U.S. Navy vessels entirely and continue behaving as if the vessels and any risks associated with those vessels did not exist. Sperm whales might engage in any one of these options.

5.3.2 Potential Responses of Listed Species to Active Sonar

As discussed in the *Approach to the Assessment* section of this Opinion, we conduct response analyses to determine whether and how listed species and designated critical habitat are likely to respond after being exposed to an Action's effects. For the purposes of consultations on activities that involve active sonar or underwater detonations, our assessments try to detect the probability of lethal responses, sensory impairment (permanent and temporary threshold shifts and acoustic masking), physiological responses (particular stress responses), behavioral responses, and social responses that are likely to directly or indirectly reduce the fitness of listed individuals.

Our response analyses consider and weigh all of the evidence available on the response of marine animals upon being exposed to active sonar and probable fitness consequences for the animals that exhibit particular responses or sequence of responses. It is important to acknowledge, however, that there is limited empirical evidence on how endangered or threatened marine animals respond upon being exposed to active sonar and sound pressure waves associated with underwater detonations in natural settings. Therefore, the narratives that follow this introduction summarize the best scientific and commercial data available on the responses of other species to active sonar, sound pressure waves associated with underwater detonations, or other acoustic stimuli. Based on those data, we identify the probable responses of endangered and threatened marine animals to mid-frequency active sonar transmissions.

Figure 2 illustrates the conceptual model we use to assess the potential responses of marine animals when they are exposed to active sonar or sound pressure waves associated with

underwater detonations. The narratives that follow are generally organized around the items listed in the column titled "Proximate Responses by Category" in that Figure. These analyses examine the evidence available to determine if exposing endangered and threatened species to mid-frequency active sonar is likely to cause responses that might reduce the fitness of individuals that might be exposed.

The information that follows is presented as if endangered or threatened marine animals in the Gulf of Mexico would only be exposed to high- or mid-frequency active sonar or sound pressure waves associated with underwater detonations when, in fact, any individuals that occur in the area of a training event would be exposed to multiple potential stressors and would be responding to a wide array of cues from their environment including natural cues from other members of their social group, from predators, and other living organisms. However, the information that is available generally focuses on the physical, physiological, and behavioral responses of marine mammals to one or two stressors or environmental cues rather than the suite of anthropogenic and natural stressors that most free-ranging animals must contend with in their daily existence. We present the information from studies that investigated the responses of animals to one or two stressors, but we remain aware that we might observe very different results if we presented those same animals with the suite of stressors and cues they would encounter in the wild.

5.3.3.1 Physical Damage

For the purposes of this assessment, "injuries" represents physical trauma or damage that is a direct result of an acoustic exposure, regardless of the potential consequences of those injuries to an animal (we distinguish between injuries that result from an acoustic exposure and injuries that result from an animal's behavioral reaction to an acoustic exposure, which is discussed later in this section of the Opinion). Based on the literature available, active sonar might injure marine animals through two mechanisms (see "Box P" in Figure 2): acoustic resonance and noise-induced loss of hearing sensitivity (more commonly-called "threshold shift").

ACOUSTIC RESONANCE. Acoustic resonance results from hydraulic damage in tissues that are filled with gas or air that resonates when exposed to acoustic signals (Box P1 of Figure 2 illustrates the potential consequences of acoustic resonance; see Rommel et al. (2006). Based on studies of lesions in beaked whales that stranded in the Canary Islands and Bahamas associated with exposure to naval exercises that involved sonar, investigators have identified two physiological mechanisms that might explain some of those stranding events: tissue damage resulting from resonance effects (Cudahy and Ellison 2002; Ketten et al. 2004) and tissue damage resulting from "gas and fat embolic syndrome" (Fernández et al. 2005; Jepson et al. 2003; Jepson et al. 2005). Fat and gas embolisms are believed to occur when tissues are supersaturated with dissolved nitrogen gas and diffusion facilitated by bubble-growth is stimulated within those tissues (the bubble growth results in embolisms analogous to the "bends" in human divers).

Cudahy and Ellison (2002) analyzed the potential for resonance from low frequency sonar signals to cause injury and concluded that the expected threshold for *in vivo* (in the living body) tissue damage for underwater sound is on the order of 180 to 190 dB. There is limited direct empirical evidence (beyond Schlundt et al. 2000a) to support a conclusion that 180 dB is "safe" for marine mammals; however, evidence from marine mammal vocalizations suggests that 180 dB is not likely to physically injure marine mammals. For example, Frankel (1994) estimated the source level for singing humpback whales to be between 170 and 175 dB; McDonald et al. (2001) calculated the average source level for blue whale calls as 186 dB, Watkins et al. (1987) found source levels for fin whales up to 186 dB, and Møhl et al. (2000) recorded source levels for sperm whale clicks up to 223 dB_{rms}. Because whales are not likely to communicate at source levels that would damage the tissues of other members of their species, this evidence suggests that these source levels are not likely to damage the tissues of the endangered and threatened species being considered in this consultation.

Crum and Mao (1994) hypothesized that received levels would have to exceed 190 dB in order for there to be the possibility of significant bubble growth due to super-saturation of gases in the blood. Jepson et al. (2003; Jepson et al. 2005) and Fernández et al. (2004; Fernández et al. 2005) concluded that *in vivo* bubble formation, which may be exacerbated by deep, long-duration, repetitive dives may explain why beaked whales appear to be particularly vulnerable to sonar exposures.

Based on the information available, the endangered or threatened marine mammals and sea turtles that we are considering in this Opinion are not likely to experience acoustic resonance. All of the available evidence suggests that this phenomenon poses potential risks to smaller cetaceans like beaked whales rather than the larger cetaceans that have been listed as endangered. Thus far, this phenomenon has not been reported for or associated with sea turtles, perhaps because they do not engage in dive patterns that are similar to those of beaked whales.

NOISE-INDUCED LOSS OF HEARING SENSITIVITY. Noise-induced loss of hearing sensitivity[3] or "threshold shift" refers to an ear's reduced sensitivity to sound following exposure to loud noises; when an ear's sensitivity to sound has been reduced, sounds must be louder for an animal to detect and recognize it. Noise-induced loss of hearing sensitivity is usually represented by the increase in intensity (in decibels) sounds must have to be detected, compared to a metric of normal baseline detection thresholds. Although noise-induced losses in hearing sensitivity rarely affect the entire frequency range an ear might be capable of detecting, only a few investigators have reported the frequency range affected by a hearing loss.

[3] Animals can experience losses in hearing sensitivity through other mechanisms. The processes of aging and several diseases cause some humans to experience permanent losses in their hearing sensitivity. Body burdens of toxic chemicals can also cause animals, including humans, to experience permanent and temporary losses in their hearing sensitiviy (for example, see Mills and Going 1982 and Fechter and Pouyanos 2005).

An animal can experience temporary threshold shift (TTS) or permanent threshold shift (PTS). 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 (Box P2 of Figure 2 illustrates the potential consequences of noise-induced loss in hearing sensitivity).

Although the published body of science literature contains numerous theoretical studies and discussion papers on hearing impairments that can occur with exposure to a strong sound, only a few studies provide empirical information on noise-induced loss in hearing sensitivity in non-human animals. Most of the few studies available have reported the responses of captive animals exposed to sounds in controlled experiments. Schlundt et al.(2000a), see also Finneran et al. (Finneran 2003; 2001) provided a detailed summary of the behavioral responses of trained marine mammals during TTS tests conducted at the Navy's SPAWAR Systems Center with 1-second tones. Schlundt et al. (2000a), reported on eight individual TTS experiments that were conducted in San Diego Bay. Fatiguing stimuli durations were 1 second. Because of the variable ambient noise in the bay, low-level broadband masking noise was used to keep hearing thresholds consistent despite fluctuations in the ambient noise.

Finneran et al. (Finneran 2003; 2001) conducted TTS experiments using 1-second duration tones at 3 kHz. The test method was similar to that of Schlundt et al. except the tests were conducted in a pool with a very low ambient noise level (below 50 dB re 1 $\mu Pa^2/Hz$), and no masking noise was used. The signal was a sinusoidal amplitude modulated tone with a carrier frequency of 12 kHz, modulating frequency of 7 Hz, and SPL of approximately 100 dB re 1 μPa. Two separate experiments were conducted. In the first, fatiguing sound levels were increased from 160 to 201 dB SPL. In the second experiment, fatiguing sound levels between 180 and 200 dB re 1 μPa were randomly presented.

Richardson et al. (1995a) hypothesized that marine mammals within less than 100 meters of a sonar source might be exposed to mid-frequency active sonar transmissions at received levels greater than 205 dB re 1 μPa which might cause TTS. There is no empirical evidence that exposure to active sonar transmissions with this kind of intensity can cause PTS in any marine mammals; instead the probability of PTS has been inferred from studies of TTS (see Richardson et al. 1995a).

More importantly, the data on captive animals and the limited information from free-ranging animals suggests that temporary noise-induced hearing losses do not have direct or indirect effect on the lifetime reproductive success of animals that experience these losses (see Figure 2). Like humans, free-ranging animals might experience short-term impairment in their ability to use their sense of hearing to detect environmental cues about their environment while their ears recover from the temporary loss of hearing sensitivity. Although we could not locate information on whether and how animals that experience noise-induced hearing loss may alter their behavior or the consequences of any altered behavior on the lifetime reproductive success of those

individuals, the limited information available would not lead us to expect temporary losses in hearing sensitivity to incrementally reduce the lifetime reproductive success of animals.

5.3.3.2 Behavioral Responses

When an animal encounters humans or human activities, 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 (Beale and Monaghan 2004b; Frid 2003; Frid and Dill 2002; Gill et al. 2001; Gill and Sutherland 2001; Harrington and Veitch 1992; Lima 1998; Romero 2004). The level of perceived risk may result from a combination of factors that characterize disturbance stimuli, along with factors related to natural predation risk (Papouchis et al. 2001). In response to that perceived threat, animals can experience physiological changes that prepare them for flight or fight responses or they can experience physiological changes with chronic exposure to stressors that have more serious consequences such as interruptions of essential behavioral or physiological events, alteration of an animal's time budget, or some combinations of these responses (Frid and Dill 2002; Romero 2004; Sapolsky 2000; Walker et al. 2005).

