DRAFT ENVIRONMENTAL ASSESSMENT

ON THE EFFECTS OF SCIENTIFIC RESEARCH ACTIVITIES ASSOCIATED WITH A BEHAVIORAL RESPONSE STUDY ON DEEP DIVING ODONTOCETES

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Abstract: The National Marine Fisheries Service (NMFS), Office of Protected Resources (OPR), proposes to issue a scientific research permit for takes of marine mammals in the wild, pursuant to the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1361 et seq.). The primary objective of the proposed 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 permit applicant intends to use this information to determine the acoustic exposures of mid-frequency (MF) sonar sounds that elicit an identifiable behavioral indicator response in beaked whales. The applicant would 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. Additionally, the applicant proposes to conduct photo-identification of cetaceans and collect skin samples for import into the United States. The action area for the proposed study is international waters outside of the U.S. Atlantic Undersea Test and Evaluation Center (AUTEC) site, Andros Island, Bahamas. Scientific research permits are generally categorically excluded from the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 et seq.) requirements to prepare an environmental assessment (EA) or environmental impact statement (EIS) (NAO 216-6). An EA is being prepared to examine whether significant environmental impacts could result from issuance of the proposed scientific research permit.

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ACRONYMS AND ABBREVIATIONS

ABR	Auditory Brainstem Response
ADC	Analog-Digital Converter
ATOC	Acoustic Thermometry of Ocean Climate
AUTEC	U.S. Atlantic Undersea Test and Evaluation Center
BRS	Behavioral Response Study
CA	Close Approach
CEE	Controlled Exposure Experiment
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
CI	Confidence of Intervals; Co-Investigator
CITES	Convention on International Trade in Endangered Species
cm	centimeter(s)
CV	Coefficient of Variation
dB	decibel(s)
DDT	Dichloro-diphenyl-trichloroethane
DOC	Department of Commerce
DON	Department of the Navy
EA	Environmental Assessment
EFH	Essential Fish Habitat(s)
EIS	Environmental Impact Statement
EKG	Electrocardiogram
ESA	Endangered Species Act
Et seq	Et sequencial
FAO	Fisheries and Agriculture Organization
FF	Focal Follow
FM	Frequency Modulated
FOEIS	Final Overseas Environmental Impact Statement
FONSI	Finding of No Significant Impact
FR	Federal Register
ft	feet
Gb	Gigabyte(s)
GOMEX	Gulf of Mexico
hr	hour
Hz	Hertz
ICW	Intra-Coastal Waterway
IUCN	International Union for Conservation of Nature and Natural Resources
JASA	Journal of the Acoustical Society of America
kHz	kiloHertz
km	kilometer(s)
km/hr	kilometer(s) per hour
kt	knot(s): nautical mile(s) per hr
LF	Low Frequency
m	meter(s)
MF	Mid-Frequency
Mb	Megabyte(s)
mi	mile(s) (statute)
MICA	Mesure de l'Impact des Catures Accessoires
min	minute(s)
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
NEO	NOAA Executive Order
NEPA	National Environmental Policy Act of 1969

NMFS NOAA NURC NUWC	National Marine Fisheries Service National Oceanic and Atmospheric Administration NATO Undersea Research Centre (formerly SACLANTCEN) Naval Underwater Warfare Center
OEIS OPR OV	Overseas Environmental Impact Statement Office of Protected Resources Observation and tracking Vessel
Pa PB PBV PCB Pers. Comm. ppt psu PTS	Pascal Playback Play Back Vessel Poly-Chlorinated Biphenyls Personal Communication parts per thousand Parts per thousand salinity units Permanent Threshold Shift
RL rms	Received Level root mean squared
SACLANTCEN SAG SARA SCANS sec SEL SL SONAR SPE SPL Spp SRP	Supreme Allied Commander, Atlantic: Undersea Research Centre Surface Action Group Canada's Species at Risk Act Small Cetaceans in the North Sea Second(s) Sound Exposure Level Source Level SOund Navigation And Ranging Society of Petroleum Engineers Sound Pressure Level Species Scientific Research Permit
TAV TL TOTO TTS	Tag Attachment Vessel Transmission Loss Tongue of the Ocean Temporary Threshold Shift
UN U.S. or US U.S.C.	United Nations United States United States Code
WHOI WTV	Woods Hole Oceanographic Institution Whale Observation/Tag tracking Vessel
YoNAH	Years of the North Atlantic Humpback Whale
Symbols	
=	Equal to
/	Divided by
+	Plus
≥	Greater than or equal to
>	Greater than
<	Less than
~	Approximately
±	Plus or minus
µ	Micro (10^{-6})
Log	Logarithm

CHAPTER 1 PURPOSE OF AND NEED FOR ACTION

1.1 Description of Action

In response to receipt of an application from the National Marine Fisheries Service (NMFS) Office of Science and Technology, (File No. 1121-1900), NMFS proposes to issue a scientific research permit for "takes"[1] by "level B harassment"[2] of marine mammals in the wild pursuant to the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1361 et seq.), the regulations governing the taking and importing of marine mammals (50 CFR part 216), the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et seq.), and the regulations governing the taking, importing, and exporting of endangered and threatened species (50 CFR 222-226).

The scientific research activity proposed by the permit applicant 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 permit applicant would use this information to determine the acoustic exposures of mid-frequency (MF) sonar sounds that elicit an identifiable behavioral indicator response in beaked whales. The permit applicant would use this information to determine the acoustic exposures of mid-frequency (MF) sonar sounds that elicit an identifiable behavioral indicator response in beaked whales. The permit applicant would then 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. This would be done by performing a multi-stimulus behavioral response study (BRS) to assess responses of beaked whales and other deep-diving odontocetes to underwater natural sounds, novel synthetic sounds, and MF sonar sounds. In addition to beaked whales, other marine animals may be intentionally exposed to experimental sounds, including melon-headed whales, short-finned pilot whales, Risso's dolphin, and endangered sperm whales. As shown in Table 1 in Chapter 2 of this draft EA, other marine animals may also be unintentionally exposed to experimental sounds, including endangered blue, fin, sei whales, and northern right whales.

1.1.1 Background

Increasing evidence suggests the potential for exposure to intense underwater sounds in some settings to cause beaked whales to strand, and some of the stranded animals may die (Simmonds and Lopez-Jurado, 1991; Frantzis, 1998, Cox et al. 2006). Some reports on this problem correlate

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1 Under the MMPA, "take" is defined as to "harass, hunt, capture, kill or collect, or attempt to harass, hunt, capture, kill or collect." [16 U.S.C. 1362(18)(A)] The ESA defines "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." The term "harm" is further defined by regulations (50 CFR §222.102) as "an act which actually kills or injures fish or wildlife. Such an act 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."

2 "Harass" is defined by regulation (50 CFR §216.3) as "Any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing a disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but does not have the potential to injure a marine mammal or marine mammal stock in the wild (Level B harassment)."

the strandings with military sonars at source levels of 226+ dB that are operated intermittently for many hours in the mid frequency band (SACLANTCEN, 1998; DOC and DON, 2001). The dominant species in these strandings is Cuvier's beaked whale, *Ziphius cavirostris*, but the genus *Mesoplodon* is also involved. Thus, most marine mammal strandings that are coincident with MF sonar exercises have involved beaked whales. Until the causes of these strandings can be identified, (and possibly dose:response relationships defined) it will remain difficult to discriminate an actual hazard from random coincidences of human activities and natural strandings. One of the most direct and precise ways to test whether MF sonar sounds could pose a risk of stranding is to conduct BRSs, including a combination of observational studies and carefully controlled experiments on safe and early indicators of responses that may be linked to a causal chain of events leading to stranding.

The permit applicant proposes a two-phase field research project (2007-2008) to conduct BRSs of various underwater sounds to marine mammals (including beaked whales and other odontocetes). The exposures would be carefully controlled and measured near the subjects to make it possible to titrate what acoustic exposure leads to an indicator response. This type of field research has been repeatedly identified by the National Research Council (1994; 2000; 2003; 2005) as a critical data need and was specifically identified as the foremost data need regarding beaked whales and sonars at the Marine Mammal Commission (MMC) symposium on beaked whales two years ago (see Cox et al., 2006)[3]. The report of the UK Inter-Agency Committee on Marine Science and Technology (IACMST) Working Group on Underwater Sound and Marine Life (IACMST, 2005) also recommended BRS-type experiments "to yield much needed quantifiable information on the effects of different sound sources on marine animals." Additionally, the permit applicant proposes to collect skin samples and import them into the United States and conduct photo-identification of marine mammals.

The ignorance of the causal chain of events leading from sonar exposure to stranding, and the absence of direct dose:response information makes it exceedingly difficult to effectively regulate various activities critical to national and economic security, including the use of active military sonar and offshore oil/gas exploration technologies.

The goal of Phase I of the BRS (2007) is to determine the acoustic exposures of mid-frequency (MF) sonar sounds that elicit an identifiable behavioral indicator response in beaked whales. The goals of Phase II (2008) would depend upon Phase I results, but are planned to include acoustic exposures of underwater coherent/incoherent[4] sounds in order to attempt to understand the initial

3 Cox, T.M., T.J. Ragen, A.J. Read, E. Vox, R.W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernandez, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houser, Y. Hullar, P.D. Jepson, D. Ketten, C.D. MacLeod, P. Miller, S. Moore, D.C Mountain, D. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Mead, and L. Benner. 2006. Understanding the impacts of anthropogenic sound on beaked whales. J. Cetacean Res. Manage. 7(3):177-187.

4 In the most general sense, coherency can be defined as a measure of the phase and amplitude relationship between a set of acoustic waves (Etter, 1991). Thus, coherent sound signals are typically narrow bandwidth transmissions (nominally less than 100 Hz) where the phase and amplitude of a signal at any given time can be known or predicted based on a previous known amplitude and phase measurement of that signal (e.g., most sonar systems, including fathometers, military sonars, etc.). Effectively, coherent signals are made up of pure tones or a mathematically-defined sequence of pure tones. Incoherent sound signals (e.g., explosives, airguns, etc.) are wider bandwidth signals (nominally thousands of Hz) where the exact phase and amplitude of any particular frequency component of the

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.

1.1.2 Hypotheses to be Tested (BRS)

1. Do beaked whales have a behavioral and/or physiological response to MF active sonars that can be associated with risk of stranding?
2. Can one identify a safe behavioral response that indicates risk of stranding?
3. Do beaked whales show similar responses to underwater natural predator sounds?
4. Do other deep-diving odontocetes show similar responses?
5. Can one define acoustic exposures that can elicit the behavioral indicator for each species and stimulus type?

The first hypothesis would be tested by examining behavioral responses to underwater MF sounds (initiated with the animal at depth), including 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 (PAM) from the research vessels, PAM and localization data from the AUTEC range hydrophones, and data from electronic tags on the target animal(s). These responses would be compared to those predicted as the possible cause of sonar-related strandings in Cox et al. (2006). Every effort would be made to ensure that these exposures do not pose a risk to the subjects, and a primary effort of Phase I (2007) would be to define a safe behavioral indicator of risk of stranding; i.e., a response that, while safe in itself because of low intensity or short duration, can be related to a causal hypothesis for strandings that coincide with MF sonar sounds.

Dose:Response analyses would include assessment of:

1. Any relationship between received level (RL) and magnitude of behavioral response;
2. Any relationship to distance and other physical factors (e.g., relative movement) between sound source and animal, and magnitude of behavioral response.

1.1.3 Manner in Which the Activity Involves the Taking of Marine Mammals (BRS)

Although the primary species of concern are beaked whales, the responses of other odontocete species would be monitored. Plans are for beaked whales to be the primary subjects for tagging and playback experiments during Phase I (2007), to be conducted in the Tongue of the Ocean (east of Andros Island, Bahamas) and primarily on the U.S. Atlantic Undersea Test and Evaluation Center (AUTEC) range, Andros Island, Bahamas. However, when beaked whales are not available, other deep-diving odontocetes would be used as surrogate target species, such as pilot whales, melon-headed whales, sperm whales and Risso's dolphins (see Table 1). The subjects would be purposely exposed to anthropogenic underwater MF sounds, photo-identified, tagged and, due to the nature of tagging, skin samples would be collected and exported to the U.S. Hence, the permit applicant requests the importation of skin samples into the U.S., close

signal most likely would not be predictable. There are exceptions; e.g., broadband coherent sonars, such as chirp sonars, used for seafloor geophysical exploration, have bandwidths of 10 kHz or more.

approach for photo-identification, as well as intentional MMPA Level B takes of target and unintentional Level B takes of non-target marine mammals that could possibly be in the vicinity of the BRS research area outside of the Bahamian territorial seas[5] in the Tongue of the Ocean. Visual and passive acoustic monitoring, and other safeguards would be implemented to minimize to the greatest degree possible the potential for Level A takes of marine mammals; and there would be clear source shutdown criteria to limit exposure to Level B harassment before any injurious behavioral responses occur.

The minimum exposure level for Phase I would be selected using data from exposures of beaked whales to underwater MF sound on the AUTEC range. One of the benefits of conducting the first tests on an undersea range where beaked whales can be acoustically monitored with existing permanent seafloor hydrophones is that it is possible to assess exposures where there is no noticeable change in location and timing of foraging dives vs. exposures associated with changes in behavior, such as cessation of vocalization. Data from AUTEC, collected during range exercises involving underwater MF sound and during control periods (no underwater anthropogenic sound) would help define exposures at the onset of beaked whale click cessation, which would be factored into the minimum animal RL for Phase I playbacks.

References to Underwater Sound Levels
1. References to underwater sound pressure level (SPL) in this SRP application are values given in decibels (dBs), and are assumed to be standardized at 1 microPascal at 1 m (dB re 1 µPa at 1 m [rms] for Source Level (SL) and dB re 1 µPa [rms] for Received Level (RL), unless otherwise specified. 2. References to underwater Sound Exposure Level (SEL) in this SRP application are the measure of sound energy flow per unit area expressed in dB, and are assumed to be standardized at dB re 1 μPa^2-s, unless otherwise stated.

The proposed Phase I field research activity is planned as a pilot experiment of approximately 6 weeks in the summer/fall of 2007. The Tongue of the Ocean (east of Andros Island, Bahamas) and primarily on the AUTEC range, has been selected for the 2007 field experiment. Phase II (2008) part 1 is planned for the AUTEC range, and part 2 would be at another site in the eastern North Atlantic (including Gulf of Mexico) or the Mediterranean Sea.

