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

AUG 10 2007

Memorandum For: The Record

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

Subject: Biological Opinion on the Permits, Conservation and Education Division's proposal to issue permit 1121-1900 to the National Marine Fisheries Service, Office of Science and Technology (Responsible Party: Dr. John Boreman).

Enclosed is the National Marine Fisheries Service's (NMFS) Biological Opinion (Opinion), issued under the authority of section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA), on the NMFS Permits, Conservation and Education Division (Permits Division) proposal to issue permit 1121-1900 to NMFS Office of Science and Technology (Responsible Party: Dr. John Boreman). The permit would allow research of the responses of several deep-diving cetacean species, including sperm whales, to artificial underwater sounds in the Tongue of the Ocean (east of Andros Island, Bahamas), at the Atlantic Undersea Test and Evaluation Center (AUTEC). Take of humpback whales is included in the permit. The research would last for a period of six weeks, beginning in mid-August 2007. The permit would expire on January 1, 2008. The purpose of the research is to observe behavioral responses in several deep-diving cetacean species exposed to natural and artificial underwater sounds and quantify exposure conditions associated with various effects.

This document summarizes the best available information on the potential impacts of close vessel approaches, tagging, and sound exposure during playbacks to endangered sperm whales and humpback whales. Based on this information, we conclude that the continuance of these species is not likely to be jeopardized by issuance of the proposed research permit.

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

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

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

Proposed Action: Scientific Research Permit 1121-1900 to John Boreman of the National Marine Fisheries Service Office of Science and Technology

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

Approved by: [signature]

Date: AUG 10 2007

Section 7(a)(2) of the Endangered Species Act (ESA; 16 U.S.C. 1531 et seq.) requires each federal agency to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When an action of a federal agency "may affect" endangered or threatened species or critical habitat, that agency is required to consult with the National Marine Fisheries Service (NMFS) or U.S. Fish and Wildlife Service, depending on the species that may be affected. This biological opinion is the result of an intra-agency consultation between the Permits, Conservation and Education Division and the Endangered Species Division of the NMFS Office of Protected Resources. This opinion describes whether Permits, Conservation and Education Division's issuance of scientific research permit 1121-1900 to John Boreman of the NMFS Office of Science and Technology would likely jeopardize the existence of the endangered sperm whale and humpback whale.

This biological opinion has been prepared in accordance with section 7 of the ESA and regulations promulgated to implement that section of the ESA. This biological opinion is based on information provided in the research permit application, *Draft Environmental Assessment on the Effects of Scientific Research Activities Associated with a Behavioral Response Study on Deep Diving Odontocetes*, published and unpublished scientific information on the biology and ecology of endangered and threatened whales, and other sources of information.

A brief account of the consultation history precedes the biological opinion. The biological opinion first describes the proposed permit and research activities, including activities that may affect listed species, and the action area. Accounts of the sperm whale and humpback whale, their life histories, population status and trends, and major threats follow. The *Environmental Baseline* section contains a discussion of the past and present activities that have affected these species in the action area. The *Status of the Species* and the *Environmental Baseline* serve as the context for the analysis of the effects of the proposed action on these species. The *Effects of the Action* section describes the evidence and rationale behind our conclusion that these species are not likely to be jeopardized by issuance of the proposed research permit.

Consultation History

The Permits, Conservation and Education Division requested a consultation under the ESA in a memorandum dated June 27, 2007 for their proposal to issue scientific research permit 1121-1900 to the NMFS Office of Science and Technology (Responsible Party: Dr. John Boreman). The applicant would be conducting experiments on deep-diving cetaceans in the Tongue of the Ocean, east of Andros Island, Bahamas. The proposed start date of the research is August 14, 2007. The endangered sperm whale could be a subject of the research. Listed sea turtle species could be in the area but are unlikely to be adversely affected. The draft permit also included the take of several endangered baleen whale species, including the humpback whale, sei whale, fin whale, and blue whale that could be exposed to playbacks. However, available survey information indicates that these species are unlikely to be in the area of the proposed research. These species are, thus, also unlikely to be adversely affected. Explanations of these conclusions are provided in the biological opinion.

Biological Opinion

Description of the Proposed Action

The Permits, Conservation and Education Division of the NMFS Office of Protected Resources proposes to issue scientific research permit 1121-1900 to John Boreman of the NMFS Office of Science and Technology, pursuant to the Marine Mammal Protection Act of 1972, as amended (16 U.S.C. 1361 *et seq*.) and the ESA. The permit would allow research of the responses of several deep-diving cetacean species to artificial underwater sounds in the Tongue of the Ocean (east of Andros Island, Bahamas), at the Atlantic Undersea Test and Evaluation Center (AUTEC). The research would last for a period of six weeks, beginning in mid-August 2007. The permit would expire on January 1, 2008.

The purpose of the research is to observe behavioral responses in several deep-diving cetacean species exposed to natural and artificial underwater sounds and quantify exposure conditions associated with various effects. The proposed research is recognized as a critical data need in recent reports regarding the association between the use of multiple high-energy mid-frequency sonar and mass strandings of beaked whales (Cox *et al.* 2006; Frantzis 1998; 1991). Behavioral response studies have been specifically recommended by the National Research Council (National Research Council 2003) and identified as the foremost data need during a Marine Mammal Commission symposium on beaked whales.

The proposed research includes two phases. The goal of Phase I of the behavioral response study (proposed for 2007) is to determine the acoustic exposures of mid-frequency sonar sounds that elicit an identifiable behavioral indicator response in beaked whales. The goals of Phase II will depend upon Phase I results, but would include acoustic exposures of underwater sounds to attempt to understand the initial steps in the chain of events that lead from sound exposure to atypical mass strandings of beaked whales; and to use that understanding to strive for the development of a safe response that can be used to indicate risk. Phase II would follow in 2008, most likely also at AUTEC, with plans to contrast responses of whales to an actual mid-frequency active Navy sonar, a source capable of reproducing low-frequency active sonar signals, and impulsive sources (e.g., airguns). There are tentative plans for Phase III to be conducted in 2009 to study responses of beaked whales that do not have a history of exposure to these sounds. The splitting of the project into at least two phases allows the applicants to work out the research protocols the first year using a sound source with lower power than actual sonars involved in strandings. The phased strategy minimizes the risk to subjects in the first year as the researchers observe how whales respond, and at what exposure levels, before studying the dose/response relations to actual sonar sources during the second year. NOAA will be re-applying for a new Scientific Research Permit for Phase II, at which point analysis under ESA will occur again.

The behavioral response studies would focus on beaked whales (*Ziphius cavirostris* and *Mesoplodon* spp.) but the responses of other odontocete species, including the endangered sperm whale (*Physeter macrocephalus*), may also be monitored. Permit 1121-1900 includes takes of targeted sperm whales by close approach, tag attachment, photo-identification, focal follow, playback and takes of non-targeted sperm whales during close approaches and playbacks. The permit allows up to 13 sperm whales to be tagged, 3 of which may be exposed to playbacks. An additional 194 non-target sperm whales could be harassed during close approaches and playbacks to target animals. Although unlikely to be encountered, the permit also allows take of 3 humpback whales during playbacks directed at target animals. All activities are permitted through October in the international waters of the Tongue of the Ocean.

The applicants state an ideal goal of 20 playbacks, with an estimated 2 occurring outside Bahamian territorial seas. Most of the research is expected to occur within Bahamian territorial seas. More than one animal in a group may be tagged to monitor distance and social interactions. The applicants do not know what species will be available or how many. However, they are not likely to be able to tag 20 animals considering the multiple challenges of open ocean research (e.g., bad weather and locating diving animals).

The proposed research activity involves closely approaching animals in the wild, tagging animals with acoustic recording tags (DTAGs), focal follows of animals, and playback experiments using underwater mid-frequency sounds to tagged and non-tagged animals. Sources of the playbacks are Eryn I (primary) and Eryn II (backup). These sources have a maximum source level of 212 dB re 1 μPa and frequency range of 1 to 5 kHz. The DTAG will continuously sample animal vocal and motor behavior, to collect behavior data on animals before, during, and after playbacks. The research activities would occur for an approximately 6 week period.

Playbacks sounds include 3 mid-frequency sonar-type sounds, 2 orca sounds, and 1 broadband sound. The sounds of most interest are the sonar-type sounds and are described in more detail in the *Effects of the Action* section. These sounds last a few seconds every 25 seconds. Starting at a source level of 152 dB re 1 μ Pa, they will be ramped up by 3 dB with each ping.

Two vessels, The *Ranger* and *Blackfin*, will be used for the research. The *Ranger* is an AUTEC vessel that is used for various operations on the range. It is Bahamas-based and will be operating out of Bahamian ports in AUTEC. The *Blackfin* is used by marine mammal scientists and will also operate only out of Bahamian ports. 10 to 12-foot long rigid-hull-inflatable (RHIB) boats will be used for tagging.

The *Ranger* and/or *Blackfin* would be used for visual observation and acoustic monitoring of the animal selected for tagging. The observers would monitor this animal before tagging to test for any effects of tagging itself. The RHIB would approach the animal as cautiously as possible within a distance that allows attachment of the tag. During and after attachment, the *Ranger/Blackfin* would track and observe the animal when it is at the surface for the duration of the tag attachment, as well as a post-tagging period, where possible, to ensure that the data collected during the tag's life represent a normal repertoire and that the tag had no visible effects on the animal. Either the RHIB or the *Ranger/Blackfin* would recover the tag after it detaches from the animal. Playbacks will likely last from 1 to 3 hours.

When playbacks are planned, there will be a pre-exposure period (at least one whale dive and surface sequence) to monitor the animal's reaction to the tagging and to establish a pre-exposure behavioral baseline. The scientific research team would take photos of all animals tagged, and where possible, tagging attempts, and tag location on the animal. They would use these photos to identify the tagged animal, i.e., to compare to known catalogues for information about tagged individuals and to prevent duplicative tagging.

Behavioral responses to underwater mid-frequency sounds that will be measured include dive depth and duration, surfacing frequency and time at surface, respiration and heart rate (at the surface), vocal reactions (e.g. cessation of clicking) and changes in social cohesion. This would be accomplished with visual and passive acoustic monitoring from the research vessels, passive acoustic monitoring and localization data from the AUTEC range hydrophones, and data from electronic tags on the target animal(s).

The purpose of the playback experiments is both to detect disturbance reactions and to determine how exposure may affect the ability of exposed animals to achieve the goals of their activities. If the researchers obtain evidence of an identifiable behavioral reaction during a playback, they will not increase the received level at the subject, but may maintain exposure at that level for a pre-determined period of time (depending on the type of reaction and when it occurs during the animal's dive and surface sequence). After exposure and assuming they can identify and move the observation vessel close enough, they will continue to follow the animal and monitor how long it takes it to return to baseline behavior.

Mitigation and Monitoring Plan

The research project is designed to minimize the potential of any stress, pain or suffering. The following components reflect this design:

- DTAGS would be attached to the animal using suction-cup tags, which are non-invasive. An animal can dislodge the tag with rolling, breaching, or shaking movements.
- Playbacks are designed to avoid sound levels that could cause hearing damage. The maximum received level of 170 dB would be used for playback signals from underwater coherent MF acoustic sources.
- Exposure of animals would be limited to durations required to elicit identifiable behavioral reactions.
- Animals can avoid exposure during the playback experiments by swimming away, and if any such avoidance reactions are observed, subsequent exposures will be carefully designed to take this into account.
- Each close approach for tagging will last a few minutes, and individuals will not be approached more than three times a day.
- The playback subjects will be followed after exposure to monitor for return to baseline behavior. The playback protocol will be modified if there is any evidence of longer term changes.
- The movement and vocal behavior of whales exposed to playbacks will be compared to silent control conditions, and this comparison will be used to help establish minimum exposures associated with detectable reactions.
- A margin of error for safety will be added to account for the possibility that the acoustic models used to predict received level at the animal are not always correct
- If an animal shows a strong attempt to avoid the approaching tagging vessel, or shows a moderate (e.g., hard tail flicks or trumpet blows) or strong reaction (e.g., continuous surges, tail slashes, numerous trumpet blows), as judged by the Weinrich et al. (1992) classification researchers will cease the approach and select a different subject.
- If after three unsuccessful close approaches to an animal for tag attachment, researchers will select a different subject for tagging.
- If there is any sign of prolonged responses that might pose a risk of injury (e.g., panicked flight toward shallow water), playbacks will be suspended. Researchers will communicate with NMFS Office of Protected Resources to develop a protocol to ensure that future playbacks would limit exposure to levels below those likely to expose animals to any such risk.