The behavioral response of animals to human disturbance have been documented to cause animals to abandon nesting and foraging sites (Sutherland and Crockford 1993), cause animals to increase their activity levels and suffer premature deaths or reduced reproductive success when their energy expenditures exceed their energy budgets (Daan et al. 1996; Feare 1976; Giese 1996; Müllner et al. 2004), or cause animals to experience higher predation rates when they adopt risk-prone foraging or migratory strategies (Frid and Dill 2002).

Based on the evidence available from empirical studies of animal responses to human disturbance, marine animals are likely to exhibit one of several behavioral responses upon being exposed to sonar transmissions: (1) they may engage in horizontal or vertical avoidance behavior to avoid exposure or continued exposure to a sound that is painful, noxious, or that they perceive as threatening (Boxes BR1.1 and BR1.2 of Figure 2); (2) they may engage in evasive behavior to escape exposure or continued exposure to a sound that is painful, noxious, or that they perceive as threatening, which we would assume would be accompanied by acute stress physiology (Box BR1.3 of Figure 2); (3) they may remain continuously vigilant of the source of the acoustic stimulus, which would alter their time budget. That is, during the time they are vigilant, they are not engaged in other behavior (Box BR1.4 of Figure 2); and (4) they may continue their pre-disturbance behavior and cope with the physiological consequences of continued exposure.

Marine animals might experience one of these behavioral responses, they might experience a sequence of several of these behaviors (for example, an animal might continue its pre-disturbance behavior for a period of time, then abandon an area after it experiences the consequences of physiological stress) or one of these behaviors might accompany responses such as permanent or temporary loss in hearing sensitivity. The narratives that follow summarize the information available on these behavioral responses.

BEHAVIORAL AVOIDANCE OF INITIAL EXPOSURES OR CONTINUED EXPOSURE (HORIZONTAL AND VERTICAL AVOIDANCE. As used in this Opinion, behavioral avoidance refers to animals that abandon an area in which active sonar is being used to avoid being exposed to the sonar (regardless of how long it takes them to return), animals that avoid being exposed to the entire sound field produced by active sonar; and animals that avoid being exposed to particular received levels within a sound field produced by active sonar.

Richardson et al. (1995a) noted that avoidance reactions are the most obvious manifestations of disturbance in marine mammals. There are few empirical studies of avoidance responses of free-living cetaceans to mid-frequency sonar. However, Kvadsheim et al. (2007) conducted a controlled exposure experiment in which killer whales (*Orcinus orca*) that had been fitted with D-tags were exposed to mid-frequency active sonar (Source A: a 1.0 s upsweep 209 dB @ 1 - 2 kHz every 10 seconds for 10 minutes; Source B: with a 1.0 s upsweep 197 dB @ 6 - 7 kHz every 10 s for 10 min).

When exposed to Source A, a tagged whale and the group it was traveling with did not appear to avoid the source. When exposed to Source B, the tagged whales along with other whales that had been carousel feeding ceased feeding during the approach of the sonar and moved rapidly away from the source. When exposed to Source B, Kvadsheim and his co-workers reported that a tagged killer whale seemed to try to avoid further exposure to the sound field by immediately swimming away (horizontally) from the source of the sound; by engaging in a series of erratic and frequently deep dives that seem to take it below the sound field; or by swimming away while engaged in a series of erratic and frequently deep dives. Although the sample sizes in this study are too small to support statistical analysis, the behavioral responses of the orcas were consistent with the results of other studies.

Maybaum (Maybaum 1993) conducted sound playback experiments to assess the effects of mid-frequency active sonar on humpback whales in Hawai'ian waters. Specifically, he exposed focal pods to sounds of a 3.3-kHz sonar pulse, a sonar frequency sweep from 3.1 to 3.6 kHz, and a control (blank) tape while monitoring the behavior, movement, and underwater vocalizations. The two types of sonar signals differed in their effects on the humpback whales, the whales exhibited avoidance behavior when exposed to both sounds. The whales responded to the pulse by increasing their distance from the sound source and responded to the frequency sweep by increasing their swimming speeds and track linearity.

In the Caribbean, sperm whales avoided exposure to mid-frequency submarine sonar pulses, in the range 1000 Hz to 10,000 Hz. Blue and fin whales have occasionally been reported in areas ensonified by airgun pulses; however, there have been no systematic analyses of their behavioral reactions to airguns. Sightings by observers on seismic vessels off the United Kingdom suggest that, at times of good sightability, the number of blue, fin, sei, and humpback whales seen when airguns are shooting are similar to the numbers seen when the airguns are not shooting (Stone 1997; 1998; 2000; 2001; 2003a). However, fin and sei whale sighting rates were higher when airguns were shooting, which may result from their tendency to remain at or near the surface at

times of airgun operation (Stone 2003a). The analysis of the combined data from all years indicated that baleen whales stayed farther from airguns during periods of shooting (Stone 2003a). 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 2003b).

Sperm whales responded to military sonar, apparently from a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent and becoming difficult to approach (Watkins et al. 1985b). Brownell (2004) reported the behavioral responses of western gray whales off the northeast coast of Sakhalin Island to sounds produced by seismic activities in that region. In 1997, the gray whales responded to seismic activities by changing their swimming speed and orientation, respiration rates, and distribution in waters around the seismic surveys. In 2001, seismic activities were conducted in a known feeding area of these whales and the whales left the feeding area and moved to areas farther south in the Sea of Okhotsk. They only returned to the feeding are several days after the seismic activities stopped. The potential fitness consequences of displacing these whales, especially mother-calf pairs and "skinny whales," outside of their the normal feeding area is not known; however, gray whales, like other large whales, must gain enough energy during the summer foraging season to last them the entire year. Sounds or other stimuli that cause an animal to abandon a foraging area for several days seem almost certain to disrupt their energetics. This could force them to make trade-offs like delaying their migration south, delaying reproduction, reducing growth, or migrating with reduced energy reserves.

Captive bottlenose dolphins and a beluga whale exhibited changes in behavior when exposed to 1 second pulsed sounds at frequencies similar to those emitted by the multi-beam sonar that is used by geophysical surveys (Ridgway and Carder 1997; Schlundt et al. 2000b), and to shorter broadband pulsed signals (Finneran et al. 2000b; Finneran et al. 2002b). 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. 2000a) (Finneran et al. 2002c). Dolphins exposed to 1-sec intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa rms and belugas did so at received levels of 180 to 196 dB and above. Received levels necessary to elicit such responses to shorter pulses were higher (Finneran et al. 2000b; Finneran et al. 2002b). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran et al. 2002c). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway and Carder 1997; Schlundt et al. 2000a). It is not clear whether or to what degree the responses of captive animals might be representative of the responses of marine animals in the wild. For example, wild cetaceans sometimes avoid sound sources well before they are exposed to received levels such as those used in these experiments. Further, the responses of marine animals in the wild may be more subtle than those described by Ridgway and Carder (1997) and Schlundt et al. (2000a). Richardson et al. (1995b) and Richardson and Wursig (1997) used controlled playback experiments to study the response of bowhead whales in Arctic Alaska. In their studies, bowhead

whales tended to avoid drill ship noise at estimated received levels of 110 to 115 dB and seismic sources at estimated received levels of 110 to 132 dB. Richardson *et al*. (1995a) concluded that some marine mammals would tolerate continuous sound at received levels above 120 dB re 1 μPa for a few hours. These authors concluded that most marine mammals would avoid exposures to received levels of continuous underwater noise greater than 140 dB when source frequencies were in the animal's most sensitive hearing range.

Several authors noted that migrating whales are likely to avoid stationary sound sources by deflecting their course slightly as they approached a source (LGL and Greenridge 1987 in Richardson et al. 1995a). Malme et al. (Malme et al. 1983; 1984) studied the behavioral responses of gray whales (*Eschrictius robustus*) that were migrating along the California coast to various sound sources located in their migration corridor. The whales they studied showed statistically significant responses to four different underwater playbacks of continuous sound at received levels of approximately 120 dB. The sources of the playbacks were typical of a drillship, semisubmersible, drilling platform, and production platform.

Morton et al. (2002) exposed killer whales (*Orcinus orca*) to sounds produced by acoustic harassment devices (devices that were designed to harass harbor seals, source levels were 194 dB at 10 kHz re 1μPa at 1 meter). They concluded that observations of killer whales declined dramatically in the experimental area (Broughton Archipelago) during the time interval the harassment devices had been used (but not before or after the use). Other investigators have concluded that gray whales and humpback whales abandoned some of their coastal habitat in California and Hawai'i, respectively, because of underwater noise associated with extensive vessel traffic (Gard 1974; Reeves 1977; Salden 1988a).

Nowacek et al. (2004a) conducted controlled exposure experiments on North Atlantic right whales using ship noise, social sounds of con-specifics, and an alerting stimulus (frequency modulated tonal signals between 500 Hz and 4.5 kHz). Animals were tagged with acoustic sensors (D-tags) that simultaneously measured movement in three dimensions. Whales reacted strongly to alert signals at received levels of 133-148 dB SPL, mildly to conspecific signals, and not at all to ship sounds or actual vessels. The alert stimulus caused whales to immediately cease foraging behavior and swim rapidly to the surface.

Several studies have demonstrated that cetaceans will avoid human activities such as vessel traffic, introduced sounds in the marine environment, or both. Lusseau (2003) reported that bottlenose dolphins in Doubtful Sound, New Zealand, avoided approaching tour boats by increasing their mean diving interval. Male dolphins began to avoid tour boats before the boats were in visible range, while female dolphins only began to avoid the boats when the boats became intrusive (he attributed the differential responses to differences in energetics: the larger body size of male dolphins would allow them to compensate for the energy costs of the avoidance behavior more than female dolphins). Bejder et al. (2006a) studied the effects of vessel traffic on bottlenose dolphins in Shark Bay, Australia, over three consecutive 4.5-year

periods. They reported that the dolphins avoided the bay when two tour operators began to operate in the bay.

Marine mammals may avoid or abandon an area temporarily during periods of high traffic or noise, returning when the source of the disturbance declines below some threshold (Allen and Read. 2000; Lusseau 2004). Alternatively, they might abandon an area for as long as the disturbance persists. For example, Bryant et al. (1984 in Polefka 2004) reported that gray whales abandoned a calving lagoon in Baja California, Mexico following the initiation of dredging and increase in small vessel traffic. After the noise-producing activities stopped, the cow-calf pairs returned to the lagoon; the investigators did not report the consequences of that avoidance on the gray whales. Gard (1974) and Reeves (1977) reported that underwater noise associated with vessel traffic had caused gray whales to abandon some of their habitat in California for several years. Salden (1988b) suggested that humpback whales avoid some nearshore waters in Hawai'i for the same reason.