Dates of Proposed Research	**Location of Proposed Research**	**Ports of entry**	**Remarks**
Jun 07 thru Oct 07 Phase I	Tongue of the Ocean (east of Andros Island, Bahamas) (AUTEC range)	US, Bahamas	AUTEC is US land leased from Bahamas; a portion of the Tongue of the Ocean is outside Bahamian territorial seas

5 U.S. MMPA does not apply within a foreign country's territorial seas.

Jan 08 thru Dec 08	Eastern N. Atlantic, including Gulf of Mexico, and Med.	TBD	

AUTEC = Atlantic Undersea Test and Evaluation Center

1.1.4 Purpose and Need

There is a distinct and validated need for field research to understand behavioral and physiological responses of beaked whales to underwater anthropogenic sounds, including MF sonar sounds, and how these may pose a risk of stranding and/or injury. NOAA, Navy, and the marine biological research community in general, have not been able to gain a firm grasp on the acoustic mechanism of the observed effects on beaked whales from MF sonar sounds. This has hampered various efforts of the U.S. government to meet its mandated requirements for marine conservation while enabling military training activities that are critical to national security. The behavioral response studies to be undertaken under the proposed SRP would benefit future efforts at minimizing underwater sound impacts to beaked whales through better understanding of their responses to MF sonar sound signals. Comparison of responses of beaked whales to other odontocetes in turn could provide benefit to all deep-diving odontocete species, and would contribute to general understanding of the reactions of marine mammals to underwater sound exposure.

The proposed two-phase BRS research activity (2007-2008) is a study that would examine the responses of deep-diving odontocetes (including beaked whales) to various underwater coherent/incoherent sounds. The purpose of the field research is to quantify the behavioral responses of deep-diving odontocetes to known acoustic exposure events. This type of field research has been repeatedly identified by various reports by the National Research Council (1994; 2000; 2003; 2005) as a critical data need and was unanimously identified as the foremost data need regarding beaked whales and sonars at the Marine Mammal Commission (MMC) symposium on beaked whales two years ago (see Cox et al., 2006). Also, the absence of direct behavioral information on the potential effects of active military sonar and offshore oil/gas exploration on odontocetes is clearly one of the most challenging issues facing NMFS in managing oceanic noise issues.

The permit applicant intends to use this study to determine the acoustic exposures of mid-frequency (MF) sonar sounds that elicit an identifiable behavioral indicator response in beaked whales. The permit applicant would then 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. This would be done by performing a multi-stimulus behavioral response study (BRS) to assess responses of beaked whales and other deep-diving odontocetes to underwater natural sounds, novel synthetic sounds, and MF sonar sounds. The need for the proposed action also arises from NMFS' mandates under the MMPA and ESA. Specifically, NMFS has a responsibility to implement both the MMPA and the ESA to protect, conserve, and recover marine mammals and threatened and endangered species under its jurisdiction. The MMPA and ESA prohibit takes of marine mammals and threatened and endangered species, respectively, with only a few very specific exceptions, including for scientific research and enhancement purposes. Permit issuance criteria require that research activities are consistent with the purposes and polices of these Acts and would not have a significant adverse impact on the species or stock.

1.1.5 Objectives

The objective of the proposed research is to observe behavioral responses in several deep diving cetacean species (especially beaked whales) exposed to natural and artificial underwater sounds, quantify exposure conditions associated with various effects, collect skin samples (as a result of tagging of animal subjects), and conduct photo-identification of animal subjects targeted for close approaches, focal follows and tagging.

1.2 Other EA/EIS that Influence Scope of this EA

There are two EAs that influence the scope of this EA. The two separate EAs, prepared by NMFS in 2000 and 2003, evaluated the environmental impacts of issuing a scientific research permits to study the effects of controlled exposure of sound on the behavior of various species of marine mammals. Each of the documents is summarized below.

In response to an application (Permit No. 981-1578) from Dr. Peter Tyack, Woods Hole Oceanographic Institution (WHOI), for a permit to conduct research involving exposure of marine mammals to mid- and high-frequency sound, NMFS prepared an EA on the effects of controlled exposure of sound on the behavior of various species of marine mammals (NMFS 2000). The primary research objective was to determine what characteristics of exposure to specific sounds evoke minor behavioral responses in marine mammals. The EA examined the environmental consequences of two alternatives: No Action (denial of the permit) and the Proposed Action (permit issuance), which included mitigation measures that would be implemented as part of the permit. The specific playback protocols examined involved exposure of animals to playbacks of low-power, mid- to high-frequency active sonar designed to detect marine mammals. The proposed RLs for the playbacks were not to exceed 160 dB. Other characteristics of the signals included bandwidths of 100, 200, and 400 Hz; pulse durations of 50, 100, 200, and 400 milliseconds; chirp upsweeps centered at 1, 2.5, 4, 8, and 12 kHz; and a pulse repetition rate of not more than one ping per minute. A Finding of No Significant Impact (FONSI) was signed on August 31, 2000, based on information indicating that the short-term impacts of conducting acoustic playback experiments on cetaceans would not result in more than a temporary shift in the hearing thresholds of some individual cetaceans, and that changes in the behavior (to avoid the sounds) of individual animals were expected to have negligible impacts on the animals, and the species.

A second EA was prepared on the effects of controlled exposure of sound on the behavior of various species of marine mammals in response to another application submitted by Dr. Tyack (NMFS 2003). The principal differences in the proposed action for the second EA compared to the first were an expanded geographic scope and an increase in the sound levels produced. The second application and EA were prepared following litigation involving Dr. Tyack's original permit (No. 981-1578), in which the court invalidated amendments to the permit that were not specifically analyzed in the first EA (Hawaii County Green Party vs. Evans, C-03-0078-SC, U.S. District Court, Northern District of California). A FONSI for the second EA was signed in June 2003, based on information indicating that the short-term impacts of conducting acoustic playback experiments on cetaceans would not result in more than a temporary shift in the hearing thresholds of some individual cetaceans, and that changes in the behavior (to avoid the sounds) of individual animals were expected to have negligible impacts on the animals, and the species.

Although they were not for the same geographic area as the proposed action, analysis of the information in these EAs demonstrated that the potential impacts of the proposed action would be limited to the biological environment and, more specifically, to marine organisms within range of the sounds from the anthropogenic sound-producing systems proposed in this EA. Based on the information analyzed in these EAs there are not likely to be any measurable impacts from the proposed action on social or economic aspects, nor on the physical environment. Similarly, invertebrates, fish, sea turtles, and sea birds that may be within the range of the sounds from the anthropogenic sound-producing systems proposed in this EA are not likely to be affected, for reasons discussed in these previous EAs, and summarized in Chapters 3 and 4 below. Thus, the issues within the scope of this EA are primarily related to the potential impacts of the proposed action on marine organisms, especially marine mammals.

1.3 Decision and other Agencies Involved in this Analysis

NMFS must decide whether issuing a scientific research permit for the proposed action would be consistent with the purposes and policies of the MMPA, ESA, and NMFS implementing regulations, including making certain the permitted activities would not operate to the disadvantage of any endangered or threatened species. Pursuant to 50 CFR § 216.33 (d)(2), NMFS consults with the Marine Mammal Commission (MMC) in reviewing an application for a scientific research permit under the MMPA. However, NMFS has sole jurisdiction for issuance of scientific research permits pursuant to the MMPA and ESA for cetaceans. Thus, no other agencies are directly involved in this analysis.

1.4 Scoping Summary

The purpose of scoping is to identify the issues to be addressed and the significant issues related to the proposed action, as well as identify and eliminate from detailed study the issues that are not significant or that have been covered by prior environmental review. An additional purpose of the scoping process is to identify the concerns of the affected public and Federal agencies, states, and Indian tribes. CEQ regulations implementing the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 et seq.) do not require that a draft EA be made available for public comment as part of the scoping process. The MMPA and its implementing regulations governing issuance of special exception permits for scientific research (50 C.F.R. §216.33) require that, upon receipt of a valid and complete application for a permit, and the preparation of any NEPA documentation that has been determined initially to be required, NMFS publish a notice of receipt in the Federal Register. The notice summarizes the purpose of the requested permit, includes a statement about whether an EA or EIS was prepared, and invites interested parties to submit written comments concerning the application. A notice of receipt of the application was not published in the Federal Register for public comment, nor forwarded to the MMC for review prior to completion of this draft EA. The application is available for public comment and review by the MMC concurrent with this draft EA.

This EA, in conjunction with consultation under Section 7 of the ESA, examines whether the potential impacts of the proposed action on a limited number of marine mammals are likely to result in an adverse effect on the species to which the individuals belong. This EA will also examine the potential impacts of the proposed action on the human environment, including whether issuance of the permit in the proposed action would, in conjunction with other related actions, result in cumulatively significant effects.

1.5 Federal Permits, Licenses, and Entitlements Necessary to Implementation of the Action

Persons seeking an exemption from the take moratoria established by the MMPA and ESA must apply for permits. In the case of marine mammals (except walrus, polar bears, sea otters, manatees and dugong), such permit must be obtained from NMFS. Appendix A describes the statutory and regulatory requirements for obtaining a permit for research on marine mammals, including species listed as threatened or endangered. This Appendix also lists the terms and conditions with which permit holders must comply.

In general, NMFS does not require permits, licenses, and entitlements from other federal agencies in order to issue permits for scientific purposes under the MMPA or ESA. However, if NMFS' issuance of permits may adversely affect ESA-listed species under the jurisdiction of the FWS, NMFS is required, under Section 7 of the ESA, to consult with FWS. If FWS determines that permit issuance would result in taking of listed species where such taking is incidental to the purpose of the action and would not be likely to jeopardize the continued existence of listed species under FWS jurisdiction, or destroy or adversely modify critical habitat, FWS may provide an exception for specified levels of "incidental take." An incidental take statement provides an exemption from the taking prohibitions of section 9 of the ESA, but only where NMFS and/or the permit applicant can demonstrate clear compliance with the implementing terms and conditions. These terms and conditions are binding on NMFS and implement reasonable and prudent measures intended to minimize the impact of incidental take on listed species. These measures may in turn become binding conditions of any permit issued by NMFS.

If FWS determines that NMFS issuance of permits would jeopardize the continued existence of listed species under FWS jurisdiction, or destroy or adversely modify critical habitat, FWS may identify reasonable and prudent alternatives. Reasonable and prudent alternatives are actions FWS believes would avoid the likelihood of jeopardy to the species or destruction or adverse modification of critical habitat. NMFS must agree to adopt these measures in issuing permits in order to avoid jeopardy or adverse modification.

While NMFS may not require permits or licenses to implement its permits, permit holders may sometimes need to secure additional federal, state or local permits or licenses to conduct the research specified in their NMFS permit. In addition, NMFS regulatory permit issuance criteria (50 CFR § 216.35) stipulates that "Persons who require state or Federal licenses to conduct activities authorized under the permit must be duly licensed when undertaking such activities." This regulatory requirement is a made a condition of all NMFS permits.

CHAPTER 2 ALTERNATIVES INCLUDING THE PROPOSED ACTION

This chapter describes the range of potential actions (alternatives) determined reasonable with respect to achieving the stated objective, as well as alternatives eliminated from detailed study. This chapter also summarizes the expected outputs and any related mitigation of each alternative.

One alternative is the No Action alternative, or Status Quo alternative, where the proposed permit would not be issued. The Status Quo is the baseline for rest of the analyses. "No Action" does not mean that there would be no environmental consequences because there may be existing activities that have an impact on the environment. However, under the status quo alternative the baseline remains unaltered by the proposed action. In general, there can be impacts on the environment under the No Action alternative that result from not implementing an action that would otherwise have mitigated or minimized impacts from other human actions. The Proposed Action alternative represents the research proposed in the submitted application with the addition of special terms and conditions standard in NMFS scientific research permits and other conditions determined appropriate by NMFS.

2.1 Alternative 1 – No Action

Under this alternative, which is the "status quo" alternative, a new permit for scientific research to conduct a behavioral response study on deep diving odontocetes would not be issued at this time. Sounds would not be introduced and none of the study objectives would be met. In the absence of the proposed study, additional information about deep divingodontocetes' response and sensitivity to specific sounds would not be collected nor available for use by NMFS in making better informed management decisions.

2.2 Alternative 2 – Proposed Action

Under Proposed Action alternative, a one-year scientific research permit would be issued to NMFS Office of Science and Technology authorizing takes of marine mammals by Level B harassment as described in the application. Authorized research would include close approach for attachment of instruments, photo-identification, and behavioral observations or target animals. Harassment by exposure to the types of sounds described in the application would also be authorized. The permit would authorize collection and importation of skin samples for analysis. Visual and passive acoustic monitoring would be implemented to ensure no Level A takes of marine mammals; and there would be clear source shutdown criteria to limit exposure to Level B harassment before any injurious behavioral responses occur.

Although the primary species of concern are beaked whales, the responses of other odontocete species would be monitored. Plans are for beaked whales, pilot whales, sperm whales, melon-headed whales, and Risso's dolphins to be the primary subjects for tagging during Phase I (2007), to be conducted at the AUTEC site, Andros Island, Bahamas. Responses of other cetaceans and pinnipeds may also be monitored as possible, using focal follow techniques (which are further defined in this subchapter), including visual and acoustic monitoring. If beaked whales are not tested in Phase I, the strongest effort possible would be toward including them in Phase II (2008). The subjects would be purposefully exposed to natural and artificial underwater sounds and quantify exposure conditions associated with various effects.

The exposure range for Phase I would be selected to include exposures associated with changes in behavior of beaked whales at AUTEC. One of the benefits of conducting the first tests on an undersea range where beaked whales can be acoustically monitored with permanent seafloor hydrophones is that it is possible to assess exposures where there is no noticeable change in location and timing of foraging dives vs. exposures associated with changes in behavior, such as avoidance or cessation of vocalization. Data from AUTEC, collected during range exercises involving underwater MF sound and during control periods (no underwater anthropogenic sound) would help define exposures at the onset of beaked whale click cessation, which would be factored into the minimum animal RL for Phase I playbacks.

Under the Proposed Action alternative, a permit would authorize the intentional exposure of sperm whales, Cuvier's beaked whales, Mesoplodon spp., short-finned pilot whales, Risso's dolphins, and melon-headed whales to underwater natural sounds, novel synthetic sounds, and coherent/incoherent sounds. This is proposed to be accomplished through a two-phase approach. The goal of Phase I of the BRS (2007) is to determine the acoustic exposures of mid-frequency (MF) sonar sounds that elicit an identifiable behavioral indicator response in beaked whales. The goals of Phase II (2008) would depend upon Phase I results, but are planned to include acoustic exposures of underwater coherent/incoherent[6] sounds in order 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. The permit would also authorize unintentional exposure of a number of other marine mammals under NMFS jurisdiction to the MF sonar, as outlined in Table 1 below.

Hypotheses to be Tested:

1. Do beaked whales have a behavioral and/or physiological response to MF active sonars that can be associated with risk of stranding?
2. Can one identify a safe behavioral response that indicates risk of stranding?
3. Do beaked whales show similar responses to underwater natural predator sounds?
4. Do other deep-diving odontocetes show similar responses?
5. Can one define acoustic exposures that can elicit the behavioral indicator for each species and stimulus type?

The hypotheses proposed are discussed further in Subchapter 1.1.2.