Permit 1121-1900 includes terms and conditions that limit the research activities, specifies the number and kinds of species that can be taken, and specifies the location and manner of taking. Some of the terms and conditions are as follows:

- Researchers must suspend all permitted activities in the event serious injury or mortality of protected species occurs.
- Researchers must exercise caution when approaching animals and must retreat from animals if behaviors indicate the approach may be life-threatening.
- Researchers must not attempt to tag any cetacean calf less than 1 year old or female accompanied by a calf less than 1 year old.
- A tag attachment event must be discontinued if an animal exhibits a strong adverse reaction to the activity or the vessel (e.g., breaching, tail lobbing, underwater exhalation, or disassociation from the group).

- A playback episode must be discontinued if an animal exhibits a strong adverse reaction to the playback activity or the vessel.
- The Permit Holder must submit annual, final, and incident reports, and any papers or publications resulting from the research to the Office of Protected Resources.

Action Area

The study would be conducted in the Tongue of the Ocean (east of Andros Island, Bahamas), at the U.S. Atlantic Undersea Test and Evaluation Center (AUTEC) range, Andros Island, Bahamas. A portion of the Tongue of the Ocean is outside Bahamian territorial seas.

Status of the Species

The following endangered and threatened species could be present in the area proposed for the research under permit 1121-1900:

Common Name	Scientific Name	Listing Status
Marine mammals		
Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Northern right whale	*Eubalaena glacialis*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Sea Turtles		
Green sea turtle*	*Chelonia mydas*	Endangered/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
Coral		
Staghorn coral	*Acropora cervicornus*	Threatened
Elkhorn coral	*Acropora palmata*	Threatened

Green sea turtles in U.S. waters are listed as threatened except for the Florida breeding population, which is listed as endangered. Because we are unable to distinguish between the populations away from the nesting beaches, green sea turtles are considered endangered wherever they occur in U.S. waters.

No critical habitat has been designated in the action area for any species under NMFS jurisdiction; therefore, no critical habitat will be affected.

Species Not Likely to be Adversely Affected

Coral Species

Major reef-building corals seen off Andros Island are elkhorn corals, staghorn corals, and other corals (U.S. Department of the Navy 1997). However, the habitat of coral species will not overlap with the action area.

Staghorn coral is found throughout the Florida Keys, the Bahamas, and the Caribbean islands. Staghorn coral occur in back reef and fore reef environments from 0-98 feet (0 to 30 m) deep This coral occurs in the western Gulf of Mexico, but is absent from U.S. waters in the Gulf of Mexico. It also occurs in Bermuda and the west coast of South America. The northern limit is on the east coast of Florida, near Boca Raton.

Elkhorn coral was formerly the dominant species in shallow water (3 ft-16 ft [1-5 m] deep) throughout the Caribbean and on the Florida Reef Tract, forming extensive, densely aggregated thickets (stands) in areas of heavy surf. Coral colonies prefer exposed reef crest and fore reef environments in depths of less than 20 feet (6 m), although isolated corals may occur to 65 feet (20 m). Elkhorn coral is found on coral reefs in southern Florida, the Bahamas, and throughout the Caribbean.

The proposed research would occur in the Tongue of the Ocean, in areas outside of the territorial waters of the Bahamas. These coral species are in the shallower, Bahamian territorial waters whereas areas covered by the permit are deeper than at least 183 m (600 ft). Staghorn and elkhorn coral species would not be found in such deep waters.

Baleen whales

The distribution of the blue, fin, sei, and right whales in the North Atlantic Ocean is generally believed to be over entire coastal and offshore areas. However, predicting the presence of any one of these species within the pelagic environment is problematic. Although there are gaps in the information on the locations of these species throughout the year, available information suggest the blue, fin, sei, and right whales would not be in the AUTEC range area.

Several surveys of marine animals have taken place in the Tongue of the Ocean since 2002 (email from D. Claridge 2007). Wood's Hole Oceanographic Institute did a vessel survey in March 2002. Mobley (2004) did aerial surveys in January 2003. The Bahamas Marine Mammal Research Organization has done 5 cruises in Tongue of the Ocean in April and September 2005, March and Oct/November 2006, and May 2007. This organization also conducted shore-based surveys since 1997 off southern Abaco Island which is 80 miles north of the Tongue of the Ocean and collected stranding data, the data for which is available from the OBIS-SEAMAP (Ocean Biogeographic Information System - Spatial Ecological Analysis of Megavertebrate Populations) website (http://seamap.env.duke.edu/).

Several non-listed mammal species were observed during these surveys. The only listed species encountered were the sperm whale, humpback whale, and fin whale. The fin whale was a stranding record from March 2000 and may be the only record of this species in the Bahamas (Bahamas Marine Mammal Research Organization, unpub. data).

Brief descriptions of the location of these species are provided below. These species are likely to occupy waters in more northern latitudes where they feed during the summer. For each of these species, the potential for any interaction with the proposed research activities is extremely unlikely to occur and thus discountable. We do not expect any adverse effects to the blue, fin, sei, and right whales.

Blue Whale. During the spring, summer, and fall, the North Atlantic blue whale population shifts poleward where there may be greater availability of prey during that time (Jonsgård 1966; National Marine Fisheries Service 1998; Yochem and Leatherwood 1985). The majority of western North Atlantic blue whale observations during the spring, summer, and fall take place around Newfoundland, the Gulf of St. Lawrence, and Nova Scotia (CETAP 1982; Sears 1987; Sears 1990; Wenzel *et al.* 1988). The southern extent of its feeding range may be somewhere near 40° N latitude (Abaco Island is at about 25° N latitude) and records suggest occurrence of this species south to Florida and in the Gulf of Mexico. The information above suggests most blue whale would be in more northern latitudes, and the lack of sightings during the surveys in the Tongue of the Ocean suggests the blue whale is unlikely to be present during the proposed research.

Fin Whale. Based on passive acoustic detection using Navy SOSUS hydrophones in the western North Atlantic (Clark 1995), fin whales are believed to move southward in the fall and northward in spring. Fin whales are the most commonly sighted large whale during the winter in the U.S. Atlantic continental shelf waters. As much as a quarter of the spring/summer peak population stay in continental shelf waters year-round (CETAP 1982). During the spring, summer, and fall, fin whales occur along the Atlantic coasts of the U.S. and Canada, with smaller numbers of animals remaining through the winter. Sightings are almost exclusively limited to continental shelf waters inshore of the 1829 m (6000 ft) curve, from the Gulf of Maine south to Cape Hatteras (Agler *et al.* 1993; CETAP 1982). The greatest abundance and widest occupation of fin whales in the northeast U.S. has been shown to occur in the spring (Hain *et al.* 1985). The single record of the fin whale in the Bahamas was a stranding. Strandings occur when a mammal is ill, weak, or lost, suggesting that this species may not be a regular inhabitant of Bahamian waters. In addition, the information above suggests most fin whales would be in more northern latitudes, and the lack of sightings during the surveys in the Tongue of the Ocean suggests the fin whale is unlikely to be present during the proposed research.

Sei Whale. Sei whales are believed to have a migratory pattern – three seasons (spring, summer, and fall) in their feeding grounds and winters in separate calving/breeding grounds (Jonsgård 1966; Kellog 1929). Some sei whales are observed along the continental shelf and shelf edge in the summer, fall, and winter. However, this distribution may be an artifact of survey effort. Indications are that a major portion of the sei whale population in the western North Atlantic is centered in northerly waters such as the Scotian Shelf. The southern portion of this species' range during spring and summer includes the Gulf of Maine and Georges Bank off the northeastern U.S. south to North Carolina. Similar to the blue whale, the information above suggests most sei whales would be in more northern latitudes, and the lack of sightings during the surveys in the Tongue of the Ocean suggests the sei whale is unlikely to be present during the proposed research.

Northern right whale. Most North Atlantic right whale sightings follow a well-defined seasonal migratory pattern through several, consistently utilized habitats (Winn et al. 1986), although whales do occur in these habitats outside the typical seasons and the routes followed by the whales between these seasonal habitats are poorly known. During the spring and early summer, right whales occupy feeding habitats off the coast of Massachusetts; the highest concentrations of sightings occur in Cape Cod Bay in April (Hamilton and Mayo 1990; Kraus and Kenney 1991; Winn *et al.* 1986). The known late summer/fall feeding habitats are in Canadian waters (Gaskin 1987; Gaskin 1991; Kraus and Kenney 1991; Malik *et al.* 2000; Murison and Gaskin 1989; Sutcliffe and Brodie 1977). During the summer-fall feeding season, many animals are at the northern grounds. This pattern combined with the lack of sightings during the surveys in the Tongue of the Ocean suggests the right whale is unlikely to be present during the proposed research.

Sea Turtles

The green, loggerhead, hawksbill, Kemp's ridley, and leatherback sea turtles are known or expected to occur in the waters of the Bahamas. The west coast of Andros Islands is recognized by The Nature Conservancy as foraging grounds for juvenile green and loggerhead turtles, among other marine life, and may be proposed for protection. Green and loggerhead turtles, and perhaps to a lesser extent, leatherback, Kemp's ridley, and hawksbill turtles, could occur in the Tongue of the Ocean (U.S. Department of the Navy 1997). However, these species are probably in lower densities in the Tongue of the Ocean than in the shallow water habitats.

These species are unlikely to be adversely affected by the research activities. They are unlikely to be encountered during research activities and unlikely to be exposed to playbacks because of the short duration of the study (6 weeks) and location of activities in the deep waters of AUTEC. In the event a turtle is present during a playback, it is unlikely to hear the mid-frequency sounds.

The anatomy of sea turtle ears and measurements of auditory brainstem responses of green and loggerhead sea turtles demonstrate that sea turtles are sensitive to sounds, with an effective hearing range within low frequencies (Bartol *et al.* 1999; Lenhardt *et al.* 1983; Lenhardt *et al.* 1985; Ridgeway *et al.* 1969). Although external ears are absent, sea turtles have a tympanum composed of layers of superficial tissue over a depression in the skull that forms the middle ear. The tympanum acts as additional mass loading to the ear, allowing for reduction in the sensitivity of sound frequencies and increasing low frequency, bone conduction sensitivity (Bartol et al. 1999; Lenhardt et al. 1985). Lenhardt et al. (1983) and Moein et al. (1994) found that bone-conducted hearing appears to be an effective reception mechanism for sea turtles (loggerhead and Kemp's ridley) with both the skull and shell acting as receiving surfaces for water-borne sounds at frequencies of 250 to 1,000 Hz. More recently Bartol and Ketten (2006) measured the auditory brainstem response for green and Kemp's ridley sea turtles and found the range of hearing to be from 100 to 800 Hz. Based on this information, it is reasonable to assume that sea turtles are sensitive to low frequency sounds but insensitive to higher frequencies. Therefore, sea turtles are unlikely to hear the mid-frequency playbacks, which will be in the range of 1 kHz to 5 kHz.

To date the hearing ability and sensitivity for leatherback sea turtles have not been examined and is not known. However, it may be reasonable to assume leatherbacks are also likely to hear low frequency sounds. Given that sea turtles are not the focus of the research, are not likely to be encountered during research activities, and that they would be unable to hear the playback sounds, effects to these species would be insignificant. Therefore, the green, loggerhead, hawksbill, Kemp's ridley, and leatherback turtles are not likely to be adversely affected.

Species Likely to be Adversely Affected

The following narratives summarize the current state of knowledge on the life history, overall distribution, and population trends of the sperm whale and humpback whale, the two species that may be adversely affected by permit 1121-1900. These narratives focus primarily on the North Atlantic Ocean populations as these populations would likely be affected by the proposed action. However, sperm whale and humpback whale are listed as single entities without distinctions made on any geographically-isolated populations. The global status and trends of sperm whales, as well as the status and trends of the populations occurring in the North Atlantic Ocean, are included in this section of the Opinion. Only the biological and ecological information necessary to understand the species' status and trend in terms of its risk of extinction and to understand the information presented in the *Environmental Baseline*, *Effects of the Action*, and *Cumulative Effects* sections of this Opinion are presented here.

Sperm Whale

Species Description, Distribution and Population Structure

The sperm whale, an odontocete, is distributed in all of the world's oceans, from equatorial waters to both polar regions. Mature males travel as far as latitude 70ºN in the North Atlantic and latitude 70ºS in the Southern Ocean (Perry *et al.* 1999) whereas mature females and immature sperm whales of both sexes are found in temperate and tropical waters year round and are rarely found higher than latitudes 50ºN and 50ºS. Sperm whales inhabit deep pelagic waters along continental shelf edges and further offshore and are rarely found in waters less than 300 m in depth. They are often concentrated around oceanic islands in areas of upwelling and along the outer continental shelf and mid-ocean waters. However, significant numbers of sightings have occurred in shallow continental shelf waters south of New England and on the Nova Scotian shelf (CETAP 1982; Scott and Sadove 1997).