As Bejder et al. (2006a) argued, animals that are faced with human disturbance must evaluate the costs and benefits of relocating to alternative locations; those decisions would be influenced by the availability of alternative locations, the distance to the alternative locations, the quality of the resources at the alternative locations, the conditions of the animals faced with the decision, and their ability to cope with or "escape" the disturbance t(citing Beale and Monaghan 2004a; Beale and Monaghan 2004b; Frid and Dill. 2002; Gill and Sutherland 2001; Lima and Dill 1990). When animals shift from one site to an alternative, we should assume that the costs of tolerating a disturbance have exceeded any benefits of remaining in the location they are leaving.

The evidence available suggests that most sperm whales, like other marine mammals, will try to avoid continued exposed to mid-frequency active sonar (or, at least, some components of the sound source), the ships associated with the active sonar, or both. However, the process of avoiding exposures can be costly to marine animals if (a) they are forced to abandon a site that is important to their life history (for example, if they are forced to abandon a feeding or calving area), (b) their flight response disrupts and important life history event (for example, reproduction), or (c) their diving pattern becomes sufficiently erratic, or if they strand or experience higher predation risk during the process of abandoning a site.

The evidence available also suggests that marine mammals might experience more severe consequences if they are compelled to avoid continued exposure to active sonar, but circumstances do not allow them to avoid or "escape" further exposure. At least six circumstances might prevent an animal's from escaping further exposure to mid-frequency active sonar and could produce any of one the following outcomes:

1. when swimming away (an attempted "escape") brings marine mammals into a shallow coastal feature that causes them to strand;

2. they cannot swim away because the exposure occurred in a coastal feature that leaves marine mammals no "escape" route (for example, a coastal embayment or fjord that surrounds them with land on three sides, with the sound field preventing an "escape");
3. they cannot swim away because the marine mammals are exposed to multiple sound fields in a coastal or oceanographic feature that act in concert to prevent their escape;
4. they cannot dive "below" the sound field while swimming away because of shallow depths;
5. to remain "below" the sound field, they must engage in a series of very deep dives with interrupted attempts to swim to the surface (which might lead to pathologies similar to those of decompression sickness);
6. any combination of these phenomena.

Although causal relationships between beaked whale stranding events and active sonar remain unknown, several authors have hypothesized that stranding events involving these species in the Bahama and Canary Islands may have been triggered when the whales changed their dive behavior to avoid exposure to active sonar (Cox et al. 2006; Rommel et al. 2006). These authors proposed two mechanisms by which the behavioral responses of beaked whales upon being exposed to active sonar might result in a stranding event. First, beaked whales that occur in deep waters that are in close proximity to shallow waters, may respond to active sonar by swimming into shallow waters to avoid further exposures and strand if they were not able to swim back to deeper waters.

Second, beaked whales exposed to active sonar might alter their dive behavior (see Boxes BR1.2 and BR1.3 of Figure 2). Changes in their dive behavior might cause them to remain at the surface or at depth for extended periods of time which could lead to hypoxia directly by increasing their oxygen demands or indirectly by increasing their energy expenditures (to remain at depth) and increase their oxygen demands as a result. If beaked whales are at depth when they detect a ping from an active sonar transmission and change their dive profile leading to formation of significant gas bubbles, this could damage multiple organs or interfere with normal physiological function (Cox et al. 2006; Rommel et al. 2006; Zimmer and Tyack 2007).

Because many species of marine mammals make repetitive and prolonged dives to great depths, it has long been assumed that marine mammals have evolved physiological mechanisms to protect against the effects of rapid and repeated decompressions. Although several investigators have identified physiological adaptations that may protection marine mammals against nitrogen gas supersaturation (alveolar collapse and elective circulation; (Kooyman and Ponganis 1998; Ridgway and Howard. 1979)1979), Ridgway and Howard (1979) reported that bottlenose dolphins (*Tursiops truncatus*) that were trained to dive repeatedly had muscle tissues that were substantially supersaturated with nitrogen gas. Houser et al. (2001) used these data to model the accumulation of nitrogen gas within the muscle tissue of other marine mammal species and

concluded that cetaceans that dive deep and have slow ascent or descent speeds would have tissues that are more supersaturated with nitrogen gas than other marine mammals.

Based on these data, Cox et al. (2006) hypothesized that a critical dive sequence might make beaked whales more prone to stranding in response to acoustic exposures. The sequence began with (1) very deep (to depths as deep as 2 kilometers) and long (as long as 90 minutes) foraging dives with (2) relatively slow, controlled ascents, followed by (3) a series of "bounce" dives between 100 and 400 meters in depth (also see Zimmer and Tyack 2007). They concluded that acoustic exposures that disrupted any part of this dive sequence (for example, causing beaked whales to spend more time at surface without the bounce dives that are necessary to recover from the deep dive) could produce excessive levels of nitrogen super-saturation in their tissues, leading to gas bubble and emboli formation that produces pathologies similar to decompression sickness.

If sperm whales respond to a Navy vessel that is transmitting active sonar in the same way that they might respond to a predator, their probability of flight responses should increase when they perceive that Navy vessels are approaching them directly, because a direct approach may convey detection and intent to capture (Burger and Gochfeld 1981. The probability of flight responses should also increase as received levels of active sonar increase (and the ship is, therefore, closer) and as ship speeds increase (that is, as approach speeds increase). For example, the probability of flight responses in Dall's sheep Ovis dalli dalli {Frid, 2003 #209; Frid and Heithaus 2010), ringed seals *Phoca hispida* (Born et al. 1999), Pacific brant (*Branta bernicl nigricans*) and Canada geese (*B. Canadensis*) increased as a helicopter or fixed-wing aircraft approached groups of these animals more directly (Ward et al. 1999). Bald eagles (*Haliaeetus leucocephalus*) perched on trees alongside a river were also more likely to flee from a paddle raft when their perches were closer to the river or were closer to the ground (Steidl and Anthony 1996).

VIGILANCE. Attention is the cognitive process of selectively concentrating on one aspect of an animal's environment while ignoring other things (Posner 1994). Because animals (including humans) have limited cognitive resources, there is a limit to how much sensory information they can process at any time. The phenomenon called "attentional capture" occurs when a stimulus (usually a stimulus that an animal is not concentrating on or attending to) "captures" an animal's attention. This shift in attention can occur consciously or unconsciously (for example, when an animal hears sounds that it associates with the approach of a predator) and the shift in attention can be sudden (Dukas 2002). Once a stimulus has captured an animal's attention, the animal can respond by ignoring the stimulus, assuming a "watch and wait" posture, or treat the stimulus as a disturbance and respond accordingly, which includes scanning for the source of the stimulus or "vigilance" (Cowlishaw et al. 2004).

Vigilance is normally an adaptive behavior that helps animals determine the presence or absence of predators, assess their distance from conspecifics, or to attend cues from prey (Bednekoff and Lima 2002). Despite those benefits, however, vigilance has a cost of time: when animals focus their attention on specific environmental cues, it is not attending to other activities such as

foraging. These costs have been documented best in foraging animals, where vigilance has been shown to substantially reduce feeding rates {Saino, 1994 #1565}(Beauchamp and Livoreil 1997; Fritz et al. 2002).

Animals will spend more time being vigilant, which translates to less time foraging or resting, when disturbance stimuli approach them more directly, remain at closer distances, have a greater group size (for example, multiple surface vessels), or when they co-occur with times that an animal perceives increased risk (for example, when they are giving birth or accompanied by a calf). Most of the published literature, however, suggests that direct approaches will increase the amount of time animals will dedicate to being vigilant. For example, bighorn sheep and Dall's sheep dedicated more time being vigilant, and less time resting or foraging, when aircraft made direct approaches over them (Frid 2003; Stockwell et al. 1991).

Several authors have established that long-term and intense disturbance stimuli can cause population declines by reducing the body condition of individuals that have been disturbed, followed by reduced reproductive success, reduced survival, or both (Daan et al. 1996; Madsen 1985). For example, Madsen (1985) reported that pink-footed geese (*Anser brachyrhynchus*) in undisturbed habitat gained body mass and had about a 46% reproductive success compared with geese in disturbed habitat (being consistently scared off the fields on which they were foraging) which did not gain mass and has a 17% reproductive success. Similar reductions in reproductive success have been reported for mule deer (*Odocoileus hemionus*) disturbed by all-terrain vehicles (Yarmoloy et al. 1988), caribou disturbed by seismic exploration blasts (Bradshaw et al. 1998), caribou disturbed by low-elevation military jet-fights (Luick et al. 1996), and caribou disturbed by low-elevation jet flights (Harrington and Veitch 1992). Similarly, a study of elk (*Cervus elaphus*) that were disturbed experimentally by pedestrians concluded that the ratio of young to mothers was inversely related to disturbance rate (Phillips and Alldredge 2000).

The primary mechanism by which increased vigilance and disturbance appear to affect the fitness of individual animals is by disrupting an animal's time budget and, as a result, reducing the time they might spend foraging and resting (which increases an animal's activity rate and energy demand). For example, a study of grizzly bears (*Ursus horribilis*) reported that bears disturbed by hikers reduced their energy intake by an average of 12 kcal/min (50.2 x 10_3kJ/min), and spent energy fleeing or acting aggressively toward hikers (White et al. 1999).

CONTINUED PRE-DISTURBANCE BEHAVIOR, HABITUATION, OR NO RESPONSE. Under some circumstances, some individuals that are exposed to active sonar transmissions will continue their normal behavioral activities; in other circumstances, individual animals would become aware of the sonar transmissions at lower received levels and move to avoid additional exposure or exposures at higher received levels (Richardson et al. 1995b).

It is difficult to distinguish between animals that continue their pre-disturbance behavior without stress or other physiological responses (such as changes in heart rate, body temperature, and hormonal levels), animals that continue their behavior but experience stress or other physiological responses (that is, animals that cope with disturbance), animals that habituate to

disturbance (that is, they may have experienced low-level stress or other physiological responses initially, but those responses abated over time), and animals that do not respond to the potential disturbance (Bejder et al. 2009). Because stress and other physiological responses usually do not have visible, external indicators and usually are not detectable in free-ranging animals, some investigators mistakenly interpret the absence of observable responses as evidence of habituation.