Kinds of Approaches and Follows

Close approach (CA) – A CA is defined as any approach to a single focal animal including any animals in its group to $\leq$15 m (49 ft) to allow for tag attachment and/or photo-identification. Animals need to be CA'd to within $\leq$10 m (33 ft) for tag attachment. This would be done in a way to minimize disruption: slowly, deliberately, and for as short a time as possible. Following the recommendations of NMFS, the permit applicant is requesting as takes, and would report, all approaches within this range, regardless of whether signs of behavioral disruption during such

6 In the most general sense, coherency can be defined as a measure of the phase and amplitude relationship between a set of acoustic waves (Etter, 1991). Thus, coherent sound signals are typically narrow bandwidth transmissions (nominally less than 100 Hz) where the phase and amplitude of a signal at any given time can be known or predicted based on a previous known amplitude and phase measurement of that signal (e.g., most sonar systems, including fathometers, military sonars, etc.). Effectively, coherent signals are made up of pure tones or a mathematically-defined sequence of pure tones. Incoherent sound signals (e.g., explosives, airguns, etc.) are wider bandwidth signals (nominally thousands of Hz) where the exact phase and amplitude of any particular frequency component of the signal most likely would not be predictable. There are exceptions; e.g., broadband coherent sonars, such as chirp sonars, used for seafloor geophysical exploration, have bandwidths of 10 kHz or more.

approaches are observed. One reason for such an extremely conservative approach is that the environmental analysis is based in part upon the requested number of takes. If this is higher than expected, then the analysis would be particularly conservative. It is appropriate that this permit authorize any potential takes, because subtle signs of disruption of behavior may be found in post-test analyses.

Focal Follow (FF) – Following a single focal animal (typically, but not exclusively, the tagged animal) or several whales in a group including the focal animal during the tagging evolution to relate data on the tag to observed surface behaviors. Sometimes focal follows can be conducted on individuals using natural markings, and behavioral data from this kind of FF can be useful, but many focal follows in the requested permitted research would use the tag to facilitate the FF. Since a radio transmitter on the tag broadcasts the bearing to the whale every time the tagged whale surfaces, and since the tag itself is visible, it is possible to follow tagged whales from standoff distances considerably farther than non-tagged whales. Where possible, the FF may include time before the tag is attached and after the tag releases from the animal to determine any effects of tagging on behavior. These focal follows are typically 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 can be performed from considerably farther away, often 1-2 km (0.54-1.08 nm). The FF is conducted with a goal of not affecting the behavior of the focal animal, and researchers seldom have detected any sign of behavioral disruption. However, following recommendations of NMFS, the permit applicant is requesting focal follows as takes, and would report all focal follows, whether or not behavioral disruption was observed, because this is a setting in which it is possible that it might occur. This overestimate makes analyses of possible impact very conservative.

Playbacks (PB) – PBs involve a series of experiments, starting at a low exposure level, and only increasing exposure after no significant disruption of biologically important behavior has been observed at the lower level. If significant disruption of biologically important behavior is observed at one exposure level, responses at that exposure would be carefully studied before exposure is changed. This design minimizes the exposure necessary to define the relationship between exposure and possible responses.

The Phase I PB experiments would use underwater sound projectors capable of producing MF sounds. The vessel-based PBs may involve a stationary source of sound, or the source vessel may slowly reposition in relation to the subject(s). The RL at the subject animal would be limited to less than a maximum sound exposure level, which would be set below levels that might cause injury. The permit applicant proposes a maximum RL at the whale of 170 dB SPL for underwater MF coherent sounds. The permit applicant would take all scientifically reasonable precautions in controlling the SL of the PBs to ensure the RL at the animal would not exceed the maximum RL above. Before starting each PB, the scientific research team would estimate range to the animal subject using acoustic localization or visual sighting data and adjust the SL to achieve a specified RL at the animal. PBs involve a series of experiments, starting at a low exposure level, and only increasing exposure 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 carefully studied before exposure level is increased. This design minimizes the exposure necessary to define the relationship between exposure and possible responses.

Tagging – This is the attachment of the digital archival recording tag to a single focal animal via suction cup. Each attempt to attach a tag is counted as a take, regardless of whether attachment is successful. This is based on the MMPA definition of Level B harassment, which includes activities that have the potential to disturb a marine mammal. Whether or not a tag attachment attempt is successful, researchers would have closely approached the marine mammal and engaged in activities of a type that have been shown to result in disruption of behavioral patterns (i.e., harassment). It usually takes several of these attempts/touches for a successful tag attachment. Sometimes when the tag touches the whale, there is no obvious behavioral reaction. Once a tag 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. The only reaction to tagging the permit applicant has observed that may have a longer effect is for the whale to start a dive soon after the tag attachment and before the normal surfacing interval is completed. 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.

DTAGs

The sampling method would be using electronic tags. The DTAG is the name given to a miniature solid-state acoustic recording tag. Two versions of the DTAG have been built. The first version (DTAG1) has worked very well for large whales such as sperm and baleen whales. The second version (DTAG2) is smaller, with capabilities for higher acoustic sampling rates, and we propose to use DTAG2 for the research to be conducted under this SRP. The DTAG2 uses solid-state non-volatile memory in place of magnetic media to overcome the limitations of hard drives which necessitate pressure housings. This has the advantage that the tag can be potted, eliminating the need for a pressure housing and enhancing the robustness of the device.

The DTAG2 outside dimensions (including packaging) are approximately 4.25 in x 1.6 in x 0.9 in (11 x 4 x 2 cm), which is 40 percent of the volume of DTAG1, and weighs approximately 330 g (12 oz) in air, with positive buoyancy. The new tag has a modular audio acquisition section and can be assembled with a high-performance stereo ADC (24 bits, 192 kHz/channel) suitable for all odontocetes other than *Kogia* and porpoises. The sensor suite of DTAG1 has been retained on the DTAG2.

DTAG2 has a fairing for odontocetes that has been used successfully with beaked and sperm whales. With fairing, DTAG2 dimensions are approximately 8 in x 4.1 in x 1.4 in (20 x 10 x 4 cm). Initially, the memory capacity was 400 MB, but new chips have become available that allow a memory capacity of up to 12 GB. The DTAG2 incorporates a digital signal processor capable of real-time detection and compression of audio signals, making efficient use of the memory. The sampling rate and compression algorithm used by the tag are fully programmable. The tag also includes sensors for pressure, pitch, roll, heading, surfacing events, and temperature. All programming and data offload occur through an infrared communications port enabling the entire system to be potted, further increasing the efficiency and robustness of the instrument in the field. The DTAG2 itself has no inherent attachment mechanism. This was a purposeful design so that attachment can be customized for the species being studied.

Sound playback experiments or controlled exposures of sound

Two different kinds of research have been used to study disturbance reactions: observations of opportunistic exposures and experimental PBs of sound stimuli. The former provides the most realistic circumstances for a 'natural' experiment, but leaves many factors uncontrolled. Playbacks (McGregor, 1992) allow similar exposures to be repeated to different subjects. Having a standardized experimental exposure that can be repeated allows pooling of data from different subjects, enabling statistical analysis of responses. In addition, experiments are much better suited than correlational studies to determine whether sounds actually cause behavioral responses (Gisiner, 1998). Controlled experiment exposures of sound have classically been called "playbacks" (McGregor, 1992), and controlled exposure experiments (CEEs per se) carefully control acoustic exposure at the subject in order to titrate what exposure evokes a behavioral response.

Since the animals in these studies would be responding to sound stimuli, when considering factors that may affect response, it is critical to focus on features that will be salient to the animals, features such as the loudness, frequency, duration, location, and distance or motion of the sound source. Carefully designed controlled exposures can reveal stark differences in response to sounds with different features. For example, Malme et al. (1983, 1984) demonstrated that 50 percent of gray whales migrating past the central California coast avoided continuous sounds at received levels of near 120 dB SPL, but avoided the sounds of airguns at received levels of near 170 dB SPL (average pulse pressure level), a 50 dB difference. In the same setting, Tyack and Clark (1998) showed that avoidance responses of migrating gray whales scale with RL for a sound source placed in the migration corridor, but this response disappeared when the source was placed offshore, even for received levels 20-30 dB above levels that elicited avoidance from the inshore source (in the whale's migration corridor). Some behavioral changes become statistically significant for a given exposure, such as increases in descent rate and increases or decreases in ascent rate of northern elephant seals (*Mirounga angustriostris*) in response to Acoustic Thermometry of Ocean Climate (ATOC) LF underwater signals (Costa et al., 2003). However, it remains unknown when and how these changes translate into biologically significant effects that have repercussions for the animal beyond the time of disturbance, effects on the animal's ability to engage in essential activities, and effects that have potential consequences at the population level.

Reason for Alternative 2

A major goal of this field research is to determine the acoustic exposures of mid-frequency (MF) sonar sounds that elicit an identifiable behavioral indicator response in beaked whales. Phase I of this research would involve acoustic monitoring of responses of toothed whales to ongoing anthropogenic sound on the AUTEC range. This can help define the exposure range for subsequent experiments with tagged animals. These experiments are required for more precise calibration of behavioral responses and acoustic exposure. The PB experiments involve controlled exposures that are less frequent and lower in level than many of these species may face from anthropogenic sound sources in normal regular use. The maximum level of exposure is lower than or equal to the exposures restricted by regulation. If this research helps in the formulation of regulations improving the protection of ESA or MMPA species from noise exposure, then this would help the stocks benefit, as individual animals are protected by monitoring and mitigation measures and as acoustic habitat degradation is reversed. In this context, it is essential to work with those species thought to be most sensitive. It would not be conservative to develop a policy based upon data from less sensitive species and then apply it to more vulnerable ones.

Table 1 presents a list of species that may be present in the action area (see far right column for Bahamas), their status under the MMPA, ESA, and CITES, the type of harassment expected, and the probability of the presence of each species. Table 2 presents the estimated maximum number of takes expected for each species, outside of the Bahamian territorial seas, during the course of the BRS-07 experiment due to tagging, close approaches, focal follows and playbacks. An explanation of these takes follows Table 2.

Table 1. Marine Mammal Species in Vicinity of Proposed Activity (AUTEC Range, Andros Island, Bahamas)

Scientific Name	Common Name	MMPA, ESA, CITES Status	Stock(s)	Type of Take (acous. ensor tagging)	Probability of Being Present: H=high; M=medium; L=low; VL=very low; R=rare; N=none documented		
					Mediterranean Sea	e. North Atlantic	Bahamas
Balaenoptera musculus	blue whale	ESA end. CITES App.I	w. N. Atlantic, e. N. Atlantic	Incidental	N	VL	N
Balaenoptera physalus	fin whale	ESA end. CITES App.I	w. N. Atlantic; British Isles, Spain & Portugal; Med.	Incidental	H	L	VL
Balaenoptera borealis	sei whale	ESA end. CITES App.I	Nova Scotia, e. N. Atlantic	Incidental	VL	VL	N
Balaenoptera edeni	Bryde's whale	CITES App.I	n. GOMEX, N. Atlantic	Incidental	N	VL	VL
Balaenoptera acutorostra	minke whale	CITES App.I	Can.E.Coast; ne N. Atlantic	Incidental	L	L	L
Megaptera novaeangliae	humpback whale	ESA end. CITES App.I	Gulf of Maine; N. Atlantic	Incidental	VL	VL	L (summer)
Eubalaena glacialis	n. right whale	ESA end. CITES App.I	w. Atlantic	Incidental	R	R	N
Physeter macrocephalus	sperm whale	ESA end. CITES App.I	N. Atlantic; n. GOMEX, Med	**Intentional**	M	M	M
Kogia breviceps	pygmy sperm whale	CITES App.II	w. N. Atlantic; n. GOMEX, e. N. Atlantic	Incidental	N	VL	M
Kogia simus	dwarf sperm whale	CITES App.II	w. N. Atlantic; n. GOMEX, e. N. Atlantic	Incidental	R	VL	M
Hyperoodon ampullatus	n. bottlenose whale	CITES App.I	w. N. Atlantic, Scotian Shelf (SARA), e. N. Atlantic	Incidental	R	VL	N

Scientific Name	Common Name	MMPA, ESA, (	Stock(s)	Type of Take (acous. enson. and tagging)	Probability of Being Present: H=high; M=medium; L=low; VL=very low R=rare; N=none documented		
					Mediterranean Sea	e. North Atlantic	Bahamas
Ziphius cavirostris	Cuvier's beaked whale	CITES App.II	w. N. Atlantic; n. GOMEX, e. N. Atlantic, Med.	**Intentional**	L	L	L
Mesoplodon bidens	Sowerby's beaked whale	CITES App.II	w. N. Atlantic, e. N. Atlantic	**Intentional**	R	VL	N
Mesoplodon densirostris	Blainville's beaked whale	CITES App.II	w. N. Atlantic, n. GOMEX, e. N. Atlantic	**Intentional**	R	L	H
Mesoplodon europaeus	Gervais' beaked whale	CITES App.II	w. N. Atlantic; n. GOMEX, e. N. Atlantic	**Intentional**	R	L	L
Mesoplodon mirus	True's beaked whale	CITES App.II	w. N. Atlantic, e. N. Atlantic	**Intentional**	N	L	L
Orcinus orca	killer whale	CITES App.II	w. N. Atlantic; n. GOMEX, e. N. Atlantic	**Incidental**	VL	VL	VL
Pseudorca crassidens	false killer whale	CITES App.II	n. GOMEX, e. N. Atlantic	Incidental	VL	VL	VL
Feresa attenuata	pygmy killer whale	CITES App.II	w. N. Atlantic; n. GOMEX, e. N. Atlantic	Incidental	N	VL	VL
Peponocephala electra	melon-headed whale	CITES App.II	w. N. Atlantic, n. GOMEX, e. N. Atlantic	**Intentional**	N	VL	VL (summer)
Globicephala macrorhync	short-finned pilot whale	CITES App.II	w. N. Atlantic, n. GOMEX, e. N. Atlantic	**Intentional**	N	L	M
Globicephala melas	long-finned pilot whale	CITES App.II	w. N. Atlantic, e. N. Atlantic, Med.	**Intentional**	M	L	N
Grampus griseus	Risso's dolphin	CITES App.II	w. N. Atlantic, n. GOMEX, e. N. Atlantic, Med.	**Intentional**	M	M	VL (summer)
Delphinus delphis	common dolphin	CITES App.II	w. N. Atlantic, e. N. Atlantic, Med.	Incidental	M	H	N
Steno bredanensis	rough-toothed dolphin	CITES App.II	n. GOMEX, e. N. Atlantic	Incidental	VL	L	L
Stenella coeruleoalba	striped dolphin	CITES App.II	w. N. Atlantic, n. GOMEX, e. N. Atlantic, Med.	Incidental	H	M	VL

Scientific Name	Common Name	MMPA, ESA, (	Stock(s)	Type of Take (acous. enson and tagging)	Probability of Being Present: H=high; M=medium; L=low; VL=very low R=rare; N=none documented		
					Mediterranean Sea	e. North Atlantic	Bahamas
Stenella clymene	short-snouted spinner dolphin; Clymene dolphin	CITES App.II	w. N. Atlantic, n. GOMEX, e. N. Atlantic	Incidental	N	VL	N
Stenella longirostris	long-snouted spinner dolphin	CITES App.II	w. N. Atlantic, n. GOMEX	Incidental	N	VL	N
Stenella attenuata	pantropical spotted dolphin	CITES App.II	w. N. Atlantic, n. GOMEX	Incidental	N	VL	L
Stenella frontalis	Atlantic spotted dolphir	CITES App.II	w. N. Atlantic, n. GOMEX, e. N. Atlantic	Incidental	N	M	M
Tursiops truncatus	bottlenose dolphin	CITES App.II	GOMEX Cont. Shelf; GOME OCS; wNA coastal; wNA offshore; e. N. Atlantic; Med.	Incidental	M	M	H (coastal Ecotype)
Lagenodelphis hosei	Fraser's dolphin	CITES App.II	n. GOMEX, e. N. Atlantic	Incidental	N	L	VL
Phocoena phocoena	harbor porpoise	CITES App.II	GoM/BOF, e. N. Atlantic	Incidental	VL	VL	N
Phoca vitulina	harbor seal		w. N. Atlantic, e. N. Atlantic	Incidental	N	VL	N
Monachus monachus	Mediterranean monk se	ESA end. CITES App.I	e. N. Atlantic; Med.	Incidental	VL	N	N

Take Table for BRS-07 (Phase I)

- Males and females of all target species may be tagged.
- All sex and age classes of a species may be exposed to playback sounds.
- For expected import/export of marine mammal parts.
- Transport methods: Not Applicable.
- Location of take: Tongue of the Ocean, outside Bahamian territorial seas.
- Location of import or export: Andros Island, AUTEC, Bahamas.
- Dates or time period when activity would occur: approximately 6 week time period in the August through October 2007 timeframe.