There is no clear understanding of the global population structure of sperm whales (Dufault *et al.* 1999). One study found moderate, but statistically significant, differences in sperm whale mitochondrial (mtDNA) between oceans (Lyrholm and Gyllensten 1998), but it is generally accepted that sperm whales worldwide are genetically homogeneous (Whitehead 2003). Genetic studies indicate that movements of both sexes over substantial parts of ocean basins are common, and that males, but not females, often breed in different ocean basins than the one in which they were born (Whitehead 2003). Sperm whale populations appear to be structured socially, at the level of the social unit or clan, rather than geographically (Whitehead 2003).

The International Whaling Committee (IWC) designated two sperm whale stocks in the North Pacific: a western and eastern stock (Donovan 1991). The line separating these stocks has been debated since their acceptance by the IWC. NMFS describes in stock assessment reports three discrete population centers of sperm whales in the eastern North Pacific: (1) Alaska, (2) California/Oregon/ Washington, and (3) Hawaii.

In the North Atlantic, the IWC recognizes one North Atlantic sperm whale population (Donovan 1991). However, NMFS describes in stock assessments reports a northern Gulf of Mexico stock and a western North Atlantic stock (Perry et al. 1999, Waring et al. 2007) separate from the northeastern Atlantic stock. It is not yet clear if the northwestern Atlantic stock is truly distinct from the northeastern Atlantic stock (Waring *et al.* 2007). In the western North Atlantic, concentrations of female and immature groups are found in the Caribbean Sea and south of New England along the eastern coast of the United States (Perry et al. 1999). The northern distributional limit of female/immature schools is probably around Georges Bank or the Nova Scotian shelf (Whitehead *et al.* 1991). In the eastern North Atlantic waters, female and immature groups aggregate off the Azores, Madeira, Canary, and Cape Verde Islands (Perry et al. 1999).

In the Northern Indian Ocean the IWC assigned separate stock identities to the Northern and Southern Hemisphere populations in the Indian Ocean (Donovan 1991). Little is known about the Northern Indian Ocean stocks (Perry et al. 1999).

Life History

Female sperm whales become sexually mature at about 9 years of age (Kasuya 1991). Male sperm whales take between 9 and 20 years to become sexually mature, but will require another 10 years to become large enough to successfully compete for breeding rights (Kasuya 1991). The calving interval is estimated to be about four to six years (Kasuya 1991). Female sperm whales rarely become pregnant after the age of 40 (Whitehead 2003).

The age distribution of the sperm whale population is unknown, but sperm whales are believed to live at least 60 years, with females living up to 80 years (Whitehead 2003). Potential sources of natural mortality in sperm whales include killer whales (Whitehead 2003) and papilloma virus (Lambertsen *et al.* 1987).

Sperm whale social groups are composed of mature females and juveniles of both sexes and usually number between 20 to 30 individuals (Barlow and Taylor 2005; Whitehead 2003; Whitehead and Rendell 2004) from one or more matrilineal units (Dufault et al. 1999) In winter, females and immature groups migrate to equatorial waters in both hemispheres (Perry et al. 1999). Sexually mature males lead a mostly solitary existence, but join these groups during the winter (Perry et al. 1999). Research off the coast of Chile indicates that mature males roam between groups of females and juveniles for a few hours at a time, sometimes revisiting the same group over a few days (Jaquet *et al.* 2003). Male dominated hierarchies and/or female choice may be significant factors in sperm whale mating systems (Coakes and Whitehead 2004).

Several authors have established that sperm whales feed primarily on mesopelagic squid, but also consume octopus, other invertebrates, and various species of fish. In the North Pacific, North Atlantic, and waters near New Zealand, medium-sized, bottom dwelling fish form a substantial part of the diet, particularly for male sperm whales (Whitehead 2003). Variables including sea surface temperature, bottom topography, and associated primary productivity are thought to all be important in determining sperm whale distribution (Perry et al. 1999).

Hearing and Acoustics

The hearing abilities of sperm whales can be inferred from the hearing abilities of other marine mammals, their anatomy, and a single auditory brainstem response (ABR) study of a sperm whale neonate that stranded in Texas in September 1989. The calf's ABR wave response peaked at frequencies from 2.5 to 60 kHz, which are similar to those reported for other mammals and very similar to those observed in other odontocetes (Carder and Ridgway 1990). These data suggest that, at least for immature animals, sperm whales may have medium- and high-frequency hearing abilities similar to other smaller odontocete species tested to date. Whether this is true for adult sperm whales is unknown, however, we may assume they are able to hear in the range of their clicks and creaks (0.1 to 20 kHz).

Listing Status

Sperm whales were listed as endangered under the ESA in 1973. They are also protected by the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) and the MMPA. Sperm whales have been protected from commercial harvest by the IWC since 1981, although the Japanese captured sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997) and continues to capture them a research program that involves lethal take of whales. Critical habitat under the ESA has not been designated for sperm whales.

Status and Trends

Past abundance estimates have largely relied on historic whaling data, which the IWC considers unreliable (Perry et al. 1999). Using modern visual survey research, 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 (CV=0.36) whales. Whitehead's (2002) estimate is about 20% of past global abundance estimates which were based on historic whaling data.

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: 32,100 (CV=0.36) based on acoustic detection methods, and 26,300 (CV=0.81) based on visual surveys.

Current estimates for population abundance, status, and trends for the Alaska stock of sperm whales are not available. The most precise, recent estimate for the California/Oregon/ Washington stock of sperm whales is a combined weighted estimate of 1,233 (CV=0.41), based on summer/fall ship surveys conducted in 1996 and 2001 (Carretta *et al.* 2007). The abundance appears to be variable with no obvious trends. The best available abundance estimate for the

Hawaiian stock is 7,082 sperm whales (CV=0.30) with no population trend data available based on a 2002 shipboard line-transect survey of the Hawaiian Islands EEZ (Carretta *et al.* 2007).

Based on historic whaling data, 190,000 sperm whales were estimated to have been in the entire North Atlantic, but catch per unit effort (CPUE) data from which this estimate is derived is unreliable according to the IWC (Perry et al. 1999). According to the 2005 NMFS Stock Assessment Report, the total number of sperm whales in the western North Atlantic is unknown. The best available current abundance estimate for western North Atlantic sperm whales is 4,804 (CV=0.38), based on data from 1998. There is insufficient data to determine the population trend (Carretta *et al.* 2007).

Impacts of Human Activity

Sperm whales were hunted all over the world during the 1800s, largely for its spermaceti oil used during the Industrial Revolution. Harvesting of sperm whales subsided by 1880 when petroleum replaced the need for sperm whale oil (Whitehead 2003). Modern commercial harvest began again in the 1950s through 1981. It is estimated that in the North Pacific between 1800 and 1987, at least 436,000 sperm whales were taken through commercial whaling (NMFS Marine Mammal Stock Assessments). Although the effect of whaling on the sperm whales is uncertain, Whitehead (2003) suggests that whaling may have impacted sperm whale sex ratios, and it may have contributed to a low calving rate in the eastern tropical Pacific. Modern whaling concentrated primarily on males, which may have affected the sex ratio worldwide. In the southeastern Pacific, particularly off Chile and Peru, whaling was especially intense and primarily targeted males.

In 2000, the Japanese Whaling Association proposed to kill 10 sperm whales in the Pacific Ocean for research purposes. Between 2000 and 2004, Japan reported taking 31 sperm whales in the North Pacific (IWC 2005).

Sperm whales interact with commercial fisheries either by becoming entangled in fishing gear and/or by eating fish hooked on long-line gear. In the Pacific, sperm whales are known to have been incidentally taken in drift gillnet operations, which killed or seriously injured an average of 9 sperm whales per year from 1991 to 1995 (Carretta *et al.* 2007). In 1997, the Pacific Offshore Cetacean Take Reduction Plan (Plan) was implemented that prescribed measures to reduce sperm whale entanglements. Since implementation of the Plan, the California/Oregon drift gillnet fishery is estimated to have an average of 1.0 (CV=0.89) sperm whale mortality per year, based on data from 1997 to 2001 (Carretta *et al.* 2007).

Drift gillnet fisheries targeting swordfish and sharks along the Pacific coast of Baja California, Mexico, may also interact with sperm whales (Carretta *et al.* 2007). The swordfish fishery operates similarly to the United States drift gillnet fishery, and it was estimated in 1992 to have approximately 2,700 sets and an observed rate of 10 marine mammals entangled per set, though the exact species entangled were not reported (Carretta *et al.* 2007). In other parts of the world, such as off the coast of Ecuador and in the Mediterranean Sea, mortality as a result of entanglement in gill and drift nets has also been reported (Whitehead 2003). Whitehead (2003) suggests that entanglement alone is not currently threatening sperm whale populations.

Interactions between longline fisheries and sperm whales in the Gulf of Alaska have been reported over the past decade. Observers aboard Alaskan sablefish and halibut longline vessels have documented sperm whales feeding on longline-caught fish in the Gulf of Alaska (Hill et al. 1999) and in the South Atlantic (Ashford *et al.* 1996). 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.

While there have been some reports of sperm whales struck by ships, it does not appear that ship strikes are a significant threat to sperm whales (Whitehead 2003). However, mortality from ship strikes may go unreported because the whales do not always drift inshore afterwards, and if they do, they may not have obvious signs of trauma.

Sperm whales have been known to ingest plastic debris, such as plastic bags (Evans *et al.* 2003; Whitehead 2003). While this has led to mortality, the scale to which this is affecting sperm whale populations is unknown, but Whitehead (2003) suspects it is not substantial at this time.

Summary of Sperm Whales

Sperm whales die fairly often from entanglement in fishing gear, especially pelagic driftnets, and as a result of vessel collisions. There is also concern about the residual effects of whaling. The removal of large males may have reduced pregnancy rates, and the loss of adult females within matricentric pods may have made these groups less well equipped to survive. Because population structure and abundance estimates are largely unknown, it is unclear how the combination of anthropogenic impacts is affecting sperm whale species.

Humpback Whale

Species Description, Distribution, and Population Structure

The humpback whale, a baleen whale, occurs throughout the world's oceans although it is less common in Arctic waters. The species is listed as endangered throughout its range and is generally found over continental shelves, shelf breaks, and around some oceanic islands (see Balcomb and Nichols 1978; Whitehead and Arnbom 1987). Recent tagging data indicates humpback whales may also occur in remote offshore areas. Humpback whales exhibit seasonal migrations between warmer temperate and tropical waters in winter and cooler waters of high prey productivity in summer, although the seasonal distributions of this species are not fully understood (Reeves *et al.* 2004a).

In the Southern Hemisphere, humpback whales occur during winter along the tropical and western sides of continents, along eastern coastlines, and around islands (Perry *et al.* 1999). During the austral summer, the species occurs in South Georgia, the South Shetlands, and along the west and east coasts of Africa, Australia, and South America (Dawbin 1966 as cited in Perry et al. 1999; Tormosov *et al.* 1998). Feeding grounds in the Southern Hemisphere have been linked to breeding grounds and the IWC recently compiled information on these grounds, migration routes, and demographics in the Southern Hemisphere (Bannister 2005).

In the North Atlantic, humpback whales in summer are found in six separate feeding areas in northern waters, covering waters off the eastern coast of the United States (including the Gulf of Maine), the Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, off Iceland, Scotland, northern Norway, and in the Barents Sea (Christensen *et al.* 1992; Katona and Beard 1990; Palsbøll *et al.* 1997; Perry *et al.* 1999). The six regions represent relatively discrete subpopulations (Clapham and Mayo 1987). In the fall and winter, humpback whales from all feeding areas migrate to calving and mating grounds in the Caribbean, where mixing among subpopulations occurs (Bérubé *et al.* 2004; Clapham and Mattila 1993; Katona and Beard 1990; Palsbøll *et al.* 1997; Todd *et al.*). Approximately 85 percent of the humpback whales migrating between higher latitudes on the western side of the North Atlantic to lower latitudes can be found in winter on Silver and Navidad Banks off the coast of the Dominican Republic. The remainder are found in the eastern part of Samana Bay in the Dominican Republic (Mattila *et al.* 1994), the northwest coast of Puerto Rico, the Virgin Islands, and along the eastern Antilles south to Venezuela. In addition, there are reports of humpback whales in winter off Greenland, Norway, Newfoundland, the southern Gulf of Maine, Bermuda, and also in the eastern North Atlantic off the Cape Verde Islands (Katona et al. 1994; NMFS 2006l). The species uses the U.S. mid-Atlantic as a migratory pathway and apparently as a feeding area, at least for juveniles (Swingle *et al.* 1993; Wiley *et al.* 1995). Since 1989, observations of juvenile humpbacks in the mid-Atlantic have been increasing during the winter months, peaking January through March (Swingle *et al.* 1993). Biologists theorize that non-reproductive animals may be establishing a winter feeding range in the mid-Atlantic since they are not participating in reproductive behavior in the Caribbean.