Watkins (1986a) review of data on the behavioral reactions of fin, humpback, right and minke whales that were exposed to continuous, broadband low-frequency shipping and industrial noise in Cape Cod Bay is informative. He concluded that underwater sound was the primary cause of behavioral reactions in these species of whales and that the whales responded behaviorally to acoustic stimuli within their respective hearing ranges. Watkins also noted that whales showed the strongest behavioral reactions to sounds in the 15 Hz to 28 kHz range, although negative reactions (avoidance, interruptions in vocalizations, etc.) were generally associated with sounds that were either unexpected, too loud, suddenly louder or different, or perceived as being associated with a potential threat (such as an approaching ship on a collision course). In particular, whales seemed to react negatively when they were within 100 m of the source or when received levels increased suddenly in excess of 12 dB relative to ambient sounds. At other times, the whales ignored the source of the signal and all four species habituated to these sounds.

Nevertheless, Watkins (1986b) concluded that whales ignored most sounds in the background of ambient noise, including the sounds from distant human activities even though these sounds may have had considerable energies at frequencies well within the whale's range of hearing. Further, he noted that fin whales were initially the most sensitive of the four species of whales, followed by humpback whales; right whales were the least likely to be disturbed and generally did not react to low-amplitude engine noise. By the end of his period of study, Watkins (1986b) concluded that fin and humpback whales have generally habituated to the continuous, broad-band, noise of Cape Cod Bay while right whales did not appear to change their response.

5.3.3.3 Impaired Communication

Communication is an important component of the daily activity of animals and ultimately contributes to their survival and reproductive success. Animals communicate to find food (Elowson et al. 1991; Marler et al. 1986), acquiring mates (Krakauer et al. 2009; Ryan 1985), assessing other members of their species (Owings et al. 2002; Parker 1974), evading predators (Greig-Smith 1980), and defending resources (Zuberbuhler et al. 1997). Human activities that impair an animal's ability to communicate effectively might have significant effects on the animals experiencing the impairment.

Communication usually involves individual animals that are producing a vocalization or visual or chemical display for other individuals. Masking, which we discuss separately (below), affects animals that are trying to receive acoustic cues in their environment, including vocalizations from other members of the animals' species or social group. However, anthropogenic noise presents separate challenges for animals that are vocalizing. This subsection addresses the

probable responses of individual animals whose attempts to vocalize or communicate are affected by active sonar.

When they vocalize, animals are aware of environmental conditions that affect the "active space" of their vocalizations, which is the maximum area within which their vocalizations can be detected before it drops to the level of ambient noise (Brumm 2004; Lohr et al. 2003). Animals are also aware of environment conditions that affect whether listeners can discriminate and recognize their vocalizations from other sounds, which are more important than detecting a vocalization (Brumm 2004; Patricelli and Blickley 2006).

Most animals that vocalize have evolved with an ability to make vocal adjustments to their vocalizations to increase the signal-to-noise ratio, active space, and recognizability of their vocalizations in the face of temporary changes in background noise (Brumm 2004; Patricelli and Blickley 2006). Vocalizing animals will make one or more of the following adjustments to preserve the active space and recognizability of their vocalizations:

1. Adjust the amplitude of vocalizations (Box BR2.1 of Figure 2). Animals responding in this way increase the amplitude or pitch of their calls and songs by placing more energy into the entire vocalization or, more commonly, shifting the energy into specific portions of the call or song.

This response is called the "Lombard reflex" or "Lombard effect" and represents a short-term adaptation to vocalizations in which a signaler increases the amplitude of its vocalizations in response to an increase in the amplitude of background noise (Lombard 1911). This phenomenon has been studied extensively in humans, who raise the amplitude of the voices while talking or singing in the face of high, background levels of sound (Lombard 1911).

Other species experience the same phenomenon when they vocalize in the presence of high levels of background sound. Brumm et al. (2004) studied the songs of territorial male nightingales (*Luscinia megarhynchos*) in the city of Berlin, Germany, to determine whether and to what degree background noise (from automobile traffic) produced a Lombard effect in these birds. Based on his studies, the birds increased the volume of their songs in response to traffic noise by 14 dB (their songs were more than 5 times louder than birds vocalizing in quiet sites). Cynx et al. (1998) reported similar results based on their study of zebra finches (*Taeniopygia guttata*) exposed to white noise.

Although this type of response also has not been studied extensively in marine animals, Holt et al. (2007) reported that endangered southern resident killer whales (*Orcinus orca*) in Haro Strait off the San Juan Islands in Puget Sound, Washington, increased the amplitude of their social calls in the face of increased sounds levels of background noise.

2. Adjust the frequency structure of vocalizations (Box BR2.2 of Figure 2). Animals responding in this way adjust the frequency structure of their calls and songs by increasing the minimum frequency of their vocalizations while maximum frequencies

remain the same. This reduces the frequency range of their vocalizations and reduces the amount of overlap between their vocalizations and background noise.

Slabbekorn and Ripmeester (2008), Slabbekorn and den Boer-Visser (2006), and Slabbekorn and Peet (2003b) studied patterns of song variation among individual great tits (*Parus major*) in an urban population in Leiden, The Netherlands, and among 20 different urban and forest populations across Europe and the United Kingdom. Adult males of this species that occupied territories with more background noise (primarily traffic noise) sang with higher minimum frequencies than males occupying non-urban or quieter sites. Peak or maximum frequencies of these songs did not shift in the face of high background noise.

3. Adjust temporal structure of vocalizations (Box BR2.3 of Figure 2). Animals responding this way adjust the temporal structure of their vocalizations by changing the timing of modulations, notes, and syllables within vocalizations or increasing the duration of their calls or songs.

Cody and Brown (1969) studied the songs of adult male Bewick wrens and wrentits that occupied overlapping territories and whose songs had similar physical characteristics (similar song lengths, frequency structure, and amplitude). They reported that wrentits adjusted the timing of their songs so they occurred when the songs of the Bewick wrens subsided.

Ficken et al. (1974) studied vocalizations of ten red-eyed vireos (*Vireo olivaceus*) and least flycatchers (*Empidonax minimus*) at Lake Itasca, Minnesota (a total of 2,283 sSongs). They reported that flycatchers avoided acoustic interference from red-eyed vireos by inserting their shorter songs between the longer songs of the vireos. Although there is some mutual avoidance of acoustic interference, the flycatcher tends more strongly to insert its short songs in between the longer songs of the vireo rather than vice versa. Indeed, most of the overlap occurred when the flycatcher began singing just after the vireo had begun, suggesting that the flycatcher had not heard the vireo begin singing.

A few studies have demonstrated that marine mammals make the same kind of vocal adjustments in the face of high levels of background noise. Miller et al. (2000) recorded the vocal behavior of singing humpback whales continuously for several hours using a towed, calibrated hydrophone array. They recorded at least two songs in which the whales were exposed to low-frequency active sonar transmissions (42 second signals at 6 minute intervals; sonar was broadcast so that none of the singing whales were exposed at received levels greater than 150 dB re 1µPa). They followed sixteen singing humpback whales during 18 playbacks. In nine follows, whales sang continuously throughout the playback; in four follows, the whale stopped singing when he joined other whales (a normal social interaction); and in five follows, the singer stopped singing, presumably in response to the playback. Of the six whales whose songs they analyzed in detail, songs were 29% longer, on average, during the playbacks. Song duration returned to normal after exposure, suggesting that the whale's response to the playback was temporary.

Foote et al. (2004) compared recordings of endangered southern resident killer whales that were made in the presence or absence of boat noise in Puget Sound during three time periods between

1977 and 2003. They concluded that the duration of primary calls in the presence of boats increased by about 15% during the last of the three time periods (2001 to 2003). They suggested that the amount of boat noise may have reached a threshold above which the killer whales need to increase the duration of their vocalization to avoid masking by the boat noise.

4. Adjust the temporal delivery of vocalizations (Boxes BR2.4 and BR2.5 of Figure 2). Animals responding in this way change when they vocalize or change the rate at which they repeat calls or songs.

For example, tawny owls (*Strix aluco*) reduce the rate at which they call during rainy conditions (Lengagne and Slater 2002). Brenowitz (1982) concluded that red-winged blackbirds (*Agelaius phoeniceus*) had the largest active space, or broadcast area, for their calls at dawn because of relatively low turbulence and background noise when compared with other times of the day. Brown and Handford (2003) concluded that swamp and white-throated sparrows (*Melospiza georgiana* and *Zonotrichia albicollis*, respectively) tended to sing at dawn, as opposed to other times of the day, because they encountered the fewest impediments to acoustic transmissions during that time of the day.

Many animals will combine several of these strategies to compensate for high levels of background noise. For example, Brumm et al. (2004) reported that common marmosets (*Callithrix jacchus*) increased the median amplitude of the twitter calls as well as the duration of the calls in response to increased background noise. King penguins (*Aptenodytes patagonicus*) increase the number of syllables in a call series and the rate at which they repeat their calls to compensate for high background noise from other penguins in a colony or high winds (Lengagne et al. 1999). California ground squirrels (*Spermophilus beecheyi*) shifted the frequencies of their alarm calls in the face of high ambient noise from highway traffic (Rabin et al. 2003). However, they only shifted the frequency of the second and third harmonic of these alarm calls, without changing the amount of energy in the first harmonic. By emphasizing the higher harmonics, the ground squirrels placed the peak energy of their alarm calls above the frequency range of the masking noise from the highway. Wood and Yezerinac (2006) reported that song sparrows (*Melospiza melodus*) increased the frequency of the lowest notes in their songs and reduced the amplitude of the low frequency range of their songs. Fernandez-Juricic et al. (2005) reported that house finches (*Carpodacus mexicanus*) adopted the same strategy to compensate for background noise.

Although this form of vocal adjustment has not been studied extensively in marine animals, Dahlheim (1987) studied the effects of man-made noise, including ship, outboard engine and oil-drilling sounds, on gray whale calling and surface behaviours in the San Ignacio Lagoon, Baja, California. She reported statistically significant increases in the calling rates of gray whales and changes in calling structure (as well as swimming direction and surface behaviours) after exposure to increased noise levels during playback experiments. Although whale responses varied with the type and presentation of the noise source, she reported that gray whales generally increased their calling rates, the level of calls received, the number of frequency-modulated calls, number of pulses produced per pulsed-call series and call repetition rate as noise levels increased.