These take tables are based on the number of individuals approached or incidentally harassed (outside Bahamian territorial seas) rather than a table based on each attempted action. To illustrate, consider an animal that is approached three times and tagged on the third approach. In that example, one animal was taken three times. The permit would specify the total number of individuals of a given marine mammal species or stock that could be taken, as well as the manner in which the takes could occur, including where individual animals may be taken more than once by a suite of activities.

The four categories of potential research takes are presented in Table 2 and include:

1) "Close approach, tag attachment, photo-identification, focal follow, playback".

2) "Close approach, tag attachment, photo-identification, focal follow". This category includes those animals that might be tagged, but playback does not follow attachment.

3) "Incidental harassment during close approaches to target animal". This category includes the non-target animals within the group that contains the target animal that the scientists are attempting to tag, and target animals that were not successfully tagged. This value is detailed in Table 3.

4) "Incidental harassment by exposure to playbacks directed at target animal". This category includes the exposure of non-targeted species in the vicinity. This category includes both the incidental exposure of animals that are not the focus of a research effort, as well as the members of the group containing a tagged animal that is the focus of the research. For non-target species, only an "incidental" exposure calculation (see Table 5) is listed in the summary Table 2.

For the six targeted species, this value is a combination of intentionally (Table 4) and incidentally (Table 5) exposed animals.

Table 2 Summary Take Table for BRS-07—outside of Bahamian territorial seas
Proposed activities over a specified period. This is the summary of a number of calculations which will be presented in more detail in the following Subsections.

Take Category	**1**	**2**	**3**	**4**
NMFS Take Type Categorization **Taxon**	Close approach, **SUCCESSFUL** tag attachment, photo-identification, focal follow, playback	Close approach, **SUCCESSFUL** tag attachment, photo-identification, focal follow	Incidental harassment during close approaches to target animal	Incidental harassment by exposure to playbacks directed at target animal
Humpback whale (*Megaptera novaeangliae*)				3
Minke whale (*Balaenoptera acutorostrata*)				6
Bryde's whale (*Balaenoptera edeni*)				6
Sei whale (*Balaenoptera borealis*)				3
Fin whale (*Balaenoptera physalus*)				6
Blue whale (*Balaenoptera musculus*)				3
Sperm whale (*Physeter macrocephalus*)	3	2	24	92
Beaked whales (*Mesoplodon* spp.)	3	2	45	35
Cuvier's beaked whale (*Ziphius cavirostris*)	3	2	30	21
Pilot whales-short finned (*Globicephala macrorhynchus*)	6	3	45	42
Bottlenose dolphin (excluding mid-Atlantic coastal stock) (*Tursiops truncatus*)				18

Take Category	1	2	3	4
NMFS Take Type Categorization **Taxon**	Close approach, tag attachment, photo-identification, focal follow, playback	Close approach, tag attachment, photo-identification, focal follow	Incidental harassment during close approaches to target animal	Incidental harassment by exposure to playbacks directed at target animal
Common dolphin (*Delphinus delphis* and *D. capensis*)				381
Atlantic spotted dolphin (*Stenella frontalis*)				18
Pantropical spotted dolphin (*Stenella attenuata*)				18
Striped dolphin (*Stenella coeruleoalba*)				68
Spinner dolphin-long snouted (*Stenella longirostris*)				246
Spinner dolphin-short snouted (*Stenella clymene*)				96
Rough-toothed dolphin (*Steno bredanensis*)				21
Kogia spp. (*K. simus* and *K. breviceps*)				6
Risso's dolphin (*Grampus griseus*)	3	2	56	98
Killer whale (*Orcinus orca*)				11
False Killer whale (*Pseudorca crassidens*)				44
Pygmy killer whale (*Feresa attenuata*)				45
Melon-headed whale (*Peponocephala electra*)	3	2	184	1,041

<u>Category 1: Estimating the number of animals that may be taken by close approach, successful tag attachment, photo-identification, focal follow, and playback during the course of the proposed research activity—outside of Bahamian territorial seas:</u>

The values in this category are the tagging goal for each species. Only animals that are successfuly tagged, focal followed and presented with a playback stimulus, are included in this category.

<u>Category 2: Estimating the number of animals that may be taken by close approach, sucessful tag attachment, photo-identification and focal follow (but no playback) during the course of the proposed research activity—outside of Bahamian territorial seas:</u>

The goal of the proposed research is to observe the behavior of animals that are presented with an acoustic stimulus. However, there is the possibility that animals may be successfully tagged, and there may be logistical or technical reasons that would prevent a playback of the acoustic stimulus. In this case, the animals may still be focal followed to obtain additional data on their movement and behavior. Since this represents a contingency rather than a planned activity, the numbers requested here are approximately one-half of the tagging goal.

<u>Category 3: Estimating the number of animals that may be taken by unintentional Close Approach during the course of the proposed research activity—outside of Bahamian territorial seas:</u>

This number is larger than the Maximum Number of Tagging Takes because some CAs are required for photo-identification etc., and because the tagging team may not be able to touch a tag to the animal on every CA. Sometimes the animal may dive or move away. If the tagging team feels that the animal is showing a negative reaction to the CA (e.g., panicked flight), they would break off. The probability that a CA would lead to the tag touching the animal depends upon the species. In addition, in most species, an animal selected for tagging may surface close enough to other individuals that a CA to the selected animal requires the tagging vessel to also approach relatively close to the other individuals. This number of close companions also varies by species. These close companions are also counted as incidental CAs. Therefore, for these species, the permit applicant is requesting a larger number of CA takes than tagging takes. This increase in the estimated number of takes, likely overestimated, makes the environmental analyses of this SRP more conservative.

Group size for cetaceans at sea is often defined as all of the animals that can be sighted together. For estimating CA takes, it is more appropriate to consider smaller subgroups and the permit applicant proposes to count animals surfacing within a few body lengths of the focal animal. This subgroup size is considered to be one-half of the total group size for most species (see Table 3 below). Since the group size of melon-headed whales tends to be much larger, the subgroup size is considered to be 10 percent of the group size. Therefore, in order to estimate the potential number of incidental CA takes for these species, the permit applicant has multiplied the number of tagging attempts by the subgroup size.

The tagging goal for each species is listed in Table 3, as well as the estimated success rate for tag attachment. The number of tag attachments to reach the goal is the tagging goal divided by the estimated success rate. This number is larger than the tagging goal because not every tagging take yields the data we need for a successful tagging. NMFS counts a tagging take as every time any part of the tag touches an animal. The probability that a tag will stay on the animal once it has touched depends upon the species, and the duration of attachment needed for success depends on other factors as well.

Table 3 Estimation of Incidental CA takes for BRS-07—outside of Bahamian territorial seas

A. Taxon	B. Tagging Goal	C. Est. tagging success rate	D. Max Number of tagging takes: (B/C)	E. Sub-group size	F. Incidental CA takes (D x E)
Sperm Whale	3	40%	8	3	24
***Mesoplodon* spp.**	3	20%	15	3	45
Cuvier's beaked whale	3	20%	15	2	30
Short-finned pilot whale	6	40%	15	3	45
Melon-headed whale	3	40%	8	23	184
Risso's dolphin	3	40%	8	7	56

Category 4: Estimating the number of animals that may be taken by unintentional playback during the course of the proposed research activity—outside Bahamian territorial seas:

As can be seen in Table 4 below, the total targeted PB takes is larger than the goal number of PBs. This is for the following two reasons: 1) some animals may be incidentally exposed to PBs in the course of an experiment directed at another species; and 2) most of the species covered by this SRP application are social such that any PB directed at one or a few tagged members of a group are likely to lead other members of the group to be exposed as well. Since sound travels well underwater, more animals could potentially be affected by PB than by the CAs for tagging. Therefore, the group size is used to estimate PB takes. Given the expectation that few animals further away than the focal animal would be harassed by FF, the estimated numbers may seem unreasonably high. However, one of the goals of these studies is to detect and report any disruption of behavior. The conservative process for estimating large numbers of potential takes ensures that even the most subtle behavioral changes, potentially discovered well after the field work is over, would be covered by the requested SRP.

The subject of each PB experiment is the tagged animal(s), but animals other than the tagged ones may also be exposed to the playback of underwater MF sound signals. This project would help to determine the thresholds for disturbance to these animals, and would help to estimate what kinds of exposures elicit what kinds of behavioral reactions. For the purposes of estimating number of incidental harassment takes for the requested SRP, the scientific research team would report all animals in the group of the study subject as potential harassment takes during PB experiments. Each stage of estimating potential takes is overestimated for several reasons. This overestimation reduces the probability that the SRP limits the field research from achieving its goals. Since some of the research covered in this permit application is specifically designed to detect and measure behavioral disruption, and since the relationship between exposure and response is not completely understood, it is also important that the estimated number of takes allows for unanticipated subtle responses being detected in post-test analyses.

Table 4 Estimation of intentional target animal PB takes for BRS-07--outside of Bahamian territorial seas

A. Taxon	B. Number of Playbacks	C. Est. Group Size	D. Tagged Animal Playback Takes (B x [C-1])	E. Non-tagged Animal Playback Takes (B x C)	F. Total Targeted Animal Playback Takes (D + E)
Sperm Whale	2	6	10	12	22
Beaked Whale Mesoplodon	2	5	8	10	18
Beaked Whale Ziphius	2	3	4	6	10
Short-finned Pilot Whale	2	6	10	12	22
Melon-headed Whale	2	232	462	0	462
Risso's Dolphin	2	14	26	0	26

The intentional targeted tagged animal PB takes are calculated as the number of PBs x (group size -1). One is subtracted to account for the tagged animal, which is tabulated separately. The non-tagged animal playback takes column is to allow a maximum number of playback experiments without a tag attachment. This is the total group size x the number of PBs. Non-tagged animal playbacks are expected for sperm whales, beaked whales and short-finned pilot whales since these animals can be readily tracked using the passive acoustic capabilities of the AUTEC range. The total targeted number of PB takes is the sum of these two values.

Table 4 represents the maximum number of individual animals to be intentionally exposed to PBs, and it includes the best estimates of group size. However, larger group sizes may be encountered in the course of the experiment. Therefore, to account for this possibility, the total targeted animal PB takes is multiplied by 1.5 and then added to the incidental (non-targeted) animal PB takes that are calculated below (Table 5). This multiplication is included as a conservative measure and results in larger numbers of exposures than are actually expected.

In the area where this research is proposed, individuals of other marine mammal species may be present. A major goal of the proposed research is to help define acoustic criteria that cause changes in behavior that may be considered takes by harassment. In the absence of such data, the permit applicant proposes to follow current NMFS practice and report all marine mammals or sea turtles sighted within a range from the source vessel during PBs where the animal RL is predicted to be 160 dB SPL in a tally of animals that might be used to estimate potential unintentional harassment takes (NMFS 2003). The target species for PBs in the Tongue of the Ocean, and primarily on the AUTEC range, are beaked whales, pilot whales, melon headed whales, Risso’s dolphins and, sperm whales. In order to cover the possibility of unintentional exposure during PB, the permit applicant is requesting potential takes by harassment of other marine mammal species that may be present in the research area and outside of Bahamian territorial seas. The maximum range out to the 160 dB isopleth may be as short as 1000 m for a SL of 220 dB, depending on which underwater acoustic sound source would be used for the 2007 Phase I (BRS-07) research. Therefore, the estimates of incidental harassment takes for the non-target species are likely over-estimated.

Table 5 Estimation of incidental non-target animal playback takes for BRS-07—outside of Bahamian territorial seas

Species	Density – Based Calculation	Group Size-Based Calculation	Caribb. Group Size	Max # Incidental Non-target Animal Playback Takes
Humpback whale (*Megaptera novaeangliae*)	1	3	2 (Mattila et al. 1994)	3 incidental
Minke whale (*Balaenoptera acutorostrata*)	6	2	1 (Claridge 2006)	6 incidental
Bryde's whale (*Balaenoptera edeni*)	6	3	2 (Silber et al. 1994)	6 incidental
Sei whale (*Balaenoptera borealis*)	1	3	2 (Schilling et al. 1992)	3 incidental
Fin whale (*Balaenoptera physalus*)	6	3	2 (Panigada et al. 2005)	6 incidental
Blue whale (*Balaenoptera musculus*)	1	3	2 (Reilly and Thayer 1990)	3 incidental
Sperm whale (*Physeter macrocephalus*)	59	9	6 (Claridge 2006)	59 incidental
Beaked whales (*Mesoplodon* spp.)	6	8	5 (Claridge 2006)	8 incidental
Cuvier's beaked whale (*Ziphius cavirostris*)	6	5	3 (Claridge 2006)	6 incidental
Pilot whales-short finned (*Globicephala macrorhynchus*)	6	9	6 (Claridge 2006)	9 incidental
Bottlenose dolphin (excluding mid-Atlantic coastal stock) (*Tursiops truncatus*)	6	18	12 (Claridge 2006)	18 incidental
Common dolphin (*Delphinus delphis and D. capensis*)	6	381	254 (Silber et al. 1994)	381 incidental
Atlantic spotted dolphin (*Stenella frontalis*)	6	18	12 (Claridge 2006)	18 incidental
Pantropical spotted dolphin (*Stenella attenuata*)	6	18	12 (Claridge 2006)	18 incidental
Striped dolphin (*Stenella coeruleoalba*)	6	68	45 (Claridge 2006) and Mobley 2004	68 incidental

Species	Density – Based Calculation	Group Size-Based Calculation	Caribb. Group Size	Max # Incidental Non-target Animal Playback Takes
Spinner dolphin-long snouted (*Stenella longirostris*)	6	246	164 (Mullin and Fulling 2004)	246 incidental
Spinner dolphin-short snouted (*Stenella clymene*)	6	96	64 (Mullin and Fulling 2004)	96 incidental
Rough-toothed dolphin (*Steno bredanensis*)	6	21	14 (Claridge 2006)	21 incidental
Kogia spp. (*K. simus* and *K. breviceps*)	6	5	3 (Claridge 2006)	6 incidental
Risso's dolphin (*Grampus griseus*)	59	21	14 (Claridge 2006)8	59 incidental
Killer whale (*Orcinus orca*)	1	11	7 (Claridge 2006)	11 incidental
False Killer whale (*Pseudorca crassidens*)	1	44	29 (Mullin and Fulling 2004)	44 incidental
Pygmy killer whale (*Feresa attenuata*)	1	45	30 (Claridge 2006)	45 incidental
Melon-headed whale (*Peponocephala electra*)	6	348	232 (Claridge 2006) and (Mobley 2004)	348 incidental

Incidental non-target animal PB takes are considered to be the non-intentional exposure of animals in the research area (outside of Bahamian territorial seas) that are not being focal followed or observed during the PB stimuli. Two calculations were performed to estimate the maximum number of incidental non-target animal PB takes. The first is a density-based calculation using the estimated density of the animals in the research area multiplied by the area over which the 160 dB re 1 µPa sound field could cover, which is in turn multiplied by the number of PBs projected to be conducted. The group size-based estimate assumes (for the purposes of calculation) that one group of each species would be nearby the source vessel during each PB. Thus, this estimate is the group size multiplied by the number of PBs. The larger of the two values was used to derive column 5 values in this table. The Category 4 values in Table 2 include these values, as well as the intentional target animal PB take estimates presented in Table 4 above multiplied by 1.5.