In the North Pacific, humpback whales are found off the Hawaiian Islands, from Mexico north to the Gulf of Alaska and Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and Sea of Okhotsk (Craig *et al.* 1984 as cited in NMFS 1991a; Nemoto 1957; NMFS and USFWS 1991; Tomilin 1957). In Asia, humpbacks have been observed in the vicinity of Taiwan, the Ogasawara Islands, and the Northern Mariana Islands (NMFS and USFWS 1991). Humpback whales are also found in the Arabian Sea of the northern Indian Ocean, but are not thought to migrate to temperate waters, instead foraging and breeding in tropical locations (Mikhalev 1997; Perry *et al.* 1999).

The population structure of humpback whales remains unknown. In the Southern Hemisphere, Donovan (1991) reported four groupings of humpbacks found in IWC Areas II through IV. However, migration of the species between oceans is noted, such as between the Indian Ocean and South Atlantic, based on genetic data (Pomilla and Rosenbaum 2006). Recent compilation by the IWC of data on breeding stocks suggests multiple groupings of humpbacks (Bannister 2005). How such aggregations translate into biological populations is not clear.

In the North Atlantic, the IWC recognizes one stock of humpback whales (Donovan 1991), and in the past humpbacks in the North Atlantic were treated as a single population for management purposes (Waring *et al.* 2001). However, humpback whales in the Gulf of Maine were recently recognized as a separate feeding aggregation based upon the strong fidelity of individual whales to this region; analyses show significant differences in mtDNA haplotype frequencies of the four western feeding areas, including the Gulf of Maine (Palsbøll *et al.* 2001 as cited in Waring et al.

2004). In the winter, whales from all six Atlantic feeding areas (including the Gulf of Maine) mate and calve primarily in the West Indies, where spatial and genetic mixing among sub-populations occurs (Clapham and Mattila 1993; Katona and Beard 1990; Todd *et al.*).

In the North Pacific, NMFS recognizes three stocks of humpback whales for management purposes under the MMPA: the western North Pacific, central North Pacific, and eastern North Pacific. The IWC considers there to be one North Pacific management stock, and there exists no clear consensus on population structure for the species in this ocean (Calambokidis *et al.* 2001).

Life History

The age distribution of humpback whale populations is unknown, but the portion of calves in various populations has been estimated at 4 to 12 percent (Bauer 1986; Chittleborough 1965; Clapham and Mayo 1987; Herman *et al.* 1980; Whitehead 1982). The causes of natural mortality in humpback whales are generally unknown, but possible sources include parasites, disease, predation (e.g., by killer whales, false killer whales, and sharks), biotoxins (such as the algal toxin domoic acid, though no confirmed toxicity events have been reported in whales; Lefebvre *et al.* (1998)), and entrapment in ice (Mitchell 1979).

Humpback whale reproductive activities occur primarily in winter. Gestation takes about 11 months (Hays *et al.* 1985), followed by a nursing period of up to 12 months (Baraff and Weinrich 1993). Calving occurs in the shallow coastal waters of continental shelves and some oceanic islands (Perry *et al.* 1999); and the calving interval is likely two to three years (Clapham and Mayo 1987), although some evidence exists of calving in consecutive years (Clapham and Mayo 1987; Glockner-Ferrari and Ferrari 1985 as cited in NMFS 2005b; 1990; Weinrich *et al.* 1993). Annual pregnancy rates have been estimated at about 0.40–0.42 (Nishiwaki 1959; NMFS unpublished as cited in NMFS 2005), and sexual maturity in humpback whales is reached at between four and six years of age. During the breeding season, humpback whales form small unstable groups (Clapham 1996). The breeding season can best be described as a floating lek or male dominance polygyny (Clapham 1996). On the breeding grounds males sing long, complex songs directed toward females, other males, or both. Competition between males for proximity to females can be intense as expected by the sex ratio on the breeding grounds which may be as high as 2.4:1 (NMFS 2005).

Humpback whales exhibit a wide range of foraging behaviors, and feed on a range of prey types including small schooling fishes, euphausiids, and other large zooplankton. In the Southern Hemisphere, humpbacks feed on krill and *Calanus* spp. in the circumpolar waters of Antarctica. In the North Atlantic, humpback whales are frequently piscivorous, feeding on herring (*Clupea harengus*), sand lance (*Ammodytes* spp.), and other small fishes (Waring *et al.* 2004). In the northern Gulf of Maine, euphausiids are also frequently consumed (Paquet *et al.* 1997). On feeding grounds, dives range from 2.1–5.1 minutes in the North Atlantic (Goodyear unpub. manus. as cited in NMFS 2005); however, because most humpback prey are likely found above 300 m depths, most humpback dives are probably relatively shallow. During the feeding season they form small groups that occasionally aggregate on concentrations of food. Feeding groups are sometimes stable for long periods of times, and there is good evidence of some territoriality on both feeding (Clapham 1996) and wintering grounds (Tyack 1981).

The maximum diving depth for humpback whales is approximately 150 m (usually <60 m), with a very deep dive (240 m) recorded off Bermuda (Hamilton *et al.* 1997). Humpback whales may remain submerged for up to 21 minutes during dives (McSweeny *et al.* 1989).

Hearing and Acoustics

Richardson *et al.* (1995) described categories of humpback whale sound production as including songs produced in late fall, winter, and spring by solitary whales; sounds produced by whales within groups on the winter grounds; and sounds produced while on the summer feeding grounds. Humpback whales are reported to be less vocal when found on their high-latitude feeding grounds in summer compared with their lower-latitude winter ranges (Richardson *et al.* 1995). Au (2000) compiled information on humpback whale vocalizations and reported sounds to include grunts in the frequency range of 25-1,900 Hz (see Thompson *et al.* 1986), pulses in the frequency range 25-89 Hz (dominant frequencies of 25-80 Hz; see Thompson *et al.* 1986), and songs with components ranging from 30-8,000 Hz (dominant frequencies of 120-4,000 Hz; see Payne and Payne 1985).

No studies have directly measured the sound sensitivity of humpback whales; however, like other baleen whales, morphology of its auditory apparatus (Ketten 1997) and vocalizations in the low-frequency range (Richardson *et al.* 1995) indicates the species is able to hear at least low-frequencies. Houser et al. (2001) modeled the audiogram for the humpback whale based on the length of the basilar membrane and data from the cat and human. Houser et al. (2001) predicted sensitivity to frequencies from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 and 5 kHz. We assume that humpback whales can hear the ranges at which they vocalize.

Listing Status

Humpback whales have been listed as endangered under the ESA since 1973; critical habitat has not been designated for this species. The IWC first protected humpback whales in the North Pacific in 1965, and this species is also protected by the Convention on International Trade in Endangered Species of wild flora and fauna (CITES) and the MMPA. The humpback is listed as "vulnerable" under the IUCN Red List of Threatened Species (IUCN 2005a).

Status and Trends

Historically, humpback whale populations worldwide were greatly affected by commercial whaling activities. In the Southern Hemisphere, Soviet whaling after World War II killed over 48,000 humpback whales (Clapham and Baker 2002 as cited in NMFS 2006j). In the 1959/1960 whaling season almost 13,000 humpback whales were harvested, mainly from the high-latitude waters south of Australia, New Zealand, and western Oceania (Clapham and Baker 2002 as cited in NMFS 2006j). This population of humpback whales that use the coastal waters of New Zealand to migrate to the feeding areas to the south collapsed in 1960; sightings of humpback whales have occurred in recent years, although few in number (Clapham and Baker 2002 as cited in NMFS 2006j).

In the western North Atlantic, whaling operations took a total of 522 humpback whales off West Greenland from 1886 to 1976 (Kapel 1979); and operations off eastern Canada from 1903 to 1970 took 1,397 humpback whales (Mitchell 1974). In the eastern North Atlantic and the Arctic, from 1868 to 1955 at least 1,579 humpback whales were harvested; whaling by Spanish and Portuguese vessels also occurred in the eastern North Atlantic (from the mid-1800s to the mid-1950s), but no data are available on the number of whales caught (Perry *et al.* 1999). The IWC granted this stock protected status in the North Atlantic in 1955; however, 11 animals were still harvested for local consumption between 1955 and 1967 in Norway, the Faeroe Islands, and Madeira (Brown 1976; NMFS 2005). A subsistence catch off West Greenland between 1977 and 1982 harvested 81 animals, which exceeded the IWC-recommended quota of 10 whales per year (IWC 1980). From 1988 to 1995, the subsistence harvest totaled nine humpback whales caught off West and East Greenland and St. Vincent and the Grenadines (IWC 1996). The current IWC quota for subsistence harvest of western North Atlantic humpback whales is 20 animals total over the seasons 2003–2007, to be caught by the Bequians of St. Vincent and the Grenadines (IWC 2004).

Although population structure remains uncertain for humpback whales, various studies and estimates of abundance are available. Table 1 contains historic and current estimates of humpback whales by region, management stock, population, or study area. Roman and Palumbi (2003) examined mtDNA from 188 humpback whales and calculated historical abundance for humpback whales globally. Although the authors acknowledge that further, comprehensive genetic studies are needed to verify and refine these estimates, they calculate there may have been as many as 1,000,000 humpback whales worldwide prior to commercial whaling.

In the North Atlantic, historical abundance of humpback whales was calculated by Roman and Palumbi (2003) based on mtDNA. Although the authors acknowledge that further genetic studies are needed to verify and refine these estimates, the authors estimate there may have been as many as 240,000 (95% C.I. = 156,000–401,000) humpback whales in the North Atlantic. Current estimates for the North Atlantic humpback whale population include the estimates by Palsbøll *et al.* (1997) of 4,894 males and 2,804 females, based on genetic tagging data. However, some authors believe the combined total of 7,698 whales to be an underestimate of population size (Clapham 1995; Palsbøll *et al.* 1997). The best available estimate of abundance in the North Atlantic comes from the 2001 analyses of photographic mark-recapture data from 1992–93 by Stevick *et al.* , which generated an estimate of 11,570 humpback whales (as cited in Waring *et al.* 2004).

Current estimates of humpback whale abundance in portions of the North Atlantic are also available. In the Gulf of Maine, Clapham *et al.* (2003) used line-transect survey data from 1999 to estimate between 816 and 902 humpback whales. And in the northeastern North Atlantic, Øien (2001 as cited in Waring et al. 2004) used sighting survey data to generate an estimate of 889 humpback whales in the Barents and Norwegian Seas region.

Several researchers report an increasing trend in abundance for the North Atlantic population, and an independent increase in numbers of individuals sighted within the Gulf of Maine feeding aggregation (Barlow and Clapham 1997; Katona and Beard 1990; Smith *et al.* 1999; Waring *et* *al.* 2001). Katona and Beard (1990) used photographic mark-recapture data to estimate the annual rate of population growth in the North Atlantic humpback whale population at 9.4 percent from 1979 to 1986, although the lower 95 percent confidence interval for this estimate was below zero. Stevick *et al.* also used photographic mark-recapture data and estimated the average annual rate of population increase in the North Atlantic at 3.2 percent. In the Gulf of Maine, Barlow and Clapham (1997) used photographic mark-recapture data and calculated a 6.5 percent increase in the number of individuals seen in that feeding aggregation. Although this indicates that humpback whale abundance appears to be increasing in the Gulf of Maine, since this represents a feeding aggregation and not a discrete population, trends in abundance for the North Atlantic humpback whale population may not be extrapolated from the Gulf of Maine data. Additionally, recent analyses of demographic parameters for the Gulf of Maine by Clapham *et al.* (2003; 2002) suggest a lower rate of increase than the 6.5 percent reported by Barlow and Clapham (1997), but these results may have been confounded by distribution shifts (Waring *et al.* 2004).

Researchers have also reported that calf survival in the North Atlantic population appears to have increased since 1996 (Waring *et al.* 2004); and that since 1989, observations of juvenile humpback whales in the mid-Atlantic have been increasing during the winter months, peaking January through March (Swingle *et al.* 1993).