Parks and Tyack (2007) reported that surface active groups of North Atlantic right whales would adopt this strategy as the level of ambient noise increased. As ambient noise levels increased from low to high, the minimum frequency of right whale "scream calls" increased from 381.4 Hz (± 16.50), at low levels of ambient noise, to 390.3 Hz (± 15.14) at medium noise levels, to 422.4 Hz (± 15.55) at high noise levels. Surface active groups of North Atlantic right whales would also increase the duration and the inter-call interval of their vocalizations as the level of ambient noise increased. As noise levels increased from low to high, the duration of right whale "scream calls" would increase from 1.18 seconds (± 0.08) at low levels of ambient noise to 1.22 seconds (± 0.08) at high noise levels (durations decreased to 1.11 seconds ± 0.07 at medium noise levels). The inter-call intervals of these vocalizations would increase from 17.9 seconds (± 5.06) at low levels of ambient noise, to 18.5 seconds (± 4.55) at medium noise levels, to 28.1 seconds (± 4.63) at high noise levels.

FITNESS CONSEQUENCES OF VOCAL ADJUSTMENTS. Although the fitness consequences of these vocal adjustments remain unknown, like most other trade-offs animals must make, some of these strategies probably come at a cost (Patricelli and Blickley 2006). For example, vocalizing more loudly in noisy environments may have energetic costs that decrease the net benefits of vocal adjustment and alter the bird's energy budget (Brumm 2004; Wood and Yezerinac 2006). Lambrechts (1996) argued that shifting songs and calls to higher frequencies was also likely to incur energetic costs.

In addition, Patricelli and Blickley (2006) argued that females of many species use the songs and calls of males to determine whether a male is an appropriate potential mate (that is, she must recognize the singer as a member of their species); if males must adjust the frequency or temporal features of their vocalizations to avoid masking by noise, they may no longer be recognized by conspecific females (Brumm 2004; Slabbekoorn and Peet 2003a; Wood and Yezerinac 2006). Although this line of reasoning was developed for bird species, the same line of reasoning should apply to marine mammals, particularly for species like fin and sei whales whose song structures appear to be very similar. However, if an animal fails to make vocal adjustments in the presence of masking noise, that failure might cause the animal to experience reduced reproductive success or longevity because it fails to communicate effectively with other members of its species or social group, including potential mates.

Based on the evidence available, endangered sperm whales may experience impaired communication because they vocalize at frequencies that overlap with those of the high- and mid-frequency active sonar systems the U.S. Navy plans to employ during RDT&E activities in the NSWC PCD Study Area. As a result, we assume that some of the sperm whales that are exposed to active sonar transmissions during one or more of the proposed missions might experience impaired communication as a result of that exposure. To preserve the saliency of their vocalizations, these whales may have to make one or more of the vocal adjustments discussed in this subsection. Because any reductions in the active space of whale vocalizations that result

from active sonar transmissions associated with the proposed missions would be temporary and episodic, vocal adjustments these whales would have to make would also be temporary.

Because the endangered and threatened sea turtles that are considered in this Opinion do not appear to vocalize, they are not likely to experience impaired communication by active sonar transmissions associated with the proposed research, development, test, and evaluation activities the U.S. Navy proposes to conduct.

MASKING. Marine mammals use acoustic signals for a variety of purposes, which differ among species, but include communication between individuals, navigation, foraging, reproduction, and learning about their environment (Erbe and Farmer 2000; Tyack 2000). Masking, or *auditory interference*, generally occurs when sounds in the environment are louder than and of a similar frequency to auditory signals an animal is trying to receive. Masking, therefore, is a phenomenon that affects animals that are trying to receive acoustic information about their environment, including sounds from other members of their species, predators, prey, and sounds that allow them to orient in their environment. Masking these acoustic signals can disturb the behavior of individual animals, groups of animals, or entire populations (Box BR2 of Figure 2 illustrates the potential responses of animals to acoustic masking).

Richardson et al. (1995a) argued that the maximum radius of influence of an industrial noise (including broadband low frequency sound transmission) on a marine mammal is the distance from the source to the point at which the noise can barely be heard. This range is determined by either the hearing sensitivity of the animal or the background noise level present. Industrial masking is most likely to affect some species' ability to detect communication calls and natural sounds (i.e., vocalizations from other members of its species, surf noise, prey noise, etc.; Richardson et al. 1995b).

Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses produced by echosounders and submarine sonar (Watkins 1985; Watkins and Schevill. 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones. 1995). Sperm whales have moved out of areas after the start of air gun seismic testing. 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 1993; Au et al. 1985; Au et al. 1974) indicate that some species may use various processes to reduce masking effects (e.g., adjustments in echolocation call intensity or frequency as a function of background noise conditions). There is

also evidence that the directional hearing abilities of odontocetes are useful in reducing masking at the high frequencies these cetaceans use to echolocate, but not at the low-to-moderate frequencies they use to communication (Zaitseva et al. 1980).

Based on the evidence available, endangered sperm whales might experience acoustic masking because they are high-frequency hearing specialists who attend to environmental cues at frequencies that overlap with those produced by high- or mid-frequency active sonar transmissions. The evidence available leads us to the opposite conclusion for sea turtles because their hearing sensitivities do not overlap with the high- and mid-frequency range of the active sonar the U.S. Navy plans to employ in the NSWC PCD Study Area so those transmissions are not likely to mask sea turtle hearing.

5.3.3.4 Allostasis

Classic stress responses begin when an animal's central nervous system perceives a potential threat to its homeostasis. That threat perception triggers stress responses regardless of whether a stimulus actually threatens the animal; the mere perception of a threat is sufficient to trigger a stress response (Moberg 2000; Sapolsky 2006; Selye 1950). Once an animal's central nervous system perceives a threat, it mounts a biological response or defense that consists of a combination of the four general biological defense responses: behavioral responses, autonomic nervous system responses, neuroendocrine responses, or immune response.

In the case of many stressors, an animal's first and most economical (in terms of biotic costs) response is behavioral avoidance of the potential stressor or avoidance of continued exposure to a stressor (Box S2 of Figure 2). An animal's second line of defense to stressors involves the autonomic nervous system and the classical "fight or flight" response which includes the cardiovascular system, the gastrointestinal system, the exocrine glands, and the adrenal medulla to produce changes in heart rate, blood pressure, and gastrointestinal activity that humans commonly associate with "stress." These responses have a relatively short duration and may or may not have significant long-term effect on an animal's welfare.

An animal's third line of defense to stressors involves its neuroendocrine or sympathetic nervous systems; the system that has received the most study has been the hypothalmus-pituitary-adrenal system (also known as the HPA axis in mammals or the hypothalamus-pituitary-interrenal axis in fish and some reptiles). Unlike stress responses associated with the autonomic nervous system, virtually all neuroendocrine functions that are affected by stress – including immune competence, reproduction, metabolism, and behavior – are regulated by pituitary hormones. Stress-induced changes in the secretion of pituitary hormones have been implicated in failed reproduction (Moberg 2000) (Box S2 of Figure 2) and altered metabolism (Elsasser et al. 2000), reduced immune competence (Blecha 2000) and behavioral disturbance. Increases in the circulation of glucocorticosteroids (cortisol, corticosterone, and aldosterone in marine mammals have been equated with stress for many years (Romano et al. 2004).

The primary distinction between *stress* (which is adaptive and does not normally place an animal at risk) and *distress* is the biotic cost of the response. During a stress response, an animal uses

glycogen stores that can be quickly replenished once the stress is alleviated. In such circumstances, the cost of the stress response would not pose a risk to the animal's welfare. However, when an animal does not have sufficient energy reserves to satisfy the energetic costs of a stress response, energy resources must be diverted from other biotic functions which impairs those functions that experience the diversion. For example, when mounting a stress response diverts energy away from growth in young animals, those animals may experience stunted growth. When mounting a stress response diverts energy from a fetus, an animal's reproductive success and its fitness will suffer. In these cases, the animals will have entered a pre-pathological or pathological state which is called "distress" (*sensu* Seyle 1950) or "allostatic loading" (McEwen and Wingfield 2003). This pathological state will last until the animal replenishes its biotic reserves sufficient to restore normal function.

Relationships between these physiological mechanisms, animal behavior, and the costs of stress responses have also been documented fairly well through controlled experiment; because this physiology exists in every vertebrate that has been studied, it is not surprising that stress responses and their costs have been documented in both laboratory and free-living. 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). Trimper (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; Smith et al. 2004b) identified noise-induced physiological stress responses in hearing-specialist fish that accompanied short- (TTS) and long-term (PTS) hearing losses. Welch and Welch (1970) reported physiological and behavioral stress responses that accompanied damage to the inner ears of fish and several mammals.

Hearing is one of the primary senses cetaceans use to gather information about their environment and to communicate with other members of their species. Although empirical information on the relationship between sensory impairment (TTS, PTS, and acoustic masking) on cetaceans remains limited, it seems reasonable to assume that reducing an animal's ability to gather information about its environment and to communicate with other members of its species would be stressful for animals that use hearing as their primary sensory mechanism. Therefore, we assume that acoustic exposures sufficient to trigger onset PTS or TTS would be accompanied by physiological stress responses because terrestrial animals exhibit those responses under similar conditions (NRC 2003a). More importantly, marine mammals might experience stress responses at received levels lower than those necessary to trigger onset TTS. Based on empirical studies of

the time required to recover from stress responses (Moberg 2000), we also assume that stress responses are likely to persist beyond the time interval required for animals to recover from TTS and might result in pathological and pre-pathological states that would be as significant as behavioral responses to TTS.

5.4 The Probable Responses of Listed Species

Based on the evidence available, RDT&E activities the U.S. Navy proposes to conduct in the NSWC PCD Study Area from January 2011 through January 2012 are not likely to kill or injure sperm whales or sea turtles. However, little is known about the effect of short-term disruptions of a marine animal's normal behavior (Richardson et al. 1995b). Most of the evidence available suggests that most sources of disturbance do not directly kill or injure marine animals. The evidence available also does not lead us to expect sperm whales or sea turtles to strand or suffer resonance effects from the high- and mid-frequency sonars associated with the Proposed Action.

PROBABLE RESPONSES OF SPERM WHALES. Based on the U.S. Navy's exposure models, over the 12-month period between January 2011 and January 2012, we would expect 2 instances in which sperm whales might be exposed to active sonar during RDT&E activities and experience behavioral changes that would be sufficient to constitute "take" (as that term is defined for the purposes of the MMPA) as a result of that exposure. We would also expect another instance in which one sperm whale might be exposed to sound pressure waves associated with underwater detonations and experience behavioral changes that would be sufficient to constitute "take" (as that term is defined for the purposes of the MMPA) as a result of that exposure. We would not expect sperm whales to be exposed to the shock wave associated with underwater detonations or projectiles associated with the activities the U.S. Navy plans to conduct in the Study Area.