Tissue Samples and Tagging

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. Any such skin would be collected for genetic analysis (Amos et al., 1992). Thus, the maximum number of skin samples collected and imported would equal the goal for animals successfully tagged for each species as indicated in Table 3.

Sampling method

The sampling method would be using electronic tags. The DTAG is the name given to a miniature solid-state acoustic recording tag. Two versions of the DTAG have been built. The first version (DTAG1) has worked very well for large whales such as sperm and baleen whales. The second version (DTAG2) is smaller, with capabilities for higher acoustic sampling rates, and they propose to use DTAG2 for the research to be conducted under the requested SRP. The DTAG2 uses solid-state non-volatile memory in place of magnetic media to overcome the limitations of hard drives which necessitate pressure housings. This has the advantage that the tag can be potted, eliminating the need for a pressure housing and enhancing the robustness of the device.

The DTAG2 outside dimensions (including packaging) are approximately 4.25 in x 1.6 in x 0.9 in (11 x 4 x 2 cm), which is 40 percent of the volume of DTAG1, and weighs approximately 330 g (12 oz) in air, with positive buoyancy. The new tag has a modular audio acquisition section and can be assembled with a high-performance stereo ADC (24 bits, 192 kHz/channel) suitable for all odontocetes other than *Kogia* and porpoises. The sensor suite of DTAG1 has been retained on the DTAG2.

DTAG2 has a fairing for odontocetes that has been used successfully with beaked and sperm whales. With fairing, DTAG2 dimensions are approximately 8 in x 4.1 in x 1.4 in (20 x 10 x 4 cm). Initially, the memory capacity was 400 MB, but new chips have become available that allow a memory capacity of up to 12 GB. The DTAG2 incorporates a digital signal processor capable of real-time detection and compression of audio signals, making efficient use of the memory. The sampling rate and compression algorithm used by the tag are fully programmable. The tag also includes sensors for pressure, pitch, roll, heading, surfacing events, and temperature. All programming and data offload occur through an infrared communications port enabling the entire system to be potted, further increasing the efficiency and robustness of the instrument in the field. The DTAG2 itself has no inherent attachment mechanism. This was a purposeful design so that attachment can be customized for the species being studied.

Method of attachment
The DTAG2 was designed to acquire data at high rates so that fine details of an individual's behavior can be documented. Being a high data-rate tag, the DTAG2 need only be attached to an animal for relatively short periods of time (i.e., 5-48 hr). The permit applicants believes that non-invasive attachment mechanisms are the most appropriate to meet the target life of hours to a day or two. The most appropriate non-invasive attachment method for using these tags with most cetacean species involves the use of suction cups. The DTAG2 itself does not include an attachment mechanism, an intentional strategy to allow for specialized attachment techniques for the species being studied.

Method of application
The basic principle for tag delivery is to conduct it in such a manner as to minimize the potential for disturbing the animal. For large, slow moving whales, researchers would use a pole delivery system similar to that developed by Moore *et al.* (2001) for right whale blubber thickness measurement. This uses a 10-12 m (33-39 ft) pole cantilevered from

the bow of a small boat to attach the tag from greater distance than is typically possible with pole deployments. In some settings, for example with beaked whales, it is simpler to hand hold a 2-4 m (7-13 ft) pole to deploy the tag. Baird successfully attached tags similar to the DTAG2 to porpoises in Puget Sound (Hanson and Baird, 1998) and pilot whales in the Mediterranean (Baird et al. 2002) using this approach. Successful attachment of DTAGs to *Mesoplodon* and *Ziphius* have been achieved using this kind of hand-held pole (Tyack et al. 2006a).

The tagging protocol for each species may differ according to its morphology and environmental conditions, but would follow a general model. Where possible, an observation and tracking vessel (OV) would use visual observation and acoustic monitoring to follow an animal selected for tagging. The observers would monitor this animal as carefully as possible before tagging so that these observations can be used to test for any effects of tagging itself. The tag attachment vessel (TAV) would approach the animal as cautiously as possible while still achieving a position to allow attachment of the tag. During and after attachment, the OV 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 both that the data collected during the tag's life represent as normal a repertoire as possible and that the tag had no visible effects on the animal. Sightings from the OV are also used to locate the animal's track in geographical space. Either the tagging vessel or the OV would recover the tag after it releases from the animal. Where PBs are planned, they would be conducted after a pre-exposure period (at least one beaked whale dive + 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.

Location of attachment

The tags would be attached on the dorsal surface of the animal caudal to (i.e., behind) the blowhole and closer to the dorsal fin than to the blowhole.

Duration of attachment

Researchers have repeatedly been able to obtain attachment durations of 4-12 hr on sperm whales (Watwood et al. 2006), and routinely up to 16 hr on beaked whales (Tyack et al. 2006a), up to the maximum programmed recording time. The playback design requires tags to be attached for about four to sixteen hours, and the target attachment duration is 4-16 hr.

Method of release

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 a release mechanism that uses an electrically corrosive wire assembly to release the tag package (DTAG, batteries, flotation, suction cups, plastic housing, and RF transmitter) from the animal. The corrosive wire assembly opens a tube to release the suction, and is not in contact with the animal at any time, so poses no threat. This usually occurs in 1-3 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.

Collection of samples
Tables 6(a) and 6(b) discuss the exportation of samples collected from the BRS.

Table 6. Exports of Marine Mammals from the U.S.

(a) The country of exportation, country of origin, export destinations:

Species	**Part for import/export**	**Import: country of origin and exportation**	**Export: destination country**
Sperm whale (*Physeter macrocephalus*)	Skin samples	Bahamas	U.S., U.K.
Beaked whales (*Ziphius, Mesoplodon* spp.)	Skin samples	Bahamas	U.S., New Zealand
Pilot whale (*Globicephala* spp.)	Skin samples	Bahamas	U.S.
Melon headed whale (*Peponocephala electra*)	Skin samples	Bahamas	U.S.
Risso's dolphin (*Grampus grise*	Skin samples	Bahamas	U.S.

(b) A description of how the marine mammal part/product to be imported were taken in the country of origin:

Species affected	**Part collected**
beaked whale (sp.), pilot whale (sp.), sperm whale, melon headed whale, Risso's dolphin	Skin samples collected from skin sloughed with suction cup tag

2.3 Alternatives Considered but Eliminated from Detailed Study

Other alternatives considered but eliminated from detailed study included: 1) other locations for conducting BRS-07; 2) alternate season; 3) not using the endangered sperm whale in the study; and 4) limiting animal age classes.

Other locations considered were the Canary Islands, Ligurian Sea, the Azores, Bay of Biscay, Caribbean Islands, Alboran Sea, and Yokosuka, Japan. However, the AUTEC location was selected for Phase I (BRS-07) based on its unique resource-- an array of hydrophones with sufficient bandwidth to detect and record the clicks of beaked whales, sperm whales and delphinids such as pilot whales, melon headed whales and Risso's dolphins. Naval Undersea Warfare Center (NUWC) has installed marine mammal monitoring on Navy Ranges (M3R) software that can detect, locate, and display odontocete clicks and whistles. The system works well to locate the sounds of sperm whales and dolphins. The clicks of beaked whales are so directional that at times it can be difficult to detect the same click on enough hydrophones to perform precise localization of the animal. Also, before Phase I takes place, the permit applicant proposes to analyze acoustic monitoring data from the AUTEC Range during sonar activities and control periods. The analysis would seek to define exposures at the onset of beaked whale click cessation, which would be factored into the minimum animal RL for Phase I playbacks. Therefore, this alternative (other locations for conducting BRS-07) was eliminated from further consideration.

Another alternative considered but eliminated from detailed study included conducting the study during a different season. The availability of the range, assets, sources, personnel, and the need to conduct the study during a season when there would presumably be sufficient animals determined that the study should be conducted in the summer of 2007. Therefore, this alternative (alternate season) was eliminated from further consideration.

Finally, the last two alternatives considered but eliminated from detailed study were not including sperm whales, and limiting animal age classes. These alternatives were eliminated because, if this research, as anticipated, helps in the formulation/modifications of regulations improving the protection of ESA or MMPA species from noise exposure, then this would help the stocks benefit, as individual animals are protected by monitoring and mitigation measures and as acoustic habitat degradation is reversed. In this context, it is essential to work with those species thought to be most sensitive. It would not be conservative to develop a policy based upon data from less sensitive species and then apply it to more vulnerable ones. For sperm whales, this is particularly important for airgun signals produced during seismic surveys (Phase II, BRS-08), which are increasingly common in sperm whale habitat as offshore oil exploration and production moves to deeper water.

The sperm whale is the only one of the BRS species that is listed by the U.S. as endangered. The NMFS published a Draft Recovery Plan For the Sperm Whale (*Physeter macrocephalus*) in June 2006. One of the key features of the proposed recovery plan is to "determine and minimize any detrimental effects of anthropogenic noise in the oceans". The proposed research directly addresses this objective. The beaked whales are not listed as endangered or threatened under the ESA, but only limited information are available on the structure and size of their populations. The NMFS 2005 Stock Assessments for Cuvier's and Blainville's beaked whales in the western North Atlantic state "This is a strategic stock because of uncertainty regarding stock size and evidence of human induced mortality and serious injury associated with acoustic activities.” Again, the proposed research addresses the principal impact that caused these whales to be listed as strategic stocks.

This same logic can be applied to animal age classes within a population. For example, dependent sperm whale young may be seen as a particularly vulnerable component of the population. Whitehead (1996) points out that calves may remain near the surface as adults dive and adults are reported to stop clicking in response to man-made underwater noise. If adults fall silent when an anthropogenic underwater sound starts, juveniles might not be as effective at keeping contact with members of their group. This concern highlights the importance of attending to these potentially most vulnerable members of a population that are likely to be affected by man-made noise. The scientific research team would pay particular attention during the PBs to any animal silencing responses and visual observers would pay particular attention to sighting and following any young animals in a group. Following the principle of special monitoring of vulnerable elements of a population, if researchers are easily able to tag sperm whale juveniles with no more than minor responses from any of the animals, the permit applicant proposes to attempt to do so to test whether their behavior is affected or whether they are affected by changes in the behavior of the adults around them.

Chapter 3 Affected Environment

This chapter presents baseline information necessary for consideration of the alternatives, and describes the resources that would potentially be affected by the alternatives, as well as environmental components that would affect the alternatives if they were to be implemented. The effects of the alternatives are discussed in Chapter 4. Figure 1 shows the location of Andros Island, the AUTEC range, and the "Tongue of the Ocean."

Figure 1. AUTEC, Andros Island, and the "Tongue of the Ocean."

3.1 Social and Economic

Although economic and social factors are listed in the definition of effects in the NEPA regulations, the definition of human environment states that "economic and social effects are not intended by themselves to require preparation of an EIS." However, an EIS or EA must include a discussion of a proposed action's economic and social effects when these effects are related to effects on the natural or physical environment. The social and economic effects of the Proposed Action mainly involve the effects on the people involved in the research, as well as any industries that support the research, such as charter vessels, and suppliers of equipment needed to accomplish the research.

Fishing in the Bahamas is carried out by Bahamian fishermen and foreigners that participate in sport fishing and illegal fishing activities. Commercial fishing inside a 322 km (200 mi) zone is reserved for Bahamians. Catches by Bahamian fishing boats are most important to the industry. The most important species is crawfish, followed by groupers, conch, and snappers. Sport fishery catches are generally medium to large migratory pelagic fish such as dolphin, barracuda, wahoo, and blue marlin. Bonefish are caught by a fleet of small charter boats. The local fishing industry makes a significant contribution to the economy, earning local vessel owners and operators $56 million (Bahamian) and exporting over $50 million (Bahamian) during 1991. This represented revenues of $2.5 million (Bahamian) for the Government (FAO, 1992).

Major shipping lanes do not pass through the Tongue of the Ocean or near AUTEC. Only small local supply vessels and private fishing or pleasure boats are expected to pass through these areas. Based on fish hearing abilities (as discussed in Subchapter 3.3.2), mid-frequency sonar is not expected to affect fish and therefore is not expected to affect local or private fishing activities. There are no significant social or economic impacts of the Proposed Action interrelated with significant natural or physical environmental effects. Thus, the draft EA does not include any further analysis of social or economic effects of the proposed action.

3.2 Physical Environment

Phase I (BRS-07) would be conducted at the AUTEC site, Andros Island, Bahamas. AUTEC is located approximately 13 nautical miles (nm) east of the north-central part of Andros Island, on the eastern edge of the Bahamian Islands, approximately 190 nm east to southeast of Miami, Florida. Andros Island is the largest island in the Bahamas archipelago and the fifth largest in the Caribbean. The climate is semi-tropical, the acoustic environment is quiet, and there is a lack of commercial encroachment.

A predominant physiographic feature of the Bahamas Islands is the Bahama Banks. The Great Bahama Bank borders Andros Island mainly on the western and southern sides. The water depths range from 7 to 11 m (23 to 36 ft). A shallow shelf extends approximately 1 to 2 nm offshore of the east coast of Andros Island forming a lagoon, containing a coral barrier reef on the seaward side. Coral heads and patch reefs are throughout this lagoon. Seaward of the barrier reef, the rocky bottom slopes downward, reaching a depth of approximately 27 m (90 ft) and then sharply drops off. This cliff borders the western edge of the Tongue of the Ocean and extends from the edge of the outer platform down to 182 m (600 ft) (Busby et al., 1966). The Tongue of the Ocean, a very deep submarine canyon, is located here. The U.S. Navy (1974) and Armstrong (1953) investigated the benthic environment of the Tongue of the Ocean. The water depth in the area is approximately 900 to 2700 m (2950 to 8860 ft). The bottom in most of the areas consists of fine grained, unconsolidated sediment. The bottom was reported to be almost barren, with benthic fauna to be extremely scarce. Temperatures at the bottom were around 4 deg C (39.2 deg F). 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, near the Great Bahama Bank, about 63 km (34 nm) in diameter. Along the Tongue of the Ocean on the eastern coast of Andros Island, the water becomes very shallow with small beaches in protected areas (Newell et al., 1951). Figure 2 below is a bathymetric chart of AUTEC, including the Tongue of the Ocean and surrounding areas.