In the North Pacific, the pre-exploitation population size may have been as many as 15,000 humpback whales (Rice 1978a as cited in Perry et al. 1999), and current estimates place the population at between 6,000 to 8,000 whales (Calambokidis *et al.* 1997). There are currently an estimated 394 humpback whales in the NMFS Western North Pacific stock, based on combined sighting data from 1991–1993 (Angliss and Lodge 2002); 4,005 in the NMFS Central North Pacific stock, based on combined sighting data from 1991–1993 (Angliss and Lodge 2002); and 1,034 in the NMFS Eastern North Pacific stock, based on mark-recapture estimates (Carretta *et al.* 2005). Reliable information is not available to determine population trends for humpbacks in the North Pacific.

In the northern Indian Ocean, little research has been conducted on humpback whales, so available information on their current abundance and trend is limited. The IWC recently compiled information on the humpback whale breeding stocks, including in the Arabian Sea. Feeding and breeding grounds are thought to include waters off the coasts of Oman, Sri Lanka, Pakistan, and India. Mark-recapture data for 2000-2003 indicated an estimated abundance of 56 humpback whales in the breeding stock, with an unknown trend (Bannister 2005).

In summary, commercial whaling in the past significantly depleted humpback whale abundance worldwide. Other anthropogenic factors are currently affecting these whales. Humpbacks are actively hunted today only at Bequia, St. Vincent and the Grenadines, in the eastern Caribbean Sea. Although available estimates of humpback whale abundance involve some uncertainty, current abundance appears to be significantly lower than historic levels in all ocean basins. Reliable information is limited on the abundance trends for this species; however, humpback whale abundance appears to be increasing for several Southern Hemisphere breeding stocks, as well as in the North Atlantic.

Environmental Baseline

By regulation, environmental baselines for biological opinions include the past and present impacts of all state, Federal or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this biological opinion includes the effects of several activities that affect the survival and recovery of the sperm whale and humpback whale in the action area, the Tongue of the Ocean. The climate is semi-tropical, the acoustic environment is quiet, and there is no commercial encroachment. Sperm whales are regularly sighted in the waters of the Bahamas throughout the year. Humpback whales have been sighted less often and mostly in February and March, with one sighting in August (Bahamas Marine Mammal Research Organization, unpublished data).

The *Environmental Assessment on the Effects of Scientific Research Activities Associated with a Behavioral Response Study on Deep-Diving Odontocetes* provides a description of the action area. Offshore of the east coast of Andros Island, a shallow shelf extends 1 to 2 nm forming a lagoon with a coral barrier reef on the seaward side. Seaward of the barrier reef, the rocky bottom slopes downward reaching a depth of approximately 27 m (90 ft) and then drops off sharply to a platform of 182 m (600 ft) depth. The platform is the western edge of the Tongue of the Ocean, a very deep submarine canyon. The water depth is approximately 900 to 2700 m (2950 to 8860 ft). The bottom is mostly fine grained, unconsolidated sediment. The northern portion of the canyon is approximately 128 km (69 nm) long and 31 to 48 km (17 to 26 nm) wide, with a somewhat circular southern portion about 63 km (34 nm) in diameter.

Andros Island is populated by about 10,000 people. The primary activities originating on the Island that occurs in the Tongue of the Ocean are fishing and Navy testing and exercises. Fishing in the Bahamas is carried out by Bahamian fishermen and foreigners that participate in sport fishing and illegal fishing activities. Sport fishing takes place in the Tongue of the Ocean, with catches generally of medium to large pelagic fish, such as dolphin, barracuda, wahoo, and blue marlin. Bahamian fishing boats catch crawfish, groupers, conch, and snappers in the shallow banks and nearshore reefs.

AUTEC is a comprehensive undersea warfare systems test complex that has been in use for over 35 years for testing and training. By the agreement between the U.S. and Bahamas governments, no live warheads or fleet ordnance can be detonated at AUTEC. The range in the Tongue of the Ocean is in water depths greater than 183 m (600 ft). The range has been instrumented with sensors to track multiple platforms, weapons, and other objects and has been used to analyze and assess the performance of undersea warfare weapons, combat systems, and other sensor systems, as well as to provide proficiency assessment of the training participants (Ramirez and Janiesch 1999). It supports training exercises year-round for submarines, ships, and aircraft, as well as research, development, and testing. Undersea warfare test and training operations involve helicopters, surface ships, submarines, aircraft, and other naval assets. AUTEC supports the following programs (AUTEC website: http://www.npt.nuwc.navy.mil/autec/test.htm, accessed July 2007):

- Oceanographic Research Systems Development Tests
- Research and Development Testing of Advanced Undersea Warfare Combat Systems.
- Ship Performance and Maneuvering Standardization Trials
- Sea and Air-Launched Undersea Weapon Evaluations
- Unmanned Vehicle, Weapon, Surface Ship, and Submarine Acoustic Measurements and Performance Evaluations
- Fleet Readiness Test and Training Exercises, including:
    - Over-the-Horizon Targeting (OTH-T)
    - Miniwars
    - Joint Special Warfare Training
    - Mk48/ADCAP Proficiencies and Training Certification Programs
    - Aircraft-Launched Torpedo Exercises
- Range Instrumentation Development Tests
- Surface Ship, Submarine, and Aircraft Sensor Performance and Calibration Tests
- Nonacoustic Sensor Tests
- Mine Warfare Tests
- Land-Based Exercises and Situational Training

An *Environmental Review of the Adoption of a Range Management Plan for the Atlantic Undersea Test and Evaluation Center, Andros Island, Bahamas* was completed in September 1997. The report describes potential impacts on the marine environment to include the following:

- Collision with Navy ships
- Debris from tests and exercises, such as copper guidance wire, parachutes, scuttled sonobuoys, which could entangle organisms in the water column and on the bottom,
- Release of potentially toxic substances, such as fuel, hydraulic fluids, and fluorescein dye
- Small risk of eye damage to marine mammals if directly exposed to a laser beam
- Acoustic energy from sonars, sonobuoys, acoustic targets, small explosive charges, and other sources

The conclusion of the report is that with implementation of the mitigation measures and the monitoring plan, the AUTEC Range Management Plan will not result in significant adverse impacts to the resources of the Bahamas. A section 7 consultation was not sought by the Navy because the actions at the range are not in the U.S., its waters, or the high seas (Department of the Navy 1997).

It is not known whether or to what extent sperm whales or humpback whales have been exposed to the above environmental impacts from Navy activities, and if exposed how they were affected. Seventeen cetaceans, however, stranded on March 15 and 16, 2000, in the Northeast and Northwest Providence Channels coincident with exercises involving mid-frequency sonar (U.S. Department of Commerce 1983). The species that stranded include Cuvier's beaked whales, Blainville's beaked whales, Minke whales, and a spotted dolphin. Seven of the animals died while the others were returned to sea. Examination of 2 animals in fresh condition revealed trauma attributable to acoustic or impulse injuries (Ketten 2005). These strandings demonstrate fatal acoustic impacts to marine mammals. In most instances where whales were exposed to sound sources, whether seismic, sonar, or other sounds, whales altered their behavior without subsequent stranding (see Nowacek et al. 2007).

Major shipping lanes do not occur through the Tongue of the Ocean or near AUTEC. Only small local supply vessels and private fishing or pleasure boats are expected to cross through these areas.

Some scientific research also occurs in the action area, including surveys, which would expose animals to vessel and aircraft. A couple of biopsy samples have also been collected from sperm whales around the Bahamas. Based on a review of available permit monitoring reports, no authorized studies on sperm whales or humpback whales are reported to have caused mortalities. Reported responses of whales to research activities ranged from no visible responses to short-term behavioral responses.

The sources of natural mortality in sperm whales are generally unknown throughout the range of each species. For the *Environmental Baseline*, we assume that possible sources of natural mortality within the action area are similar to those sources across the range of the species, including predation by killer whales or sharks and disease (e.g., papilloma virus in sperm whales).

Summary of the Baseline

The combination of federal, state and private actions, as well as natural factors, may cause effects to sperm whales and humpback whales in the action area. The individual and synergistic effects of these existing factors in the environmental baseline on these marine mammals are not known.

There are at least seven records of strandings of sperm whales and one of humpback whales from the Bahamas (Bahamas Marine Mammal Research Organization, unpublished data). Marine mammals are known to strand for a variety of reasons, but the cause or causes of most stranding are largely unknown (Geraci *et al*. 1976; Odell *et al*. 1980; Best 1982). Several studies suggest that the physiology, behavior, habitat relationships, age, or condition of marine mammals may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. For example, several studies of stranded marine mammals suggest a linkage between unusual mortality events and body burdens of toxic chemicals in the stranded animals (Kajiwara *et al*. 2002; Kuehl and Haebler 1995; Mignucci-Giannoni *et al*. 2000). Another example is the stranding of beaked whales coincident with military exercises. Examinations of the strandings were limited and, therefore, there is no information on the possible causes of these strandings. These strandings could be natural or related to human activities.

With the relatively low vessel traffic and lack of commercial fishing in the Tongue of the Ocean, sperm whales and humpback whales are at lower risk from collision and entanglement, the two main threats to these species, in the action area.

Effects of the Action

Pursuant to Section 7(a)(2) of the ESA, Federal agencies are directed to insure that their activities are not likely to jeopardize the continued existence of any listed endangered and threatened species or result in the destruction or adverse modification of designated critical habitat. "Jeopardize the continued existence of" is defined in regulations as to engage in any action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

Issuance of permit 1121-1900 would allow the applicant to conduct research activities that would directly and incidentally harass sperm whales and humpback whales. In this section, we describe the probable risks of the research activities on individual animals and then integrate those individual risks to identify consequences to the populations, and then to the species. We examined the scientific and commercial data available to determine whether and how these individuals, populations, and species are likely to respond given exposure to the physical impacts associated with the research.

Approach to the Assessment

We measure risks to individuals using their "fitness," the ability to survive and reproduce. In particular, we examine the data available to determine if an individual's probable responses to the agency action's effects are likely to have consequences for the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When individual animals exposed to an action's effects are expected to experience reductions in fitness, we would expect reductions in the abundance, reproduction rates, or growth rates (or increase the variance in these measures) of the population those individuals represent. We then analyze the viability of the populations to determine the risks to the species. On the other hand, when animals are *not* expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations.

In determining whether individual sperm or humpback whales would be affected, it is necessary to analyze when, where, and how an animal would be exposed to the various activities associated with the proposed research. We will first describe the environmental changes brought about by the research and then whether and how animals will be exposed to these changes. Depending on the animal, it could be susceptible to the change such that it "responds" to the environmental change. An example of a response is vocal behavior modification. We examined whether such responses could lead to a change in an animal's ability to survive or reproduce. If we reasonably expect the effects to result in reductions in reproduction, numbers, or distribution, we determine if these reductions can be expected to result in an appreciable reduction in the listed species' likelihood of surviving or recovering in the wild.

There is much we do not know or understand about sperm and humpback whales. During the analysis, we made several assumptions about their ecology, hearing abilities, and behaviors. As to whether hearing impairment or behavioral changes could result in impacts to fitness of individual animals, we provided the rationale leading to our conclusions. To avoid the error of concluding that the animal is not at risk when in fact it is, we assume an effect would occur, thereby providing the "benefit of the doubt" to the species.

For some of those animals that are targeted for study or are present near the targeted animal, the response could rise to the level of harassment such that an animal is "taken." The ESA does not define harassment. However, in this biological opinion, we define harassment as an act which creates the likelihood of injury to an individual animal by disrupting one or more behavioral patterns that are essential to an individual animal's life history or to the animal's contribution to a population, or both. In the open ocean, it is difficult to observe harassment of an animal because animals dive or stay submerged. We can not know in most instances if behavioral patterns would be disrupted, if it is not able to complete some reproduction-related, feeding, or other activity, or if the animal is likely to be injured. We assume that animals are harassed when their behavior appears to be disrupted, such as ceasing to feed or exhibiting avoidance reactions upon exposure to human-made sounds. Information on whether an animal would be disrupted by certain environmental factors is available through published studies and observations. At times, information on closely related species was applied to the listed species considered in this opinion.

Exposure Analysis

The primary target species for the research under permit 1121-1900 are beaked whales. When beaked whales are not available, other deep-diving odontocetes such as the sperm whale would be used as surrogate target species. The permit allows the following activities, which may affect listed species:

- Close approach by vessels,
- Focal follows,
- Tag attachment, and
- Playback of sonar-type, orca, and broadband sounds

Permit 1121-1900 includes the take of up to 13 sperm whales during close approach, tag attachment, and focal follows. Three of these 13 sperm whales may be subjected to playback of sounds. Take by harassment of 113 non-target sperm whales during close approaches to target animals is also included. Another 81 sperm whales could be taken during to playbacks directed at target animals. The take by harassment of 3 humpback whales is included for exposure to playbacks directed at target animals. The targeted animals could include males, females, or juveniles. However, the permit does not allow the tagging of any cetacean calf less than 1 year old or female accompanied by a calf less than 1 year old.