The sperm whales that are likely to be exposed to these stressors would be individuals from the Gulf of Mexico population, which appears to be a grouping that is geographically and ecologically distinct from the sperm whales that occur in the North Atlantic Ocean. They might represent any age or gender.

Although there is no published audiogram for sperm whales, sperm whales would be expected to have good, high frequency hearing because their inner ear resembles that of most dolphins, and appears tailored for ultrasonic (>20 kHz) reception (Ketten 1994). The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate, which suggest that neonatal sperm whales respond to sounds from 2.5 to 60 kHz. Sperm whales vocalize in high- and mid-frequency ranges; most of the energy of sperm whales clicks is concentrated at 2 to 4 kHz and 10 to 16 kHz. Other studies indicate sperm whales' wide-band clicks contain energy between 0.1 and 20 kHz (Goold and Jones. 1995; Weilgart and Whitehead. 1993). Ridgeway and Carder (2001) measured low-frequency, high amplitude clicks with peak frequencies at 500 Hz to 3 kHz from a neonate sperm whale.

Based on their hearing sensitivities and vocalizations, the active sonar and sound pressure waves from the underwater detonations (as opposed to the shock waves from underwater detonations) the U.S. Navy proposes to conduct in the NSWC PCD Study Area might mask sperm whale

hearing and vocalizations. There is some evidence of disruptions of clicking and behavior from sonars (Goold 1999a; Watkins et al. 1985a; Watkins and Schevill. 1975), pingers (Watkins and Schevill. 1975), the Heard Island Feasibility Test (Bowles et al. 1994), and the Acoustic Thermometry of Ocean Climate (Costa et al. 1998). Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders (Watkins and Schevill. 1975). Goold Goold 1999a (1999) reported six sperm whales that were driven through a narrow channel using ship noise, echosounder, and fishfinder emissions from a flotilla of 10 vessels. Watkins and Scheville (1975) showed that sperm whales interrupted click production in response to pinger (6 to 13 kHz) sounds. They also stopped vocalizing for brief periods when codas were being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones. 1995).

As discussed previously, sperm whales have been reported to have reacted to military sonar, apparently produced by a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent, and becoming difficult to approach (Watkins et al. 1985b). Captive bottlenose dolphins and a white whale exhibited changes in behavior when exposed to 1 sec pulsed sounds at frequencies similar to those emitted by multi-beam sonar that is used in geophysical surveys (Ridgway et al. 1997; Schlundt et al. 2000a), and to shorter broadband pulsed signals (Finneran et al. 2000a; Finneran et al. 2002c). Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al. 2002c; Schlundt et al. 2000a). 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. 2000a; Finneran et al. 2002c). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran et al. 2002d). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997; Schlundt et al. 2000a). The relevance of these data to free-ranging odontocetes is uncertain. In the wild, cetaceans sometimes avoid sound sources well before they are exposed to the levels listed above, and reactions in the wild may be more subtle than those described by Ridgeway et al. (1997) and Schlundt et al. (2000a).

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.* (1995b) citing a personal communication with J. Gordon suggested that sperm whales in the Mediterranean Sea continued calling when exposed to frequent and strong military sonar signals. When Andre *et al.* (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 147 dB re 1 μPa in the frequency band with most energy (0.3 to 3 kHz), the whales did not avoid the vessel or substantially change their foraging behavior (Miller et al. 2009). Although the sample size is small (8 whales in 8 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.

PROBABLE RESPONSE OF SEA TURTLES. Based on the U.S. Navy's exposure models, unspecified hardshell sea turtles (green, hawksbill, Kemp's ridley, or loggerhead sea turtles) are likely to be exposed to underwater detonations and detonations associated with line charges as a result of the

RDT&E activities, but sea turtles are not likely to be exposed to high- or mid-frequency active sonar as a result of those activities. Specifically, we would expect 1 instance in which unspecified hardshell sea turtles might be exposed to sound pressure waves associated with underwater detonations in territorial waters and a second instance in which unspecified hardshell sea turtles might be exposed to underwater detonations in non-territorial waters and experience temporary, noise-induced losses of hearing sensitivity (temporary threshold shifts) as a result of that exposure. In a third instance, unspecified hardshell sea turtles might be exposed to detonations associated with line charges in territorial waters and experience temporary, noise-induced losses of hearing sensitivity as a result of that exposure.

In addition, we would expect 1 instance in which leatherback sea turtles might be exposed to sound pressure waves associated with underwater detonations in territorial waters and a second instance in which leatherback sea turtles might be exposed to underwater detonations in non-territorial waters and experience temporary, noise-induced losses of hearing sensitivity (temporary threshold shifts) as a result of that exposure. Leatherback sea turtles are not likely to be exposed to detonations associated with line charges in territorial waters or experience temporary, noise-induced losses of hearing sensitivity as a result of those detonations.

We would also expect 1 instance in which loggerhead sea turtles might be exposed to sound pressure waves associated with underwater detonations in territorial waters and a second instance in which loggerhead sea turtles might be exposed to underwater detonations in non-territorial waters and experience temporary, noise-induced losses of hearing sensitivity (temporary threshold shifts) as a result of that exposure. In a third instance, one loggerhead sea turtles might be exposed to detonations associated with line charges in territorial waters and experience temporary, noise-induced losses of hearing sensitivity as a result of that exposure.

Finally, we would expect 1 instance in which one leatherback sea turtle and 1 instance in which one loggerhead sea turtle might be exposed to detonations associated with 5-inch projectiles and experience temporary, noise-induced losses of hearing sensitivity (temporary threshold shifts) as a result of that exposure.

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) (Bartol et al. 1999; Lenhardt 1994; Lenhardt et al. 1983; Ridgway et al. 1969) . Ridgway et al. (1969) studied the auditory evoked potentials of three green sea turtles (in air and through mechanical stimulation of the ear) and concluded that their maximum sensitivity occurred from 300 to 400 Hz with rapid declines for tones at lower and higher frequencies. They reported an upper limit for cochlear potentials without injury of 2000 Hz and a practical limit of about 1000 Hz. This is similar to estimates for loggerhead sea turtles, which had most sensitive hearing between 250 and 1000 Hz, with rapid decline above 1000 Hz (Bartol et al. 1999). These hearing sensitivities are similar to the hearing sensitivities reported for two terrestrial species: pond turtles (*Pseudemys scripta*) and wood turtles (*Chrysemys inscuplta*). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below

100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3000 Hz (Wever and Vernon 1956). Wood turtles are reported to have sensitivities up to about 500 Hz, followed by a rapid decline above 1000 Hz and almost no responses beyond 3000 or 4000 Hz (Patterson 1966).

We assume that these sensitivities to sound apply to all four of the hardshell turtles (i.e., the green, hawksbill, Kemp's ridley, and loggerhead sea turtles). No audiometric data are available for leatherback sea turtles, but we assume that they have hearing ranges similar to those of other sea turtles (or at least, their hearing is more likely to be similar to other sea turtles than marine mammals). Based on this information sea turtles exposed to received levels of active mid-frequency sonar are not likely to hear mid-frequency sounds (sounds between 1 kHz and 10 kHz); therefore, they are not likely to respond physiologically or behaviorally to those received levels.

A recent study on the effects of airguns on sea turtle behavior also suggests that sea turtles are most likely to respond to low-frequency sounds. McCauley et al. (2000) reported that green and loggerhead sea turtles will avoid air-gun arrays at 2 km and at 1 km with received levels of 166 dB re 1 μPa and 175 db re 1 μPa, respectively. The sea turtles responded consistently: above a level of approximately 166 dB re 1 μPa_{rms} the turtles noticeably increased their swimming activity compared to non-airgun operation periods. Above 175 dB re 1 μPa mean squared pressure their behavior became more erratic possibly indicating the turtles were in an agitated state. Because the sonar that would be used during the proposed exercises transmits at frequencies above hearing thresholds for sea turtles, sea turtles that are exposed to those transmissions are not likely to respond to that exposure. As a result, mid-frequency active sonar associated with the proposed exercises "may affect, but is not likely to adversely affect" green, hawksbill, leatherback, or loggerhead sea turtles.

5.5 Effects Resulting from Interactions of the Potential Stressors

Several organizations have argued that several of our previous biological opinions on the U.S. Navy's use of active sonar failed to consider the "cumulative impact" (in the NEPA sense of the term) of active sonar on the ocean environment and its organisms, particularly endangered and threatened species and critical habitat that has been designated for them (for example, see NRDC 2007 and Ocean Mammal Institute 2007). In each instance, we have explained how biological opinions consider "cumulative impacts" (in the NEPA sense of the term; see Approach to the Assessment for a complete treatment of this issue). There is a nuance to the idea of "cumulative impacts," however, that we have chosen to address separately and explicitly in this Opinion: potential interactions between stressors associated with the proposed RDT&E activities and other physical, chemical, and biotic stressors that pre-exist in the environment.

Exposing living organisms to individual stressors or a suite of stressors that are associated with a specific action may be insignificant or minor when considered in isolation, but may have significant adverse consequences when they are added to other stressors, operate synergistically in combination with other stressors, or magnify or multiply the effects of other stressors. Further, the effects of life events, natural phenomena, and anthropogenic phenomena on an individual's

performance will depend on the individual's phenotypic state when the individual is exposed to these phenomena. Disease, dietary stress, body burden of toxic chemicals, energetic stress, percentage body fat, age, reproductive state, and social position, among many other phenomena can "accumulate" to have substantial influence on an organism's response to subsequent exposure to a stressor. That is, exposing animals to individual stressors associated with a specific action can interact with the animal's prior condition (the effects of stressors can "accumulate" to produce additive, synergistic, magnifying, and multiplicative effects on individual organisms) and produce significant, adverse consequences that would not occur if the animal's prior condition had been different.

An illustrative example of how a combination of stressors interact was provided by Relyea (2000; 2009) who demonstrated that exposing several different amphibians to a combination of pesticides and chemical cues of natural predators, which induced stress, increased the mortality rates of the amphibians (see also (Sih et al. 2004). For some species, exposing the amphibians to the combination of stressors produced mortality rates that were twice as high as the mortality rates associated with each individual stressor. This section considers the evidence available to determine if interactions associated with mid-frequency active sonar are likely to produce responses we have not considered already or if interactions are likely to increase the severity — and, therefore, the potential consequences — of the responses we have already considered.