The tides around Andros Island are mixed semi-diurnal, experiencing two unequal high tides and two unequal low tides per tidal day. The tidal range between mean high tide and mean low tide is approximately 0.8 m (2.6 ft). Variations are due to barometric pressure and wind direction. Though, under normal conditions, tides rarely exceed 0.3 m (1 ft). Tidal currents are generally less than 3.7 km/hr (2 kt). On the platform surrounding the Tongue of the Ocean, tidal velocities may exceed 5.6 km/hr (3 kt) in tidal cuts and reef channels (Palmer, 1979). Offshore currents in the Tongue of the Ocean are also variable in terms of direction. The current speed is usually less than 1.9 km/hr (1 kt) at the surface and diminishes with depth (U.S. Naval Oceanographic Office, 1967). The general pattern of Tongue of the Ocean circulation is attributed to the northwest-setting Antilles current, the prevailing easterly winds, and the funnel-like effects of the narrow, shallow passages between the islands and cays (Podeszwa 1991).

Water temperature and salinity in the shallow northern and eastern portions of the Great Bahama Bank are different from those in deeper regions of the Tongue of the Ocean and Northwest Providence Channel. Shallow Bahama Bank waters show sharp local and short-term fluctuations in temperature and salinity that are typical of bank waters. The deeper waters of the Tongue of the Ocean and Northwest Providence Channel are typically oceanic waters where temperature and salinity fluctuate very little over a year (U.S. Naval Oceanographic Office, 1967). Within the Tongue of the Ocean, salinities fluctuate between 36 and 37 ppt in the upper 300 m (1,000 ft) of the water column and then decline to approximately 35 ppt at 915 m (3,000 ft). Salinity remained constant below 915 m (3,000 ft) (Podeszwa 1991).

The position of Andros Island and the Tongue of the Ocean within the Great Bahamas Platform provides little exposure to open-ocean fetch and the infrequency of northwest winds suggest that swell is not a dominant influence on wave action. Wind speed rarely exceeds 55.6 km/hr (30 kt). The U.S. Navy (1986) collected wind data from a climatic study of the Bahamas and found the wind speeds to be relatively consistent at 10 to 17 kt. The mean monthly speeds range from a low of 8 kt in September to a high of 14 kt in December. The annual mean wind speed is 11.9 kt. Average wave height is 0.6 to 0.9 m (2 to 3 ft).

There is a slight seasonal change in the dissolved oxygen in the shallow areas around Andros Island. Generally, the water across the Great Bahamas Bank is 96 to 100 percent saturated with oxygen during December and 107 to 118 percent super-saturated with oxygen in April. The supersaturated condition is due to warmer temperatures and higher photosynthetic activity (Smith, 1940).

Phosphates, the limiting nutrient in nutrient-poor open ocean waters, are virtually undetectable in the surface waters of the Tongue of the Ocean. Below the surface layers, phosphate concentrations increase steadily until they reach a maximum of 70 mg/m^3 at approximately 700 m (2,300 ft). Phosphate concentrations in shallow water are essentially undetectable except in a few observations where values of 2 to 3 mg/m^3 of phosphate were found.

The climate is mild throughout the year, with average temperature ranging from 21 deg C (20 deg F) during the winter to 27 deg C (81 deg F) in the summer. Prevailing winds are from the southeast in the summer and northeast in the winter. Hurricanes threaten the area typically from mid-July through mid-November.

Sources of ambient oceanic noise at AUTEC include wind, distant shipping, rain, oceanic turbulence, sea life, tides, waves, volcanic eruptions, seismic activity, and molecular agitation from heating and cooling. Noise levels produced by human activities are determined not only by their acoustic power output (a function of the SL and frequency) but by local sound transmission conditions, including ambient noise levels, water depth and temperature and other variables (Richardson et al., 1995). Due to the properties of sound propagation and loss in water, sounds from the MF source (assuming a maximum 210 dB SL) would drop to levels of 160 dB re 1µPa within 317 m (97 ft) of the source. The quietest ambient noise levels anticipated for the region of the proposed study ranges from approximately 40 to 80 dB re 1µPa^2/Hz depending on winds, rain, surf conditions, boat traffic, etc.

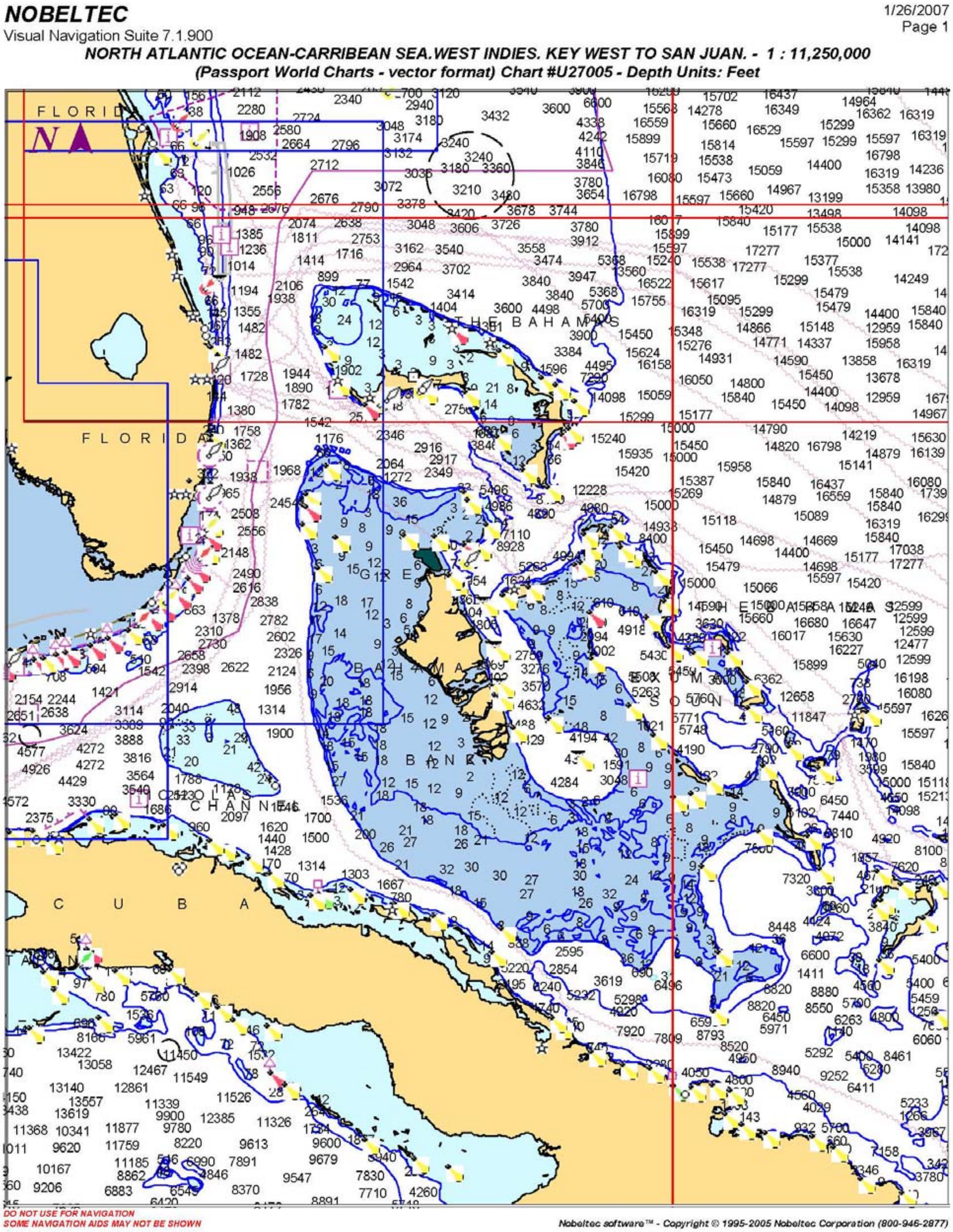


Figure 2. AUTEC Bathymetry, including the Tongue of the Ocean and surrounding areas.

3.2.1 Sanctuaries, Parks, Historic Sites, etc.

There are no National Marine Sanctuaries, state or national parks, National Wildlife Refuges, or historic sites (*i.e.*, sites listed with the National Register of Historic Places) within the action area as defined above.

3.2.2 Essential Fish Habitat

Congress defined Essential Fish Habitat (EFH) as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. 1802(10)). The EFH provisions of the Magnuson-Stevens Fishery Conservation and Management Act offer resource managers means to accomplish the goal of giving heightened consideration to fish habitat in resource management. EFH has been designated for many of the fish species along the Atlantic coast of the United States as well as around Puerto Rico. However, no EFH has been designated for the proposed study region.

3.2.3 Designated Critical Habitat

No critical habitat has been designated for any endangered species in or near the proposed study area.

3.3 Biological Environment

In addition to the target species – beaked whales, sperm whales, pilot whales, melon-headed whales, and Risso's dolphin – a wide variety of marine species could be found within the action area, including other marine mammals, sea turtles, invertebrates, teleost and elasmobranch fish, and sea birds. Since merely being present within the action area does not necessarily mean a marine organism would be affected by the proposed action, the following discussion focuses not only on the distribution and abundance of various species that may be present at the time of the proposed study, but also on whether or not the sounds produced for the study would be within the hearing range of that organism.

3.3.1 Invertebrates

A variety of invertebrates may be present within the action area including assorted mollusks, crustaceans, sponges, and jellyfish. Many invertebrates are not likely to be affected by the proposed action because: 1) they do not have delicate organs or tissues whose acoustic impedance is significantly different from water; or 2) there is no evidence of invertebrate auditory capabilities in the frequency range used by the study.

Little is known about the importance of underwater sound in invertebrates. Many invertebrates are not capable of hearing or producing sounds; in fact, no hearing organs or vocal organs have been identified for most species. However, according to Hawkins and Myrberg (1983), it appears that some sound-producing invertebrates are capable of communicating with each other. Few invertebrates have tissues with acoustic impedance sufficiently different from seawater to pose a risk of non-auditory damage (*e.g.,* from resonance). Therefore there is likely to be little risk of either auditory or non-auditory physical damage.

Among invertebrates, hearing for only cephalopods (octopus and squid) and decapods (lobster, shrimp, and crab) have been measured (Offutt, 1970; Budelmann and

Williamson, 1994). Based on Budelmann and Young's measurements, the cephalopod threshold for hearing for far-field sound waves is estimated to be 146 SEL. Statocysts were analyzed when the hair cells were stimulated with water movements from different directions. The experiment indicated that cephalopod statocysts are directionally sensitive in a way that is similar to the responses of hair cells on vertebrate vestibular and lateral line systems. The hearing threshold for the American lobster has been determined to be approximately 150 SEL (Offutt, 1970). Popper et al. (2001; 2003) also reviewed behavioral, physiological, anatomical, and ecological aspects of sound and vibration detection by decapod crustaceans.

Decapod crustaceans are known to produce acoustic signals. Many decapods also have an array of hair-like receptors within and upon the body surface that potentially or respond to water- or substrate-borne displacements as well as proprioceptive organs that could serve secondarily to perceive vibrations. Hair fans on macruran decapods respond to frequencies from water flow and vibrations of up to 100 Hz. Similarly, in some cephalopods, hairs may have different lengths and therefore respond to different frequencies. Hairs on the pits of chelae on crayfish respond to the acceleration component of water vibrations up to more than 150 Hz. Behavioral studies on the hydrodynamic stimulation of the Norway lobster (*Nephrops norvegicus*) showed a set of postural responses to sound frequencies between 20 and 180 Hz in a laboratory experiment. Also, in a field experiment, they showed that the response was to particle displacement and not pressure, with thresholds near 0.9 μm over a range of 20 to 200 Hz. Both fiddler and ghost crab males produce sound, possibly to both attract females and deter other males. Most of the spectral energy in the calls is confined to frequencies between 300 Hz and 3 kHz, with variation depending on how the signal is produced. Threshold sensitivity to vibration shown by the fiddler and ghost crabs show that the crabs are most sensitive at these frequencies. Ghost crabs seem to have the greatest sensitivity at 300 to 700 Hz and fiddler crabs have the greatest sensitivity from 1 Hz to 2 kHz (Popper et al., 2001).

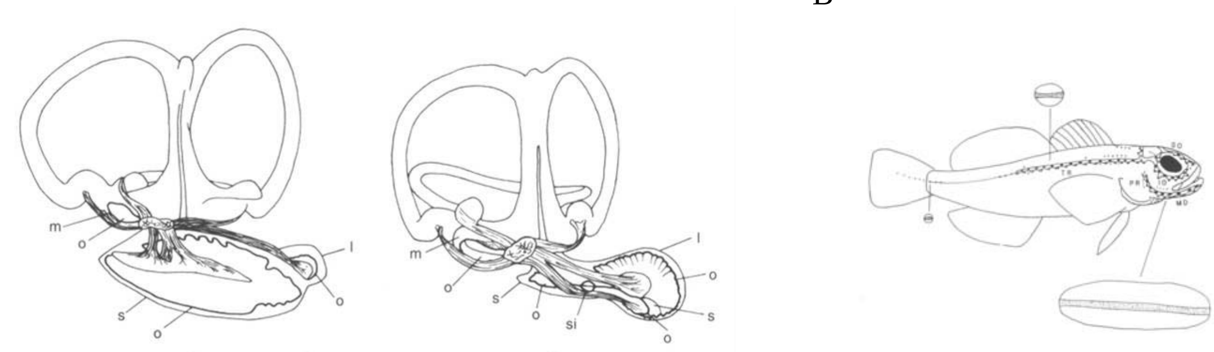
While data are still very limited, they do suggest that some of the major cephalopods and decapods may not hear well, if they hear at all. It may cautiously be suggested that given these levels of hearing thresholds, source operations may have only a minimal, if any, impact on these and other invertebrates. Also, the proposed study would take place over a short amount of time (approximately 6 weeks in the summer/fall of 2007) and on a small spatial scale (AUTEC site, Andros Island, Bahamas). Based on scientific data, some invertebrates may respond to the source. However, due to the SL, the short time period, and the small area of operation, no long-term or permanent changes in invertebrate behavior or viability are anticipated.

3.3.2 Fish

There are dozens of fish species that may occur within the action area, including various reef fish, sharks and rays, tarpon, jacks, grouper, mackerel, mahi mahi, and marlin. The octavolateralis system (a.k.a. lateral line, ear, and electroreptor system) of fish is used to sense sound, vibrations, and other forms of water displacement in the environment, as well as to detect angular acceleration and changes in the fish’s position relative to gravity

(Popper et al., 2003). The major components of the octavolateralis system (Figure 3) are the inner ear and the lateral line. The basic functional unit in the octavolateralis system is the sensory hair cell, a highly specialized cell that is stimulated by mechanical energy (e.g., sound, motion) and converts that energy to an electrical signal that is compatible with the nervous system of the animal. The sensory cell found in the octavolateralis system of fish and elasmobranchs is the same sensory cell found in the ears of terrestrial vertebrates, including humans (Coffin et al., 2004). Both components of the octavolateralis system, the ear and the lateral line, send their signals to the brain in separate neuronal pathways. However, at some levels the two systems interact to enable the fish to detect and analyze a wide range of biologically relevant signals (Coombs et al., 1989).