As described under the Description of the Proposed Action, the research would occur during a 6-week period in mid-August through September in the Tongue of the Ocean.

Given that the species in this opinion are in the water column, effects that occur in the air would not affect these animals. Thus, we only discuss those impacts in the water or those that cross the air-water interface.

Vessel Presence and Approach

The Ranger or Blackfin would be used to observe whales and a RHIB would be used to obtain photographs or tag animals. Close approach and focal follows of cetaceans will expose them to the presence of vessels and noise emitted by vessels. Exposed animals may be of any age or sex. The approach of vessels or their presence may be a stressor to sperm and humpback whales, causing disruptions in behaviors and activities or other effects.

Ship propulsion and electricity generation engines, engine gearing, compressors, bilge and ballast pumps, as well as hydrodynamic flow surrounding a ship's hull and any hull protrusions contribute to a large vessels' noise emission into the marine environment. Prop-driven vessels also generate noise through cavitation, which accounts for much of the noise emitted by a large vessel depending on its travel speed. Noise emitted by vessels can be characterized as low-frequency, continuous, and tonal. The sound pressure levels at the vessel will vary according to speed, burden, capacity and length (Richardson *et al*. 1995).

A single focal animal and any animals in its group would be closely approached for photo-identification and/or tag attachment. A close approach is a continuous sequence of maneuvers involving a vessel, aircraft, or researcher's body in the water, including drifting, directed toward a whale or group of whales for research purposes and involving one or more instances of coming closer than 100 yards to the whale or group of whales. Animals would be approached to within 10 m (33 ft) for tag attachment. The focal follows would be conducted from 100-500 m (328-1640 ft) from the animal, depending on weather conditions and visibility from the platform. When binoculars can be used from a ship, focal follows would be done from considerably farther away, often 1 to 2 km (0.54 to 1.08 nm). The focal follow is conducted with a goal of not affecting the behavior of the focal animal, and researchers have seldom detected any sign of behavioral disruption.

The permit requires researchers to exercise caution when approaching animals and to retreat from animal if behaviors indicate the approach may be life-threatening.

Tag Attachment

Up to 13 sperm whales may be tagged. The DTAG would be attached using a 10 to 12 m (33 to 39 ft) pole cantilevered from the bow of the RHIB. The pole would be lowered onto the dorsal surface of the animal caudal to (i.e., behind) the blowhole and closer to the dorsal fin than to the blowhole. The DTAG has a fairing for odontocetes that has been used successfully for sperm whales. With the fairing, DTAG dimensions are approximately 8 in x 4.1 in x 1.4 in (20 x 10 x 4 cm). Attachment durations are expected to be 4 to 12 hours.

The tag can release from the animal in at least three ways. First, the animal can dislodge it by rapid movements or breaching, by rubbing it on the seafloor, or by contact with another animal. Second, the tag can simply release on its own due to slow leakage of the seal between the cup and the animal's skin, repeated diving (i.e., pressure changes) working the suction cup loose, some other mechanical failure, or releasing with sloughed skin. Finally, there is an electrically corrosive wire assembly that will release the tag package (DTAG, batteries, flotation, suction cups, plastic housing, and RF transmitter) from the animal. The corrosive wire assembly is not in contact with the animal at any time, so poses no threat. This usually occurs in 1 to 3 min for surfaced animals, and can take up to 15 min for animals at depth. Because the tag would be attached caudal to the blowhole it has no chance of interfering with breathing as the tag migrates rearward as the animal moves through the water.

Researchers state that tag attachment would be done in a way to minimize disruption: slowly, deliberately, and in as short a time as possible.

Tissue Sampling

Permit 1121-1900 allows collection and import of tissue samples. The only tissue samples to be taken from marine mammals involve the collection of naturally sloughed skin that may adhere to the suction cup portion of the tags after the tags detach. When tags are recovered, the scientific research team would carefully inspect the tags for any sloughed skin that may have adhered to the greasy coating of the suction cup used for attaching the tag. The collection of sloughed skin will not affect the tagged animal because it will be collected after the suction cup is released.

NMFS does not expect any threatened or endangered species to be killed, harmed, or otherwise taken to generate the tissue samples for the proposed research nor is the research likely to create a market for tissue samples from these species. Therefore, we do not expect this element of the proposed permit to reduce the numbers, reproduction, or distribution of threatened or endangered species.

Playback Experiments

The sound source, Eryn I or Eryn II, would be deployed from the vessel for the playback experiments. To control received levels, the vessel may remain stationary or the source vessel may slowly reposition in relation to the subject(s). Before starting each playback, the scientific research team would estimate range to the animal subject using acoustic localization or visual sighting data and adjust the source to achieve a specified received level at the animal. Playbacks would start at a low exposure level and only be increased after no identifiable behavioral reaction has been observed at the lower level. If identifiable behavioral reaction is observed at one exposure level, responses at that exposure would be studied before exposure level is increased. This design minimizes the exposure necessary to define the relationship between exposure and possible responses.

Playbacks would include up to 6 different sets of sounds, including 3 sets of mid-frequency sonar-type sounds, 2 sets of orca sounds, and 1 broadband sound. Table 1 describes the sonar-type sounds. These sounds closely resemble some of the transmissions used by the AN/SQS-53C sonar system employed by the U.S. Navy, including that used during the 2000 Bahamas stranding incident. The starting source level would be 152 dB re 1μPa, for a received level of 90 dB re 1μPa at an animal. The maximum source level is 212 dB re 1 μPa. The researchers will limit the source levels so that no animal is exposed to levels above 170 dB re 1 μPa. The source level will be increased with each ping by 3 dB until an animal response is detected or the

Table 1. Description of sonar-type sounds to be used during playback (provided by Marine Acoustics Inc.)

Sound Sequence in Each Ping	Duration of components	Frequency Band	Duration of Ping/Repetition Interval	Remarks
Set 1				
1. LFM 2. CW 3. CW	500 ms 500 ms 300 ms	Band F3 Band F3 Band F4	1.4 sec/25 sec	100 Hz FM upslide
Set 2				
1. LFM 2. CW 3. LFM 4. CW 5. LFM 6. CW 7. CW	500 ms 500 ms 500 ms 500 ms 500 ms 500 ms 300 ms	Band F3 Band F3 Band F3 Band F3 Band F3 Band F3 Band F4	3.4 sec/25 sec	100 Hz FM upslide 100 Hz FM upslide 100 Hz FM downslide 100 ms separation
Set 3				
1. LFM 2. CW 3. CW	1000 ms 1000 ms 100 ms	Band F2&F3 Band F2&F3 Band F4	2.2 sec/25 sec	400 Hz FM downslide 100 ms separation

CW = Continuous Wave; LFM = Linear Frequency Modulation; ms = milliseconds; PRI = Pulse Repetition Interval

maximum transmit source level of 212 dB is reached. A continuous ramp-up from 152 to 212 dB re 1 μPa would take 10 minutes.

The following provides possible playback scenarios:

- Monitor at least one pre-exposure dive + surface sequence;
- After animal starts next foraging dive, commence PB signals soon after animal starts clicking;
- Start at the proposed minimum source level and slowly ramp up until identifiable behavioral reaction is elicited or maximum exposure level of 170 dB re 1μPa is attained;
- If animal ceases clicking during playback, maintain exposure level to ascertain if clicking resumes;
- After 30 min (nominally) of playback, terminate source transmissions;

    - If animal ceases clicking during playback and some other identifiable behavioral reaction is noted during the dive + surface sequence, monitor at least one post-exposure dive + surface sequence to observe whether their behavior returns to baseline;
    - If an animal ceases clicking during playback and there are no other identifiable behavioral reactions noted during the dive + surface sequence, on the next dive, continue the exposure through cessation of clicking and into the ascent and surface interval;

    - If an identifiable behavioral reaction is detected that does not return to baseline within the post-exposure monitoring period, playbacks would be temporarily suspended to re-evaluate research protocols;

- If animal did not cease clicking, execute next playback same as the first;
- If no identifiable behavioral reaction after full playbacks, use another stimulus signal.

Response Analysis

Effects of Vessel Presence and Approach

The presence or approach of vessels could result in a range of behaviors among sperm whales, from no apparent response to diving away from the vessel. When reactions are observed it is not possible to know if whales are responding to the physical presence of the vessel, noise from the vessel, or both.

A number of published studies report sperm whale reactions to the approach of vessels. Some sperm whales have been observed to be startled by closely approaching vessels (Whitehead *et al.* 1990) and diving abruptly when vessels approached within 200 meters (Würsig *et al*. 1998). Observed reactions of sperm whales in the presence of vessels include erratic surface movements, reduced surface time, fewer blows per surfacing, shorter intervals between successive blows, and increased frequency of dives without raised flukes (Cawthorn 1992, Gordon *et al.* 1992 as cited in Perry *et al.* 1999). Details on the approach and extent and length of reactions were not provided in these studies.

Studies of other whale species demonstrate the variety in responses associated with vessels and boats. Studies of bowhead (*Balaena mysticetus*) and gray whales (*Eschrichtius robustus*) clearly document a pattern of short-term, behavioral disturbance in response to a variety of actual and simulated vessel activity and noise (Malme *et al.* 1983; Richardson *et al.* 1985). Studies of bowhead whales revealed that these whales oriented themselves in relation to a vessel when the engine was on, and a significant avoidance response was invoked simply by turning the engine on, even at a distance of approximately 3,000 ft (900 m). Studies of humpback whales on their summering grounds (Baker and Herman 1989) and on their wintering grounds (Bauer (1986) found similar patterns of disturbance in response to vessel activity.

Jahoda et al. (2003) studied responses of feeding fin whales to vessels approaching with sudden speed and directional changes. Whales were approached repeatedly by a small speedboat within 5 to 10 m for approximately an hour for photo-identification and biopsy sampling. A larger vessel used for observations was also present. Whales suspended feeding indefinitely and changed swimming, diving, and respiratory behavior. Animals were on average 3.7 km from where they were initially approached; a new patch of food may not have been available at the new location. Jahoda et al. (2003) noted that the potential for long-term effects of such disturbance can not be ruled out.

As these studies show variable behavior response to vessels, some of the sperm whales targeted for study and some of the non-target sperm whales and humpback whales that would be affected are likely to respond. The disturbances that would occur during vessel approach, photo-identification, and behavioral observations are expected to be short-lived and not result in changes such that long-term effects would occur. If whales exhibit strong adverse reactions (e.g., breaching, tail lobbing, underwater exhalation, or disassociation from the group) during approach or observation the researchers are to terminate their efforts in accordance with conditions of permit 1121-1900. For whales that exhibit subtle or no changes in behavior when the vessel approaches, we can not be certain that they are not somehow disturbed by the activity. For those whales that exhibit disturbance and alter their behaviors, we can not know if such effects have long-term consequences. However, the conditions of the permit and the cautious methods proposed by the researchers would minimize disturbance of any single animal. Unlike the Jahoda et al. (2003) study of whales, the number of approaches is limited and manner of approach would be slow and careful. Also, the goal of the researchers is better met when targeted animals do not have a pronounced response, particularly in obtaining information from the tags. Assuming that an animal is no longer disturbed after the behavior returns to pre-approach behaviors, we do not expect long-term consequences for the biology or ecology of the individuals affected.

Apart from some disruption of behavior, an animal may be unable to hear other sounds in the environment due to masking by the noise from the vessel. Any masking of environmental sounds or conspecific sounds is expected to be temporary, as noise dissipates with departure of research vessels from an area.

Effects of Tag Attachment

Up to 13 sperm whales could be tagged. The DTAG would be attached by suction cup, using a 10 to 12-ft pole, if researchers are able to close approach the whales. Suction-cup tags have been deployed on blue whales, humpback whales, and sperm whales as well as other species (e.g., gray whales, killer whales, and Dall's porpoise) for attachment of crittercams, time-depth recorders, or other instruments. The suction-cup attachment method is considered the most humane method currently available for attaching instruments to animals, because nothing penetrates the skin and the duration of the attachment is limited.

The tagging protocol involves careful observation of potential behavioral reactions to the approach of the tagging vessel (RHIB) and to the actual tag attachment. Attempts to tag a particular individual will be terminated if the animal shows an adverse reaction to the proximity or behavior of the tagging vessel or after the third failed attachment attempt. A separate observation vessel will record the animal's behavior during all approaches, tag attachment, as well as post-attachment.