The active sonar activities the U.S. Navy proposes to conduct in the NSWC PCD, over the next 12-months years would add more than 1,000 hours of high-frequency and more than 70 hours of mid-frequency active sonar to ambient oceanic noise levels, which, in turn, could have cumulative impacts on the ocean environment in the Action Area and any endangered or threatened species that occur in that area. The behavioral responses of any endangered whales that occur in those sound fields are likely to result from their response to mid-frequency active sonar, per se, as well as other salient cues in their environment, including their perception of their distance from a sonar source and their perception of whether the source of those sounds are approaching them, moving parallel to them, or moving away from them. The behavioral response of endangered whales that are likely to be exposed to active sonar during the training exercises considered in this Opinion would also be shaped by their reproductive condition, their state of health, and their prior experience.

With the possible exception of hatchling sea turtles or the new-born calves, the prior experience of any individual endangered whales or listed sea turtles that occur off the Atlantic coast of the United States and in the Gulf of Mexico would include regular exposure to a wide variety of natural and anthropogenic stressors produced by commercial fisheries in Federal and State waters, vessel traffic, whale-watch vessels and researchers, and human occupation of coastal areas. Whales that occur in the Action Area are almost certain to have been exposed to ship traffic entering and leaving ports like Boston, New York, Baltimore, Virginia Beach, and Jacksonville or Port Everglades and Fort Lauderdale. As we discussed in the *Environmental Baseline* section of this Opinion, these whales will also have been exposed to the continuous,

low-frequency sounds produced by commercial vessels, may have interacted with commercial fishing gear, and may have prior experience with mid-frequency active sonar from surface vessels, sonobuoys, or submarines in other geographic areas or during previous exercises within the Action Area.

Any individual sperm whale that has high body burdens of some antibiotics (for example, aminoglycoside antibiotics and other prescription drugs (which are introduced to marine environments in sewage discharges and freshwater run-off), organic solvents, metals, and chemical asphyxiants may be more susceptible to noise-induced loss of hearing sensitivity (Fechter et al. 2000). Nevertheless, none of the information available suggests that the responses of whales to these stressors or their prior experience with these stressors is likely to produce consequences other than those we have already considered in this Opinion, although it is important to note that this statement probably results from the limits in the information available more than the absence of interactive effects.

Similarly, sea turtles that occur in the Action Area are almost certain to have been exposed to ship traffic entering and leaving ports like Boston, New York, Baltimore, Virginia Beach, and Jacksonville (if they arrive from the north) or Port Everglades and Fort Lauderdale (if they arrive from the south). As we discussed in the *Environmental Baseline* section of this Opinion, these sea turtles will also have been exposed to the continuous, low-frequency sounds produced by commercial vessels, are likely to have been captured at least once in commercial fishing gear (given that almost twice the estimated population of loggerhead sea turtles has been estimated to be captured in shrimp trawls each year for the past five years, every loggerhead sea turtle in the western Atlantic has had some probability of being captured in these fisheries), and may have prior experience with mid-frequency active sonar from surface vessels, sonobuoys, or submarines in other geographic areas or during previous exercises within the Action Area. Nevertheless, none of the information available suggests that the responses of sea turtles to these stressors or their prior experience with these stressors is likely to produce consequences other than those we have already considered in this Opinion, although it is important to note that this statement probably results from the limits in the information available more than the absence of interactive effects.

5.6 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 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.

5.7 Integration and Synthesis of Effects

In the *Assessment Approach* section of this Opinion, we stated that we measure risks to individuals of endangered or threatened species using changes in the individuals' "fitness" or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When we do not expect listed plants or animals exposed to an action's effects to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise. As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment. If, however, we conclude that listed plants or animals are likely to experience reductions in their fitness, we would assess the potential consequences of those fitness reductions for the population or populations the individuals in an action area represent.

As we summarize in the narratives that follow, our analyses led us to conclude that endangered or threatened individuals that are likely to be exposed to the RDT&E activities the U.S. Navy proposes to conduct in the NSWC PCD Study Area, are not likely to experience reductions in the fitness of the individual animals that are likely to be exposed to those activities.

SPERM WHALES. Based on the U.S. Navy's exposure models, over the 12-month period between January 2011 and January 2012, we would expect 2 instances in which sperm whales might be exposed to active sonar during RDT&E activities the U.S. Navy proposes to conduct in the U.S. NSWC PCD Study Area and experience behavioral changes that would be sufficient to constitute "take" (as that term is defined for the purposes of the MMPA) as a result of that exposure. We would also expect another instance in which one sperm whale might be exposed to sound pressure waves associated with underwater detonations and experience behavioral changes that would be sufficient to constitute "take" (as that term is defined for the purposes of the MMPA) as a result of that exposure. We would not expect sperm whales to be exposed to the shock wave associated with underwater detonations or projectiles associated with the activities the U.S. Navy plans to conduct in the NSWC PCD Study Area.

The sperm whales that are likely to be exposed to these stressors would be individuals from the Gulf of Mexico population, which appears to be a grouping that is geographically and ecologically distinct from the sperm whales that occur in the North Atlantic Ocean. They might represent any age or gender.

If exposed to high- or mid-frequency active sonar transmissions and sound pressure waves associated with underwater detonations, sperm whales are likely to hear and respond to those transmissions. The only data on the hearing range of sperm whales are evoked potentials from a

stranded neonate (Carder and Ridgway. 1990). These data suggest that neonatal sperm whales respond to sounds from 2.5-60 kHz. Sperm whales also produce loud broad-band clicks from about 0.1 to 20 kHz (Goold and Jones. 1995; Weilgart et al. 1993; Weilgart and Whitehead. 1997). 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 (Cranford 1992; Norris and Harvey. 1972). This suggests that the production of these loud low frequency clicks is extremely important to the survival of individual sperm whales. The function of these vocalizations is relatively well-studied (Goold and Jones 1995; Weilgart et al. 1993; Weilgart and Whitehead. 1997). 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 et al. 1993).

Based on the frequencies of their vocalizations, which overlap the frequency range of high- and mid-frequency active sonar, sonar transmissions might temporarily reduce the active space of sperm whale vocalizations. Most of the energy of sperm whales clicks is concentrated at 2 to 4 kHz and 10 to 16 kHz, which overlaps with the mid-frequency sonar. Other studies indicate sperm whales' wide-band clicks contain energy between 0.1 and 20 kHz (Goold and Jones. 1995; Weilgart and Whitehead. 1993). Ridgway and Carder (2001) measured low-frequency, high amplitude clicks with peak frequencies at 500 Hz to 3 kHz from a neonate sperm whale.

There is some evidence of disruptions of clicking and behavior from sonars (Goold 1999b; Watkins and Schevill. 1975), pingers (Watkins and Schevill. 1975), the Heard Island Feasibility Test (Bowles 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 Schevill. 1975). Goold (1999b) reported six sperm whales that were driven through a narrow channel using ship noise, echosounder, and fishfinder emissions from a flotilla of 10 vessels. Watkins and Scheville (1975) showed that sperm whales interrupted click production in response to pinger (6 to 13 kHz) sounds. They also stopped vocalizing for brief periods when codas were being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones. 1995).

As discussed previously, sperm whales have been reported to have reacted to military sonar, apparently produced by a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent and becoming difficult to approach (Watkins et al. 1985a). 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. 2000a), and to shorter broadband pulsed signals (Finneran et al. 2002a; Finneran et al. 2000a). Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al. 2002a; Schlundt et al. 2000a). 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. 2002a; Finneran et al. 2000a). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran et al. 2002a). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997; Schlundt et al. 2000a). The relevance of these data to free-ranging odontocetes is uncertain. In the wild, cetaceans sometimes avoid sound sources well before they are exposed to the levels listed above, and reactions in the wild may be more subtle than those described by Ridgway et al. (1997) and Schlundt et al. (2000a).

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. 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). Data from vessel-based monitoring programs in United Kingdom waters suggest that sperm whales in that area may have exhibited some changes in behavior in the presence of operating seismic vessels (Stone 1997; Stone 1998; Stone 2000; Stone 2001; Stone 2003a). 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 2003a). The results from these waters seem to show that some sperm whales tolerate seismic surveys.

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

As stated previously, 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 147 dB re 1 μPa over

octave band with most energy, the whales did not avoid the vessel or substantially alter their feeding behavior (Miller et al. 2009).

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.* (Richardson et al. 1995a) citing a personal communication with J. Gordon suggested that sperm whales in the Mediterranean Sea continued calling when exposed to frequent and strong military sonar signals. When Andre et al. (Andre and Jurado 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.

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

The evidence available suggests that sperm whales are likely to detect active sonar transmissions and the sounds of underwater detonations associated with the research, development, test, and evaluation activities the U.S. Navy plans to conduct at the Naval Surface Warfare Center. In most circumstances, sperm whales are likely to try to avoid being exposed to those sounds or are likely to avoid the specific areas in which those sounds occur. For example, sperm whales have moved out of areas after the start of air gun seismic testing (Davis et al. 1995). 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 might experience significant disruptions of normal behavior patterns that are essential to their individual fitness. Because of the relatively short duration of the acoustic transmissions associated with the RDT&E activities the U.S. Navy plans to conduct at the Naval Surface Warfare Center, we do not, however, expect these disruptions to result in the death or injury of any individual animal or to result in physiological stress responses that rise to the level of distress.

Individual sperm whales are also likely to respond to the ship traffic associated with the maneuvers; responses 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 being exposed and responding to that exposure. Particular whales' might not

respond to the vessels, while in other circumstances, sperm whales are likely to change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Au and Green 2000; Erbe 2002; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005; Watkins 1986a; Williams et al. 2002). Some of these whales might experience physiological stress responses if they attempt to avoid one ship and encounter a second ship during that attempt. However, we would not expect those stress responses to result in stress pathologies because of the relatively short duration of the RDT&E activities the U.S. Navy plans to conduct at the Naval Surface Warfare Center. Specifically, we do not expect any stress responses to continue long-enough to have fitness consequences for individual sperm whales because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and the additional demands of any stress responses. Therefore, we would not expect sperm whales to experience reductions in their annual or lifetime reproductive success as a result of their response to the RDT&E activities that U.S. Navy proposes to conduct at the Naval Surface Warfare Center at Panama City, Florida.