A B



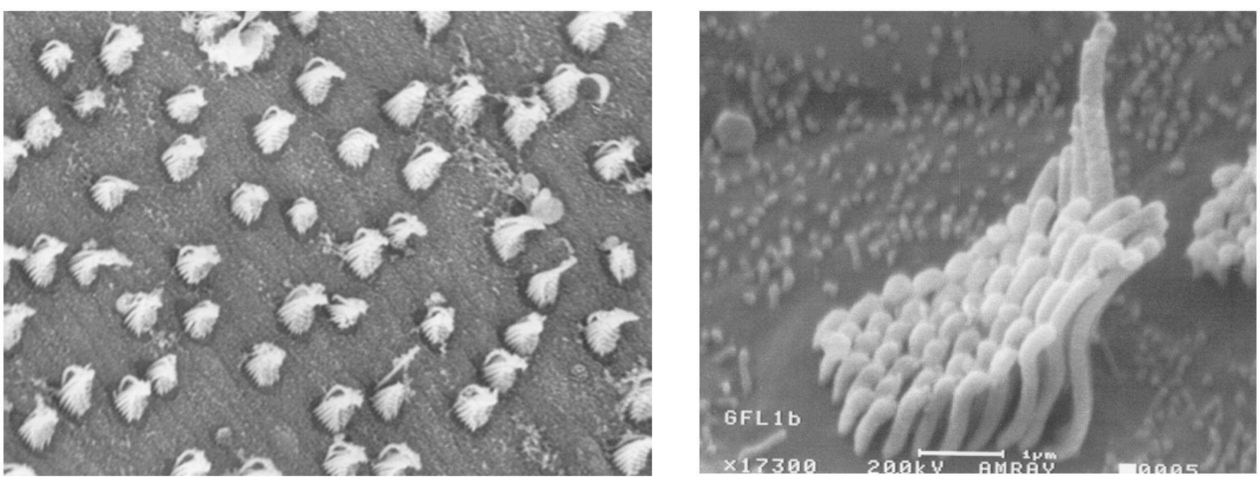
The octavolateralis system of fish includes the inner ear (A) and the lateral line system (B). (A) Drawing of the medial view of the inner ear of a zander (*Stizostedion lucioperca*) on the left and an ide (*Levciscus idus*) on the right (From Popper and Fay, 1973). l *Lagena*, m *utriculus*, o *otolith of each otolithic end organ*, s *sacculus*, si *transverse canal*. (B) Drawing of the canal and surface neuromasts on the body of the mottled sculpin (*Cottus bairdii*). The enlarged drawings show the dorsal surface of neuromasts found on the mandible, trunk, and a superficial neuromast, and stippling represents hair cells. MD *mandibular canal*; SO *supraorbital canal*; IO *infraorbital canal*; PR *preopercular canal*; TR *trunk canal*. (From Coombs, S. et al., *The Mechanosensory Lateral Line: Neurobiology and Evolution*, Springer-Verlag, New York, 1989, 301).

Figure 3. Octavolateralis system of fish.

The lateral line is divided into two parts: the canal system and the free neuromasts. Each neuromast is a grouping of sensory hair cells that are positioned so that they can detect and respond to water motion around the fish. The canal neuromasts are spaced evenly along the bottom of canals that are located on the head and extending along the body (in most, but not all, species). The free neuromasts are distributed over the surface of the body. The specific arrangement of the lateral line canals and the free neuromasts vary with different species (Coombs et al., 1992). The pattern of the lateral line canal suggests that the receptors are laid out to provide a long baseline that enables the fish to extract information about the direction of the sound source relative to the animal. The latest data suggest that the free neuromasts detect water movement (e.g., currents), whereas the receptors of the lateral line canals detect hydrodynamic signals. By comparing the responses of different hair cells along such a baseline, fish should be able to use the receptors to locate the source of vibrations (Montgomery et al., 1995; Coombs and Montgomery, 1999). Moreover, the lateral line appears to be most responsive to relative movement between the fish and surrounding water (its free neuromasts are sensitive to particle velocity; its canal neuromasts are sensitive to particle acceleration).

The ear and the lateral line overlap in the frequency range to which they respond. The lateral line appears to be most responsive to signals ranging from below one Hz to between 150 and 200 Hz (Coombs et al., 1992), while the ear responds to frequencies from about 20 Hz to several thousand Hz in some species (Popper and Fay, 1993; Popper et al., 2003). The specific frequency response characteristics of the ear and lateral line varies among different species and is probably related, at least in part, to the life styles of the particular species.

The inner ear in fish is located in the cranial (brain) cavity of the head just behind the eye. Unlike terrestrial vertebrates, there are no external openings or markings to indicate the location of the ear in the head. The ear in fish is generally similar in structure and function to the ears of other vertebrates. It consists of three semicircular canals that are used for detection of angular movements of the head, and three otolithic organs that respond to both sound and changes in body position (Schellart and Popper, 1992; Popper et al., 2003; Ladich and Popper, 2004). The sensory regions of the semicircular canals and otolith organs contain many sensory hair cells as shown in Figure 4. In the otolith organs, the ciliary bundles, which project upward from the top surface of the sensory hair cells, contact a dense structure called an otolith (or ear stone). It is the relative motion between the otolith and the sensory cells that results in stimulation of the cells and responses to sound or body motion. The precise size and shape of the ear varies in different fish species (Popper and Coombs, 1982; Schellart and Popper, 1992; Popper et al., 2003; Ladich and Popper, 2004).



Scanning electron micrographs of the ciliary bundles of hair cells from a goldfish (*Carassius auratus*) lagena (unpublished photographs by M.E. Smith). The hair cell on the right is enlarged from the general area shown on the left. (Information at bottom of right image shows magnification [17,300x) and other record keeping information. The scale bar is 1 μm.)

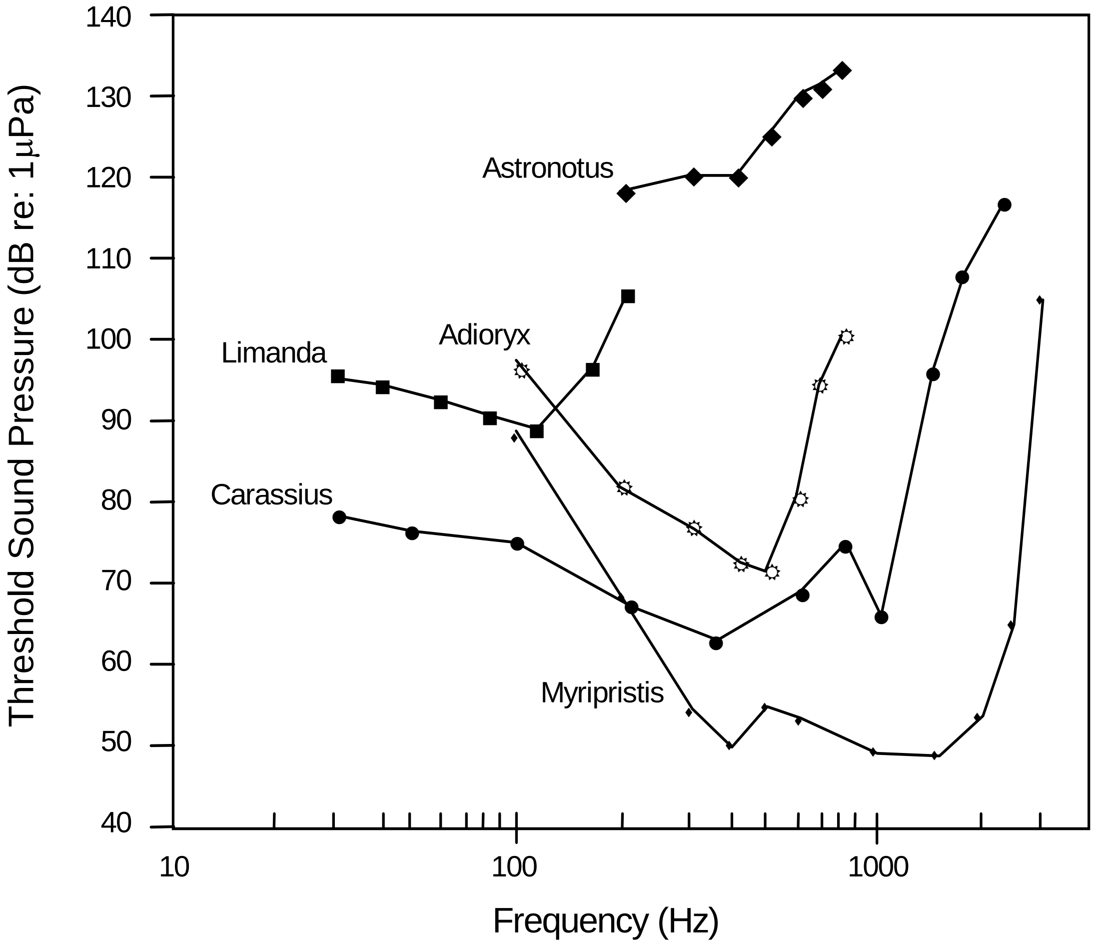
Figure 4. Electron micrograph of the sensory surface of a fish ear.

Hearing is better understood for bony fish than for other fish, such as cartilaginous fish like sharks and jawless fish (class Agnatha) (Popper and Fay, 1993; Ladich and Popper, 2004). Bony fish with specializations that enhance their hearing sensitivity have been referred to as hearing "specialists" whereas, those that do not posses such capabilities are called "nonspecialists" (or "generalists"). Popper and Fay (1993) suggest that in the hearing specialists, one or more of the otolith organs may respond to sound pressure as well as to acoustic particle motion. The response to sound pressure is thought to be mediated by mechanical coupling between the swim bladder (the gas-filled chamber in the abdominal cavity that enables a fish to maintain neutral buoyancy) or other gas bubbles and the inner ear. With this coupling, the motion of the gas-filled structure, as it expands and contracts in a pressure field, is brought to bear on the ear. In nonspecialists, however, the lack of a swim bladder, or its lack of coupling to the ear, probably results in the signal from the swim bladder attenuating before it gets to the ear. As a consequence, these fish detect little or none of the pressure component of the sound (Popper and Fay, 1993).

The vast majority of fish studied to date appear to be non-specialists (Schellart and Popper, 1992; Popper et al., 2003), and only a few species known to be hearing specialists inhabit the marine environment (although lack of knowledge of specialists in the marine environment may be due more to lack of data on many marine species, rather than on the lack of there being specialists in this environment). Some of the better known marine hearing specialists are found among the Beryciformes (i.e., soldierfish and especially Holocentridae, which includes the squirrelfish) (Coombs and Popper, 1979), and Clupeiformes (i.e., herring and shad) (Mann et al., 1998, 2001). Even though there are hearing specialists in each of these taxonomic groups, most of these groups also contain numerous species that are nonspecialists. In the family Holocentridae, for example, there is a genus of hearing specialists, *Myripristis*, and a genus of nonspecialists, *Adioryx* (Coombs and Popper, 1979).

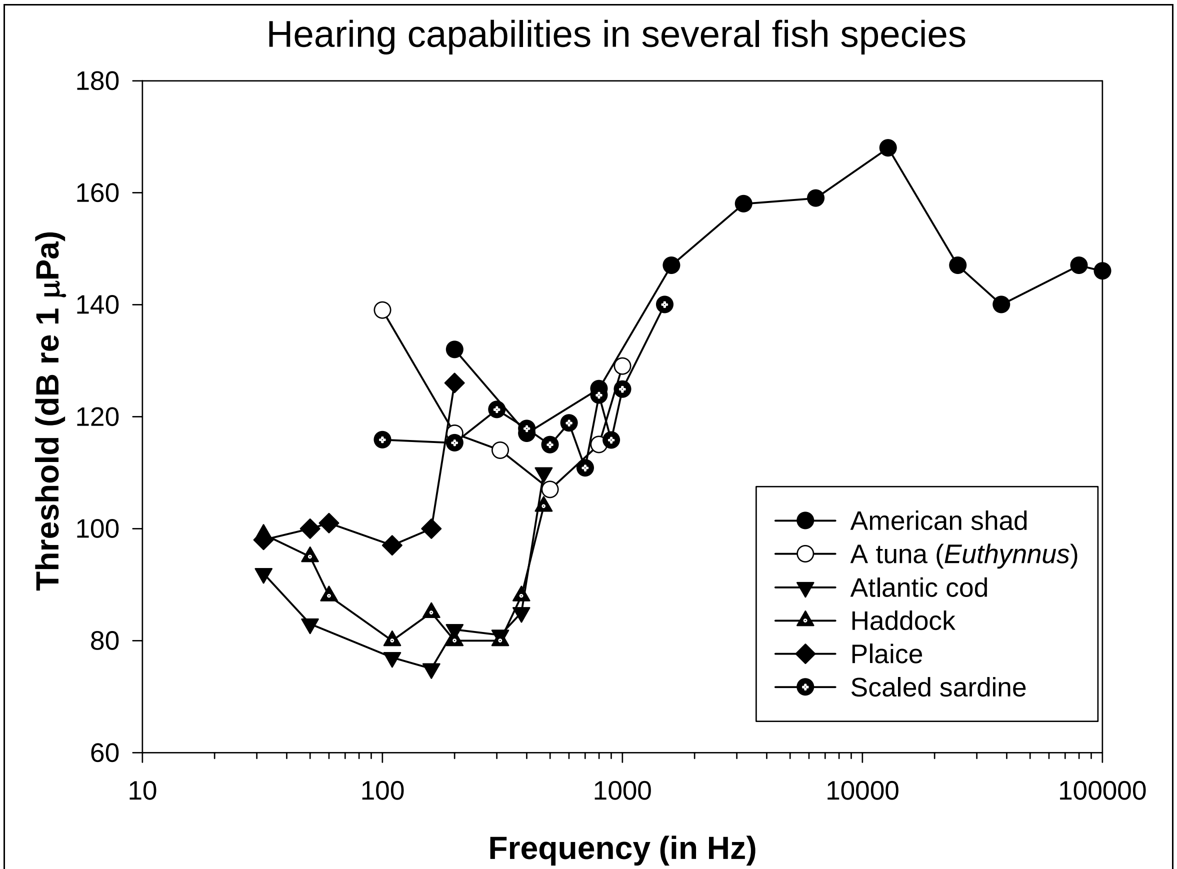
Audiograms (measures of hearing sensitivity) have been determined for over 50 fish (mostly fresh water) and four elasmobranch species (Fay, 1988a; Casper et al., 2003). An audiogram plots auditory thresholds (minimum detectable levels) at different frequencies and depicts the hearing sensitivity of the species. It is difficult to interpret audiograms because it is not known whether sound pressure or particle motion is the appropriate stimulus and whether background noise determines threshold. The general pattern that is emerging indicates that the hearing specialists detect sound pressure with greater sensitivity over a wider bandwidth (to 3 kHz or above) than the nonspecialists. Also, the limited behavioral data available suggest that frequency and intensity discrimination performance may not be as acute in nonspecialists (Fay, 1988a).