Once a DTAG has been attached, the whale may show a momentary startle reaction, roll or turn away and speed up, or slap the tail, but these reactions seldom last more than several seconds. A longer-lasting reaction to tagging that researchers have observed includes different foraging dives soon after the tag attachment (see Jochens *et al.* 2006). Sperm whales often surface for several minutes, blowing many times before a long dive. If they dive earlier after tagging than they otherwise would have, the next foraging dive involves normal diving and foraging behavior but may be shorter than the dives before or after the dive immediately following tag attachment.

Few studies have systematically investigated or recorded the effects on cetaceans from tagging, and available investigations into instrument effects on marine species are often limited to visual assessments of behavior (Walker and Boveng 1995). In addition, reactions to tagging are difficult to differentiate from reactions to close vessel approaches, because in all cases it is necessary to closely approach the whale to ensure proper tag placement. Evidence available on the short-term effects of tagging whales indicates that responses vary from little to no observable change in behavior to momentary changes such as skin twitching, startle reactions or flinching, altered swimming speed and orientation, diving, rolling, head lifts, high back arching, fluking, and tail swishing (Goodyear 1981; Watkins *et al.* 1981; Watkins *et al.* 1984; Goodyear 1989; Goodyear 1993; Baird 1994; Mate *et al.* 1997; Mate *et al.* 1998; Hooker *et al.* 2001). Infrequently, aerial displays like breaching are also noted (Goodyear 1989); and Mate *et al.* (2007) reports other infrequent behavioral responses as including fluke slaps and swishes, head lunges, defecation, decreased surfacing rates, disaffiliation with a group of whales, evasive swimming behavior, or cessation of singing (in the case of humpback whales). Cetaceans frequently react when hit by tags delivered by remote devices such as tagging poles, but are also known to react when tags miss and hit the water. Behavioral responses are noted to be short-term (Mate *et al.* 2007), with the likelihood of a reaction possibly depending on an individual's behavioral state at the time of tagging (Hooker *et al.* 2001).

At least 3 recent, separate studies of sperm whales using tags show variability in response to tagging. Davis et al. (Davis *et al.* 2007) successfully tagged (barb attachment) 5 sperm whales. These whales reacted with tail strokes followed by shallow dives but researchers noted no unusual behaviors or aggression to the tagging vessel. In contrast, 12 sperm whales tagged (suction-cup attachment) by Palka and Johnson (2007) exhibited a high rate of breaching. They noted the breaching could have been due to tag attachment, and resulted in shorter tagging periods. In the Gulf of Mexico, Jochens *et al.* (Jochens and Biggs 2003) analyzed buzz rates and pitching movements of tagged (suction-cup attachment) sperm whales during the bottom foraging portion of dives. The behavior during the first dive differed significantly from subsequent dives and the researchers attributed the difference to the tag operation.

Whether any long-term effects result from tagging remains largely unknown and available information is limited. No research has been done to assess the long-term impacts of tagging; however, Goodyear (1989) noted that humpback whales monitored several days after being suction-cup tagged did not appear to exhibit altered behavior. In addition, Mate *et al.* (2007) found that tagged whales resighted up to three years later did not appear in poor health and did not appear to behave differently than untagged whales.

In addition, studies using tags necessitate a tagged animal returning to its normal behavior after being tagged, because the purpose of these studies is to examine whale movement and habitat use and behavioral patterns such as diving and foraging.

Although these tags would create hydrodynamic drag, the proportion of the tag to a whale's size and weight is such that the energetic demand on the whale would likely be insignificant. The tag, while it is attached, is generally not expected to alter the behavior of the whales and it would likely continue with its behavior. Disturbance of whales while the tag is attached could arise from the vessel or aircraft following the animal. The procedures include tracking of the animal via vessel or aircraft after the tag is successfully attached. If tracking of the animal continues as an animal attempts to avoid the vessel or aircraft, the animal could be disturbed for a prolonged period.

Given that the permit conditions specify that the permit holder terminate activities if the animals exhibit extremely evasive or high energy behaviors and the researchers are to exercise caution when approaching or conducting research activities around animals and immediately terminate the activity if the animals appear in any way to be affected adversely by the activity. Following these conditions would likely avoid disturbing listed species for prolonged periods and would not result in injuries, particularly injuries that might affect the feeding, reproductive, or migratory behavior of the individual animal.

Based on the above, NMFS does not expect the proposed tagging to result in injuries to the 13 or fewer sperm whales individual whales. With implementation of the permit conditions, the tagging is expected to result in temporary interruptions of behaviors of target whales and of whales near the target whales. In the above studies, the behavior of the tagged animals was tracked for hours or days. These behaviors are assumed to be 'normal' or the same behaviors as without the tag. Thus, tag attachment is expected to only change a whale's behavior temporarily and these disruptions are not expected to lead to reduced opportunities in reproduction or distribution.

Effects of Playbacks

The purpose of the research is to identify behavioral responses to playbacks. With the data gather by DTAGs, behavioral responses not visible during playbacks may be elucidated. Playbacks may be directed at tagged sperm whales and if the animals are in groups, other sperm whales could also be exposed. Humpback whales may also be exposed to playback sounds. For example, the maximum source level of 212 dB for the Eryn I source would provide a maximum received level of 155 dB at an animal at 2 km from the source. Any humpback whales within 2 km of the source or even outside this distance would likely be able to hear the sounds.

Sonar is expected to affect sperm whales and humpback whales because of their assumed hearing abilities and past observations. Sonar playbacks would be mostly between 3 and 4 kHz, which falls within the assumed hearing range for sperm whales and humpback whales. As described previously, the hearing abilities of sperm whales can be inferred from the hearing abilities of other marine mammals, their anatomy, and a single auditory brainstem response (ABR) study of a sperm whale neonate that stranded in Texas in September 1989. The calf's ABR wave response peaked at frequencies from 2.5 to 60 kHz, which are similar to those reported for other mammals and very similar to those observed in other odontocetes (Carder and Ridgway 1990). Low-frequency hearing was not tested. These data suggest that, at least for immature animals, sperm whales may have medium- and high-frequency hearing abilities similar to other smaller odontocete species tested to date. Whether this is true for adult sperm whales is unknown. However, we may assume they are able to hear in the range of their clicks and creaks (0.1 to 20 kHz).

No studies have directly measured the sound sensitivity of humpback whales; however, like other baleen whales evidence indicates the species is able to hear at least low-frequencies based on the morphology of its auditory apparatus (Ketten 1997) and vocalizations in the low-frequency range (Richardson *et al.* 1995). Houser et al. (Houser *et al.* 2001) modeled the audiogram for the humpback whale based on the length of the basilar membrane and data from the cat and human. Houser et al. (2001) predicted sensitivity to frequencies from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 and 5 kHz. We assume that humpback whales can hear the ranges at which they vocalize (25 to 8,000 Hz).

Sound is critical in the marine environment and cetaceans rely on sounds to capture prey, communicate with conspecifics, avoid predators, and fulfill other needs. The introduction of human-caused sounds can cause disruptions or harm whales in several ways. For example, whales have moved away from their feeding and mating grounds (Bryant *et al.* 1984; Morton and Symonds 2002; Weller *et al.* 2002), moved away from their migration route (Richardson *et al.* 1995), and have changed their calls due to noise (Miller *et al.* 2000). Sonar exposures have lead to mass stranding events (Cox *et al.* 2006). Acoustic exposures can also result in noise-induced hearing loss that is a function of the interactions of three factors: sensitivity, intensity, and frequency (Finneran *et al.* 2002). Loss of sensitivity is referred to as a threshold shift; the extent and duration of a threshold shift depends on a combination of several acoustic features and is specific to particular species (temporary or permanent threshold shift [TTS/PTS], depending on how the frequency, intensity and duration of the exposure combine to produce damage). In addition to direct physiological effects, noise exposures can impair an animal's sensory abilities (masking) or result in behavioral responses such as aversion or attraction. The proposed research could expose sperm whales to playbacks at controlled received levels and expose other non-target sperm whales and humpback whales to playbacks.

Below are evaluations of the general information available on the variety of ways in which cetaceans have been reported to respond to sound, generally, and mid-frequency sonar, in particular. Then we assess the probable responses of sperm whales and humpback whales given their probable exposure to playbacks.

Stranding and Auditory Injury

Over the past two decades, several "mass stranding" events – strandings involving two or more individuals of the same species (excluding a single cow-calf pair) and at times, individuals from different species – have been associated with naval operations and other anthropogenic activities that introduce sound into the marine environment (Canary Islands, Greece, Vieques, U.S. Virgin Islands, Madeira Islands, Haro Strait, Washington State, Alaska, Hawaii, North Carolina). The stranding events that occurred in the Canary Islands and Kyparissiakos Gulf in the late 1990s and the Bahamas in 2000 have been the most intensively-studied mass stranding events and have been associated with naval maneuvers that were using sonar. Although these events did not involve threatened or endangered species, we consider them in this Opinion to determine if sperm whales or humpback whales are likely to strand following potential exposure to mid-frequency sonar-type sounds.

Several authors have noted similarities between some of these stranding incidents. They occurred around islands or archipelagoes with deep water nearby, several appeared to have been associated with acoustic waveguides like surface ducting, and the sound fields created by ships transmitting mid-frequency sonar (Cox *et al.* 2006; Thode *et al.* 2000). Although Cuvier's beaked whales (*Ziphius cavirostris*) have been the most common species involved in these stranding events (81% of the total number of stranded animals), other beaked whales (including *Mesoplodon europeaus*, *M. densirostris*, and *Hyperoodon ampullatus*) comprise 14% of the total. Other species including odontocetes and mysticetes (*Stenella coeruleoalba*, *Kogia breviceps* and *Balaenoptera acutorostrata*) have stranded, but in much lower numbers and less consistently than beaked whales. It is not clear whether (a) Cuvier's beaked whale is more prone to injury from high-intensity sound than other species, (b) its behavioral response to sound makes it more likely to strand, or (c) it is substantially more abundant than the other affected species at the times and places of exposure.

Because the association between the various sonars and stranding marine mammals is not consistent (some marine mammals strand without being exposed to sonar and some sonar transmissions are not associated with marine mammal strandings despite their co-occurrence), other risk factors or a groupings of risk factors probably contribute to these strandings. With the information gathered for past mass strandings in the Bahamas 2000, Madeiras 2000, Canaries 2002, and Spain 2006, the Navy avoids the following conditions, which in their aggregate, may contribute to a marine mammal stranding event:

(1) Areas of at least 1000 m depth near a shoreline where there is a rapid change in bathymetry on the order of 1000-6000 meters occurring across a relatively short horizontal distance (e.g., 5 nm).

(2) Cases for which multiple ships or submarines (≥ 3) operating mid-frequency active sonar in the same area over extended periods of time (≥ 6 hours) in close proximity (≤ 10 NM apart).

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

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

Conditions 1, 3, and 4 are present in the Tongue of the Ocean. Condition 2, however, would not be present. Sound would be generated by a single source, rather than multiple, up to a maximum source level of 212 dB re 1 μPa. Sound exposures would be controlled so that the maximum received level would be 170 dB re 1 μPa and exposures are not likely to last longer than 3 hours. As for surface ducting, researchers will be taking sound velocity profile measurements prior to playbacks so that, if there are surface ducts, playback protocols can be modified to accurately control received levels. Given the control over the single sound source, the precautions taken by the researchers, and that sperm whales and humpback whales have not been observed to strand in connection with mid-frequency active sonar exercises, we do not anticipate sperm whales to strand as a result of the research proposed under permit 1121-1900.

Behavioral and Stress Responses

Behavioral, and possibly stress, responses are the most likely effects to sperm whales and humpback whales during the research. For the up to 3 sperm whales that may be directly exposed to mid-frequency playbacks and 81 non-target sperm whales and 3 non-target humpback whales also exposed, available information from whales suggests that some of these whales will exhibit behavioral responses. Information on stress responses is also provided below.

Sperm whale clicking and behavior has been observed to be disrupted by sonars (Goold 1999; Watkins and Schevill 1975; Watkins *et al*. 1987), 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 echolocations in the presence of underwater pulses made by echosounders (Watkins and Schevill 1975). Goold (1999) reported six sperm whales that were driven through a narrow channel using ship noise, echosounder, and fishfinder emissions from a flotilla of 10 vessels. Watkins and Schevill (1975) showed that sperm whales interrupted click production in response to pinger sounds (6 to 13 kHz). 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 reacted to military sonar, apparently from a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent, and becoming difficult to approach (Watkins *et al.* 1987).