As a result, based on the evidence available, we conclude that the RDT&E activities the U.S. Navy proposes to conduct in the NSWC PCD Study Area from January 2011 through January 2012 are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual sperm whales in ways or to a degree that would reduce their fitness. As we discussed in the *Approach to the Assessment* section of this Opinion, an action that is not likely to reduce the fitness of individual sperm whales would not be likely to reduce the viability of the populations those individual whales represent by reducing the population dynamics, behavioral ecology, and social dynamics of those populations (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). Therefore, we would not expect those RDT&E activities would appreciably reduce the sperm whales' likelihood of surviving and recovering in the wild by reducing their numbers, reproduction, or distribution.

SEA TURTLES. Based on the U.S. Navy's exposure models, unspecified hardshell sea turtles (green, hawksbill, Kemp's ridley, or loggerhead sea turtles) are likely to be exposed to underwater detonations and detonations associated with line charges as a result of the RDT&E activities the U.S. Navy proposes to conduct in the NSWC PCD Study Area, but sea turtles are not likely to be exposed to high- or mid-frequency active sonar as a result of those activities. Specifically, we would expect 1 instance in which unspecified hardshell sea turtles might be exposed to sound pressure waves associated with underwater detonations in territorial waters and a second instance in which unspecified hardshell sea turtles might be exposed to underwater detonations in non-territorial waters and experience temporary, noise-induced losses of hearing sensitivity (temporary threshold shifts) as a result of that exposure. In a third instance, unspecified hardshell sea turtles might be exposed to detonations associated with line charges in territorial waters and experience temporary, noise-induced losses of hearing sensitivity as a result of that exposure.

In addition, over the 12-month period between January 2011 and January 2012, we would expect 1 instance in which leatherback sea turtles might be exposed to sound pressure waves associated with underwater detonations in territorial waters and a second instance in which leatherback sea turtles might be exposed to underwater detonations in non-territorial waters and experience temporary, noise-induced losses of hearing sensitivity (temporary threshold shifts) as a result of that exposure. Leatherback sea turtles are not likely to be exposed to detonations associated with line charges in territorial waters or experience temporary, noise-induced losses of hearing sensitivity as a result of those detonations.

Over the 12-month period between January 2011 and January 2012, we would also expect 1 instance in which loggerhead sea turtles might be exposed to sound pressure waves associated with underwater detonations in territorial waters and a second instance in which loggerhead sea turtles might be exposed to underwater detonations in non-territorial waters and experience temporary, noise-induced losses of hearing sensitivity (temporary threshold shifts) as a result of that exposure. In a third instance, one loggerhead sea turtles might be exposed to detonations associated with line charges in territorial waters and experience temporary, noise-induced losses of hearing sensitivity as a result of that exposure.

Finally, over the 12-month period between January 2011 and January 2012, we would expect 1 instance in which one leatherback sea turtle and 1 instance in which one loggerhead sea turtle might be exposed to detonations associated with 5-inch projectiles and experience temporary, noise-induced losses of hearing sensitivity (temporary threshold shifts) as a result of that exposure.

Although the information on the hearing capabilities of sea turtles is limited, the information available suggests that the auditory capabilities of sea turtles are centered in the low-frequency range (<1 kHz) (Bartol et al. 1999; Lenhardt 1994; Lenhardt et al. 1983; Ridgway et al. 1969). Ridgway et al. (1969) studied the auditory evoked potentials of three green sea turtles (in air and through mechanical stimulation of the ear) and concluded that their maximum sensitivity occurred from 300 to 400 Hz with rapid declines for tones at lower and higher frequencies. They reported an upper limit for cochlear potentials without injury of 2000 Hz and a practical limit of about 1000 Hz. This is similar to estimates for loggerhead sea turtles, which had the most sensitive hearing between 250 and 1000 Hz, with rapid decline above 1000 Hz (Bartol et al. 1999).

As we discussed during our review of the literature in the *Response Analysis* section of this Opinion, the data on captive animals and the limited information from free-ranging animals suggests that temporary noise-induced hearing losses do not have direct or indirect effect on the lifetime reproductive success of animals that experience these losses (see Figure 2). Like humans, free-ranging animals might experience short-term impairment in their ability to use their sense of hearing to detect environmental cues about their environment while their ears recover from the temporary loss of hearing sensitivity. Although we could not locate information on how animals that experience noise-induced hearing loss alter their behavior or the consequences of

any altered behavior on the lifetime reproductive success of those individuals, the limited information available would not lead us to expect temporary losses in hearing sensitivity to incrementally reduce the lifetime reproductive success of animals.

If four to seven sea turtles experience temporary, noise-induced losses in hearing sensitivity during the RDT&E activities the U.S. Navy proposes to conduct in the NSWC PCD Study Area from January 2011 through January 2012, we would not expect those sea turtles to experience reductions in their lifetime reproductive success as a result of their impaired hearing sensitivity. Therefore, we would not expect those exposures to reduce the viability of the nesting aggregations those sea turtles represent by reducing the population dynamics, behavioral ecology, and social dynamics of those populations (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, those activities would not be expected to appreciably reduce the likelihood of green sea turtles, leatherback sea turtles, loggerhead sea turtles, Hawksbill sea turtles , and kemp's ridley sea turtles surviving and recovering in the wild by reducing their reproduction, numbers, or distribution.

5.8 Conclusion for Listed Resources

After reviewing the current status of sperm whales, green sea turtles, leatherback sea turtles, loggerhead sea turtles, Hawksbill sea turtles , and kemp's ridley sea turtles; the environmental baseline for the action area; the effects of the research, development, training and evaluation activities the U.S. Navy plans to conduct in the NSWC PCD Study Area – Panama City, Florida that are likely to occur over the 12-month period between January 2011 and January 2012, and the cumulative effects, it is NMFS' biological opinion that the Navy's proposal to conduct research, development, test and evaluation activities at the Naval Surface Warfare Center – Panama City, Florida are likely to adversely affect but are not likely to jeopardize the continued existence of these threatened and endangered species under NMFS jurisdiction.

The Opinion also concluded that research, development, training and evaluation activities the U.S. Navy plans to conduct in the NSWC PCD Study Area – Panama City, Florida, are not likely to adversely affect critical habitat that has been designated for endangered or threatened species in the action area. Therefore, those activities are not likely to result in the destruction or adverse modification of that critical habitat.

5.9 Conclusion for Proposed Resources

After reviewing the current status of the proposed Northwest Atlantic distinct population segment of loggerhead sea turtles, the environmental baseline for the action area, the effects of the research, development, training and evaluation activities the U.S. Navy plans to conduct in the NSWC PCD Study Area – Panama City, Florida, that are likely to occur over the 12-month period between January 2011 and January 2012, and the cumulative effects, it is NMFS' conference opinion that the U.S. Navy's proposal to conduct research, development, training and evaluation activities within the in the NSWC PCD Study Area – Panama City, Florida, are not likely to jeopardize the continued existence of this species.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibits the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2) of the ESA, taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement (ITS).

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

Amount or Extent of Take Anticipated

The section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 CFR 402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by proposed actions while the extent of take or "the extent of land or marine area that may be affected by an action" if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (51 FR 19953). The amount of take resulting from the Navy's activities was difficult to estimate because we have no empirical information on (a) the actual number of listed species that are likely to occur in the different sites, (b) the actual number of individuals of those species that are likely to be exposed, (c) the circumstances associated with any exposure, and (d) the range of responses we would expect different individuals of the different species to exhibit upon exposure.

The instances of harassment identified in Table 9. would generally represent changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures. Therefore, they would represent significant disruptions of the normal behavioral patterns of the animals that are expected to be exposed to the U.S. Navy's RDT&E activities at the NSWC PCD Study Area.

Table 9. Expected number of instances in which individual members of endangered or threatened species are likely to be "taken" as a result of their exposure to the research, development, test and evaluation activities the U.S. Navy plans to conduct at the Naval Surface Warfare Center – Panama City Division.

Species	Estimated Number of Instances in Which Species Would be "Taken"	Form of the "Take"
Sperm whale	2	Harassment
Leatherback sea turtle	2	Harassment
Loggerhead sea turtle	2	Harassment
Unspecified hardshell sea turtle (green, hawksbill, or Kemp's ridley sea turtle)	3	Harassment

None of the endangered species that might be exposed to the RDT&E activities the U.S. Navy plans to conduct in the NSWC PCD Study Area are likely to die or be wounded as a result of their exposure to those activities.

Effect of the Take

In the accompanying biological opinion, NMFS determined that the number of individuals of endangered or threatened species that might be exposed to the RDT&E activities the U.S. Navy plans to conduct at the NSWC PCD Study Area, and that are likely to respond to that exposure in ways that NMFS would classify as "take" as that term is defined pursuant to section 3 of the ESA, is not likely to jeopardize the continued existence of sperm whales or green, hawksbill, Kemp's ridley, leatherback, or loggerhead sea turtles. Exposure to these RDT&E activities could disrupt one or more behavioral patterns that are essential to an individual animal's life history or to the animal's contribution to a population. Because of the short duration and low repetition rate of any changes in behavior, we would expect those individuals to be able to compensate for those behavioral changes (as they do when in response to other short-term changes in their behavior) we do not expect those behavioral responses to affect the reproduction, survival, or recovery of the individuals that are harassed.

Reasonable and Prudent Measures

NMFS 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 Navy shall implement a monitoring program that allows the Navy and NMFS to evaluate the assumptions contained in this Opinion and that underlie this incidental take statement.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Endangered Species Act of 1973, as amended, the Navy must comply with the following terms and conditions, which implement

the reasonable and prudent measure described above and outline reporting and monitoring requirements, as required by the section 7 regulations (50 CFR 402.14(i)):

1. The navy shall submit reports that identify the general locations, timing, number of sonar hours, and other aspects of the RDT&E activities they conduct in the PCD Study Area from January 2011 through January 2012.

CONSERVATION RECOMMENDATIONS

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

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

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

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

REINITIATION NOTICE

This concludes formal consultation on RDT&E activities the U.S. Navy plans to conduct at the NSWC PCD Study Area, from January 2011 through January 2012 and the NMFS' Permits Division's proposal to issue an LOA that would authorize the U.S. Navy to "take" marine mammals incidental to the RDT&E activities from January 2011 to January 2012. As provided in 50 CFR 402.16, reinitiation of formal consultation is normally required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion; or (4)

a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, Action Agencies are normally required to reinitiate section 7 consultation immediately.

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