Studies of captive animals provide some quantitative data on behavioral responses. Captive bottlenose dolphins and a white whale exhibited changes in behavior when exposed to 1 second pulsed sounds at frequencies similar to those emitted by multi-beam sonar that is used in geophysical surveys (Ridgway *et al.* 1997; Schlundt *et al.* 2000), and to shorter broadband pulsed signals (Finneran *et al.* 2000; Finneran *et al.* 2002). Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran *et al.* 2002; Schlundt *et al.* 2000). Dolphins exposed to 1- second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa_{rms} and belugas did so at received levels of 180 to 196 dB and above. Received levels necessary to elicit such reactions to shorter pulses were higher (Finneran *et al.* 2000; Finneran *et al.* 2002). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran *et al.* 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway *et al.* 1997; Schlundt *et al.* 2000). The relevance of these data to free-ranging odontocetes is uncertain. In the wild, cetaceans some-times avoid sound sources well before they are exposed to the levels listed above, and reactions in the wild may be more subtle than those described by Ridgway *et al.* (1997) and Schlundt *et al.* (2000).

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

Studies of sperm whales in the northern Gulf of Mexico in 2002-2003 also resulted in no changes to gross diving behavior or movement (Jochens and Biggs 2003). Tagged whales were exposed to received levels from airgun pulses between 130 and 162 dB re 1 µPa (peak to peak). Detailed dive and vocalization data was gathered during pre-exposure, exposure, and post-exposure periods and compared. The whale that was approached most closely prolonged a surface resting bout hours longer than typical, but resumed foraging immediately after the airguns ceased. Although their sample size is small and pre-exposure data had to be omitted, the information analyzed thus far suggests foraging behavior is affected. Bayesian analysis of the controlled exposure experiments suggests the odds are about three times more likely that there is a 20% reduction in foraging during airgun exposure than that there is no effect (Jochens *et al.* 2006).

Although stress-induced pathologies have been hard to identify in free-ranging marine mammals, based on work with terrestrial mammals, it is likely that marine mammals would experience the same responses. The stress caused by pursuit and capture activates similar physiological responses in terrestrial mammals (Harlow et al. 1992) and cetaceans (St. Aubin and Geraci 1992). In the case of many stressors, the first and most economical (in terms of biotic costs) response is behavioral avoidance of the potential stressor or avoidance of continued exposure to a stressor. An animal’s second line of defense to stressors involves the autonomic nervous system and the classical “fight or flight” response which includes the cardiovascular system, the gastrointestinal system, the exocrine glands, and the adrenal medulla to produce changes in heart rate, blood pressure, and gastrointestinal activity that humans commonly associate with stress. These responses have a relatively short duration and may or may not have significant long-term effect on an animal’s welfare.

An animal’s third line of defense to a stressor involves its neuroendocrine systems, usually hormones associated with the hypothalamus-pituitary-adrenal system (most commonly known as the HPA axis in mammals or the hypothalamus-pituitary-interrenal axis in fish and some reptiles). Unlike stress responses associated with the autonomic nervous system, virtually all neuroendocrine functions that are affected by stress – including immune competence, reproduction, metabolism, and behavior – are regulated by pituitary hormones. In the majority of stress studies, the HPA axis has been the primary neuroendocrine axis monitored. Stress-induced changes in the secretion of pituitary hormones have been implicated in failed reproduction (Lariviere *et al.* 2000; Moberg 1985) and altered metabolism (Elasser *et al.* 2000), immune competence (Blecha 2000) and behavior. Increases in the circulation of glucocorticosteroids (cortisol, corticosterone, and aldosterone in marine mammals) have been equated with stress for many years.

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

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

Although no information has been collected on the stress-related 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 sounds.

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

During the research, we expect up to 84 takes of sperm whales and 3 humpback whales exposed to the playbacks to respond, by avoiding the areas of sonar transmissions, ceasing to vocalize or forage, or other behavior changes. The behavioral responses may or may not be in conjunction with elevated stress hormones. Responses may be heightened during playback of orca (natural predator) sounds and could lead to "distress." As there is much variability in the responses of animals, some whales may tolerate the sounds or some animals may be habituated to sonar sounds because the action area is a Navy training range that includes activities emitting mid-frequency sonar sounds. If animals are habituated, the animals may be less likely to exhibit responses. Given that the playbacks would be few and each session lasting a short time (e.g., 3 hours), any response is expected to be short-term. Furthermore, researchers will look for a return to their habitats and resume their feeding, socializing, and other ecological behaviors. Thus, these responses are not expected to impact overall growth or survival of any animals.

Acoustic Masking

Marine mammals use acoustic signals for a variety of purposes, which differ among species, but include communication between individuals, navigation, foraging, reproduction, and learning about their environment (Erbe and Farmer 2000a; Tyack 2000). Auditory interference, or masking, generally occurs when the interfering noise is louder than, and of a similar frequency to, the auditory signal received by the animal that is processing echolocation signals or other information from conspecifics. Some of the sperm whales or humpback whales taken during the research may be affected from the masking of conspecific or other environmental sounds. Masking these acoustic signals can disturb the behavior of individual animals, groups of animals, or entire populations. Masking is also influenced by the amount of time that the noise is present. Animals can also determine the direction from which a sound arrives based on cues, such as difference in arrival times, sound levels, and phases at the two ears. Thus, an animal's directional hearing capabilities have a bearing on its vulnerability to masking (National Research Council 2003). Richardson et al. (1995) argued that the maximum radius of influence of an industrial noise (including broadband low frequency sound transmission) on a marine mammal is the distance from the source to the point at which the noise can barely be heard. This range is determined by either the hearing sensitivity of the animal or the background noise level present.

Most masking studies have measured captive animals' ability to detect signals at a single frequency (pure tones) in the presence of broadband background noise (Southall *et al.* 2000). Other studies have played back sounds that are encountered in the ocean, such as noises associated with icebreaker activity (Erbe and Farmer 2000b). Researchers found that icebreaker noise (from on-board bubbler systems and propeller cavitation), as well as naturally occurring sounds from cracking ice, masked the calls of a beluga whale. Animals may try to minimize masking by changing their behavior. These behavior changes may also include producing more calls, longer calls, or shifting the frequency of the calls. A long-term study of three social groups (pods) of killer whales suggests that killer whales may change their vocal behavior once background noise reaches a threshold level (Foote *et al.* 2004). Scientists compared killer whale calls recorded in the presence and absence of boat noise at three time periods between 1977 and 2003. They found longer call durations for all three pods in the presence of boats during the 2001-2003. The number of whale-watching vessels increased approximately fivefold from 1990 to 2000, and the scientists suggest that the ambient noise from the increased number of boats crossed the masking threshold, causing the killer whales to change their vocal behavior. There are still many uncertainties regarding how masking affects marine mammals. For example, it is not known how loud acoustic signals must be for animals to recognize or respond to another animal's vocalizations (National Research Council 2003). It is also unknown if animals listen to all the sounds they can hear or select which sounds they want to listen to. The potential impacts that masking may have on individual survival, what things marine mammals may do to avoid masking, and the energetic costs of changing behavior to reduce masking, are poorly understood.

Sperm whales have been observed to frequently stop echolocations in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975; Watkins et al. 1985). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Furthermore, because of sperm whales' apparent role as important predators of mesopelagic squid and fish, changes in their abundance could affect the distribution and abundance of other marine species. Intensive statistical analyses of aerial survey data showed some subtle shifts in the distribution of humpback and possibly sperm whales away from the Pioneer Seamount source during ATOC transmission periods (Calambokidis et al. 1998). However, Au et al. (1997) determined that the ATOC signal had a minimal effect on physical and physiological effects of cetaceans.

Humpback whales responded to sonar in the 3.1–3.6 kHz by swimming away from the sound source or by increasing their velocity (Maybaum 1993). The frequency or duration of their dives or the rate of underwater vocalizations, however, did not change. In a controlled exposure experiment involving low frequency active sonar sound, humpback whales responded with longer songs when the playback was louder (Fristrup *et al.* 2003). Nowacek *et al*. (2004) conducted controlled exposure experiments on North Atlantic right whales using ship noise, social sounds of con-specifics, and an alerting stimulus (frequency modulated tonal signals between 500 Hz and 4.5 kHz). Animals were tagged with acoustic sensors (DTAGs) that simultaneously measured movement in three dimensions. Whales reacted strongly to alert signals at received levels of 133-148 dB re 1 μPa, 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.

Masking of sperm and humpback whale sounds is probable during the proposed research. Animals able to hear sonar transmissions may not hear the vocalizations of conspecific whales or have reduced foraging success. Such interruptions in communications and feeding are expected to be temporary, without significant impacts on foraging success or inter and intra-specific communication.

Cumulative Effects

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

We are not aware of any future State, local, or private activities that are reasonably certain to occur in the Tongue of the Ocean.

Integration and Synthesis for Sperm Whales

In the *Status of the Species* and *Environmental Baseline*, we described the uncertainty in the abundance and trends of sperm whales. The threats from entanglement in fishing gear, vessel collisions, noise, and other human-related impacts probably persist to hinder the recovery of sperm whales. The proposed action presents a threat to individual sperm whales. The research involves the approach and presence of research vessels, tag attachment, and playback of sonar-type, orca, and broadband sounds. Up to 207 sperm whales could be taken under permit 1121-1900. Up to 13 of these animals may be closely approached and tagged, 3 of which could be exposed directly to playbacks. These activities would result in variable behavioral and possibly stress responses. Although the potential effects of each activity was described separately, a few sperm whales could be closely approached, tagged, and exposed to playbacks over the course of several hours. The sequence of activities could result in more than one incidence of harassment, such as when closely approached and when exposed to sonar-type sounds. The goal of the research is to gather information on the minimal behavior changes associated with exposure to sounds. As described above, the responses are expected to be temporary without any lasting effects on the essential behaviors of sperm whales. Since the research involves monitoring and observation of animals in a post-exposure and possibly post-tagging period, the researchers would have some opportunity to verify return to normal behaviors.

The intent of the researchers and conditions in permit 1121-1900 would result in cautious methods and the suspension of research if strong adverse reactions are observed. We do not expect any injury or auditory impairment. Therefore, temporary disruptions in behavior, whether a whale is feeding, resting, or socializing, is not expected to result in a reduction in any individual sperm whale's likelihood of surviving, reproducing, or completing another aspect of its life history. As we discussed earlier, an action that is not likely to reduce the fitness of individual sperm whales would not likely reduce the viability of the populations those individual whales represent. As a result, the proposed permit would not be expected to appreciably reduce the sperm whales' likelihood of surviving and recovering in the wild.

Integration and Synthesis for Humpback Whales

In the *Status of the Species* and *Environmental Baseline*, we described the uncertainty in the abundance and trends of humpback whales. However, there is some evidence that Atlantic populations could be increasing, if the data is not an indication of shifting distributions. Trends for the other ocean basins remain unknown. Treats from entanglement in fishing gear, vessel collisions, and other human-related impacts probably persist to hinder the recovery of humpback whales. Like for the sperm whale, the proposed action does present a threat to individual humpback whales. Permit 1121-1900 allows the exposure to playback sounds of up to 3 non-target humpback whales. These activities could result in variable behavioral and possibly stress responses. However, as described above, these responses are expected to be temporary without lasting effects on essential behaviors. Therefore, temporary disruptions in behavior, whether a whale is feeding, resting, or socializing, is not expected to result in a reduction in any individual humpback whale's likelihood of surviving, reproducing, or completing another aspect of its life history. As we discussed earlier, an action that is not likely to reduce the fitness of individual sperm whales would not likely reduce the viability of the populations those individual whales represent. As a result, the proposed permit would not be expected to appreciably reduce the sperm whales' likelihood of surviving and recovering in the wild.

Conclusion

After reviewing the current status of the sperm whales and humpback whales, the environmental baseline for the action area, the effects of the proposed research, and the cumulative effects, it is NMFS' biological opinion that the issuance of permit 1121-1900 is not likely to jeopardize the continued existence of these species. Critical habitat has not been designated for these species so critical habitat will not be affected.

Incidental Take Statement

Section 9 of the Act and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS as an act which actually kills or injures fish or wildlife and may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding, or sheltering. Harass is defined by FWS as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

However, as discussed in the accompanying biological opinion, the scientific research permit includes takes of animals targeted by the proposed research activities, and those near the target animals that may be harassed as part of the intended purposed of the proposed action. Therefore, NMFS does not expect the take threatened or endangered species incidental to the proposed research permit.

Reinitiation Notice

This concludes formal consultation on the NMFS' proposed issuance of scientific research permit 1121-1900. Reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, section 7 consultation must be reinitiated immediately.

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