Behavioral audiograms for both freshwater and marine fish are presented in Figure 5 for two hearing specialists (goldfish [*Carassius auratus*] and squirrelfish [*Myripristis* *kuntee*]), two nonspecialists that have a swim bladder (another squirrelfish [*Adioryx xantherythrus*] and an oscar [*Astronotus ocellatus*]), and one nonspecialist without a swim bladder (lemon sole [*Limanda limanda*]). Popper and Fay (1993) point out that threshold values are expressed as SPLs because that quantity is easily measured, although this value is strictly correct only for the fish that respond in proportion to sound pressure. It is uncertain if the thresholds for the oscar and lemon sole should be expressed in terms of sound pressure or particle motion amplitude. In comparing best hearing thresholds, hearing specialists are similar to most other vertebrates, when thresholds determined in water and air are expressed in units of acoustic intensity (i.e., Watts/cm^2) (Popper and Fay, 1993). Figure 6 provides data for additional marine species.



Two hearing specialists: *Carassius auratus* (goldfish)(Fay, 1969) *and Myripristis kuntee* (squirrelfish)(Coombs and Popper, 1979); two hearing nonspecialists having a swimbladder, *Adioryx xantherythrus* (another squirrelfish)(Coombs and Popper, 1979), and *Astronotus ocellatus* (the Oscar)(Yan and Popper, 1992); and a nonspecialist without a swimbladder, *Limanda limanda* (lemon sole)(Chapman and Sand, 1974)

Figure 5. Behavioral audiograms for marine and freshwater fish species.



Data for select marine species: American shad (*Alosa sapidissima* - Mann et al., 2001); Tuna (*Euthynnus affinis*) - Iverson, 1967), Atlantic cod (*Gadus morhua* - Chapman and Hawkins, 1973); Haddock (*Melanogrammus aeglefinus* - Chapman, 1973); Plaice (*Pleuronectes platessa* – Chapman and Sand, 1974); Scaled sardine (*Harengula jaguana*) (Mann et al., 2001)

Figure 6. Behavioral audiograms for selected marine fish species.

The region of best hearing in the majority of fish for which there are data available is from 100 to 200 Hz up to 800 Hz. Most species, however, are able to detect sounds to below 100 Hz, and often there is good detection in the LF range of sounds. It is likely that as data are accumulated for additional species, investigators would find that more species are able to detect low frequency sounds fairly well.

As for sound production in fish, Myrberg (1980) states that members of more than 50 fish families produce some kind of sound using special muscles or other structures that have evolved for this role, or by grinding teeth, rasping spines and fin rays, burping, expelling gas, or gulping air. Sounds are often produced by fish when they are alarmed or presented with noxious stimuli (Myrberg, 1981; Zelick and Popper, 1999). Some of these sounds may involve the use of the swim bladder as an underwater resonator. Sounds produced by vibrating the swim bladder may be at a higher frequency (400 Hz) than the sounds produced by moving body parts against one another. The swim bladder drumming muscles are correspondingly specialized for rapid contractions (Zelick and Popper, 1999). Sounds are known to be used in reproductive behavior by a number of fish species, and the current data lead to the suggestion that males are the most active producers. Sound activity often accompanies aggressive behavior in fish, usually peaking during the reproductive season. Those benthic fish species that are territorial in nature throughout the year often produce sounds regardless of season, particularly during periods of high-level aggression (Myrberg, 1981).

Popper (2000) concludes that “while there is a wide diversity in the hearing range and sensitivity of fishes, only a few species hear sounds above 3000 Hz and most species can hear no higher than 1000 Hz.” Additionally, “similar data have suggested that most fishes can detect sounds somewhat below 50 Hz.” Since the proposed study would use MF sound sources (which ranges nominally from 1 kHz to 10 kHz), the fish that are able to detect these sources would be in the lower end if its detection range. Also, the proposed study would take place over a short amount of time (approximately 4-6 weeks in the summer/fall of 2007) and on a smaller scale (AUTEC site, Andros Island, Bahamas). Based on scientific data, it is presumed fish may respond to the sounds in the study. However, due to the SL, the short time period, and the small area of operation, no long-term or permanent changes in fish behavior or viability are anticipated.

3.3.3 Sea Turtles

The following species of protected sea turtles may occur within the proposed action area, though not necessarily at the time of year of the proposed study: green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), Kemp’s ridley (*Lepidochelys kempii*), olive ridley (*L. olivacea*), and hawksbill (*Eretmochelys imbricate*). All sea turtles have a protected status (with respect to the ESA and the Convention on International Trade in Endangered Species [CITES]).

The distribution of most species of sea turtle is limited by water temperature and varies by season. Most sea turtle species are distributed in water temperatures above 18 deg C (64 deg F), but they can survive in waters as cool as 10 deg C (50 deg F). If the water temperature drops below 8 to 10 deg C (46 to50 deg F), cold stunning occurs and turtles lose their ability to swim and dive, and they float to the surface (Spotila et al., 1997). Sea turtle distribution is mostly limited to between 40 deg N and 35 deg S longitude, although during warmer seasons this range is substantially expanded (Davenport, 1997). The exception to this distribution is the leatherback sea turtle, which is found from 71 deg N to 47 deg S longitude, and seems to prefer water temperatures between 14 and 16 deg C (57 and 61 deg F) for foraging, but also spends extended periods in tropical waters for breeding (Marquez, 1990; Plotkin, 1995).

Sea turtles are highly migratory and therefore have a wide geographic range in tropical, sub-tropical, and temperate waters. When they are active, they must swim to the ocean surface to breathe every 5 to 10 minutes (Keinath, 1993), but can remain underwater for 30 to 40 minutes when they are resting. Sea turtles are capable of making repetitive dives in search of food, and migrating turtles usually dive to less than 20 m (65.6 ft) (Luschi et al., 2003).

Hawksbill sea turtle, green sea turtle, olive ridley sea turtle, and Kemp's ridley sea turtle adults are generally coastal species, whereas the young of some or all of these species are believed to be distributed in the open ocean. Upon emerging from their nests, hatchlings rely on the light on the horizon to find the ocean. After entering the water, both magnetic orientation and the oncoming direction of sea swell guide them away from shore (Ernst et al., 1994). Marine turtle species then remain pelagic for many years and may travel through a large range of habitats before returning to coastal environments to reside (excluding the leatherback). Once in coastal waters, juvenile turtles continue to grow and move among developmental environments, migrating to different habitats at different life stages until maturity. Their pattern of movement then becomes more regular, with adult turtles migrating hundreds to thousands of miles between established foraging and breeding areas (Wyneken, 1997; Plotkin, 2003).

Most adult females return to their natal beaches in order to lay eggs. The females come ashore two or more times a season to lay a hundred or more eggs in a deep nest cavity dug with the hind flippers. After filling the nests, the adult females return to the sea and generally remain near the nesting area until they have deposited their last clutch of eggs for the season.

Migratory behavior of adult sea turtles is much better understood than that of hatchlings and juveniles due to the development and use of satellite telemetry. Many females have been tracked after nesting. Some species have been tracked to a neritic environment where they sometimes stay for one to four years. The neritic environment is defined as a shallow water environment or the nearshore marine zone extending from the low-tide level to a depth of 200 m (656 ft). Juvenile sea turtles complete their development in the neritic habitat and adult sea turtles use it for feeding. Migratory routes and currents have been modeled and show that currents are often utilized during migration to increase their speed. However, the comparison between turtle migration routes and modeled data may not be accurate because the models of currents only show the average of the currents over large areas and periods of time. It is possible that the currents also produce feeding grounds (Luschi et al., 2003).

Data on sea turtle sound production and hearing are few. There is little known about the mechanism of sound detection by turtles, including the pathway by which sound gets to the inner ear and the structure and function of the inner ear of sea turtles (Bartol and Musick, 2003). However, assumptions have been made based on research on other species of turtles. Based on the structure of the inner ear, there is some evidence to suggest that marine turtles primarily hear sounds in the low frequency range and this hypothesis is supported by the limited amount of physiological data on turtle hearing. Bartol and Musick (2003) said that the amount of pressure needed to travel through the bone channel of the ear increases with an increase in frequency. For this reason, it is believed that turtles are insensitive to high frequencies and that they primarily hear in a low frequency range. A description of the ear and hearing mechanisms can be found in

Bartol and Musick (2003). The few studies completed on the auditory capabilities of sea turtles also suggest that they could be capable of hearing LF sounds, particularly as adults. These investigations examined adult green, loggerhead, and Kemp's ridley sea turtles (Ridgway et al., 1969; Mrosovsky, 1972; O'Hara and Wilcox, 1990; Bartol et al., 1999). There have been no published studies to date of olive ridley, hawksbill, or leatherback sea turtles (Ridgway et al., 1969; O'Hara and Wilcox, 1990; Bartol et al., 1999).

Underwater sound was recorded in one of the major coastal foraging areas for juvenile sea turtles (mostly loggerhead, Kemp's ridley and green sea turtles) in the Peconic Bay Estuary system in Long Island, NY (Samuel et al., 2005). The recording season of the underwater environment coincided with the sea turtle activity season in an inshore area where there is considerable boating and recreational activity, especially during the July-September timeframe. During this time period, RLs at the data collection hydrophone system in the 200-700 Hz band ranged from 83 dB (night) up to 113 dB (weekend day). Therefore, during much of the season when sea turtles are actively foraging in New York waters, their coastal habitats are flooded with underwater noise. The sea turtles are undoubtedly exposed to high levels of noise, most of which is anthropogenic. Results suggest that continued exposure to existing high levels of pervasive anthropogenic noise in vital sea turtle habitats and any increase in noise could affect sea turtle behavior and ecology (Samuel et al., 2005). However, there were no data collected on any behavioral changes in the sea turtles due to anthropogenic noise or otherwise during this study.

Ridgway et al. (1969) used airborne and direct mechanical stimulation to measure the cochlear response in three juvenile green sea turtles. The study concluded that the maximum sensitivity for one animal was 300 Hz, and for another 400 Hz. At the 400 Hz frequency, the turtle's hearing threshold was about 64 dB in air (re: 20 µPa). At 70 Hz, it was about 70 dB (re: 20 µPa) in air. Sensitivity decreased rapidly in the lower and higher frequencies. From 30 to 80 Hz, the rate of sensitivity declined approximately 35 dB. However, these studies were done in air, up to a maximum of 1 kHz, and thresholds were not meaningful since they only measured responses of the ear; moreover, they were not calibrated in terms of pressure levels.

Bartol et al. (1999) measured the hearing of juvenile loggerhead sea turtles using auditory evoked potentials to LF tone bursts and found the range of hearing via Auditory Brainstem Response (ABR) recordings from LF tone bursts indicated the range of hearing to be from at least 250 to 750 Hz. The lowest frequency tested was 250 Hz and the highest was 1000 Hz.

More recently, Streeter and colleagues (pers. comm., 2005) were able to train a female green sea turtle to respond to acoustic signals. The results from this study showed a hearing range of at least 100 to 500 Hz (the maximum frequency that could be used in the study, as opposed to what may be a wider hearing range) with hearing thresholds of 120-130 dB RL. However, there are several important caveats to these results. First, the study was done in a relatively noisy oceanarium. Thus, the thresholds reported may have been masked by the background noise and the "absolute thresholds" (the lowest detectable signal within a noisy environment) may be several dB lower than the reported results. Second, data are for a single animal who is well into middle age (over 50 years old) and who had lived in an oceanarium all its life. While there are no data on effects of age on sea turtle hearing, data for a variety of mammals (including humans) show there is a substantial decrement in hearing with age, and this may have also happened in this animal. This too may have resulted in thresholds being higher than in younger animals (as used by Ridgway et al., 1969). Finally, the data are for one animal and so nothing is known about variability in hearing, or whether the data for this animal are typical of the species.

Based on the data on sea turtles and sea turtle hearing, though the data are few, it is believed that sea turtles would not be affected by the source used in BR-07. The hearing data support the theory that sea turtles hear low frequencies, whereas this study proposes to operate in frequencies above 1000 Hz. Additionally, the proposed study would take place over a short amount of time (approximately 6 weeks in the summer/fall of 2007) and on a small spatial scale (AUTEC site, Andros Island, Bahamas). Due to the SL, the short time period, and the small area of operation, no long-term or permanent changes in sea turtle behavior or viability are anticipated.

3.3.4 Seabirds

There are several species of seabirds that may be found within the action area, including Audubon's shearwater, boobies, and terns. There are more than 270 species of seabirds in five orders, and each order has species that dive to depths exceeding 25 m (82 ft). There are few data on hearing in seabirds and even less on underwater hearing. There is no evidence that seabirds use sound underwater. Additionally, seabirds spend a very small fraction of their time submerged. Therefore, it is not likely there would be any detectable impact to seabirds.

As mentioned with invertebrates, fish, and sea turtles, the proposed study would contribute a negligible amount of underwater sound to the underwater acoustic environment of sea birds due to the very small area in which the sounds might even be detectable by a diving seabird, and given the short duration of time over which sounds from the MF sonars would be broadcast, and the small fraction of time that any diving seabird would actually be underwater.

3.3.5 Marine Mammals

The following is a brief summary of the occurrence of marine mammals expected in the proposed BRS-07 study area of AUTEC. See Table 1 for additional information.

Baleen whales

Blue Whale (*Balaenoptera musculus)*
Stocks: western North Atlantic, eastern North Atlantic

Blue whales range from the Arctic to at least mid-latitudes, including waters of the Gulf of Mexico. They do not occur in the Mediterranean Sea (Reeves and Notarbartolo di

Sciara, 2006). Existing data are insufficient for stock differentiation and population estimates in the Atlantic (Mitchell and Chapman 1977). In the Gulf of St. Lawrence area, 308 recognized individuals were catalogued, and this is considered the minimum population estimate for the western North Atlantic stock. This species is pelagic, primarily found feeding north of the Gulf of St. Lawrence and the Bay of Biscay during spring, summer, and fall. It is considered as a very occasional species south of those regions (Waring et al. 2006). Clark (1995) has acoustically detected calls of blue whales in the North Atlantic, especially near the Grand Banks of Newfoundland and west of the United Kingdom. Limited migration has been documented south to subtropical waters during fall and winter. This species feeds on krill and copepods, the abundance of which most likely controls migration in and out of polar areas. Blue whales are usually seen solitary or in groups of 2 or 3 individuals. This species is listed as endangered under the ESA and is listed in Appendix I of CITES.

Fin Whale (*Balaenoptera physalus*)
Stocks: western North Atlantic; British Isles, Spain and Portugal; Mediterranean

Fin whales range from the Arctic to the tropics, with concentrations north of 45°N in summer and south of 45°N in winter. The fin whale has been separated into the following different stocks in the North Atlantic for management purposes: the Western North Atlantic (Waring et al. 2006), the British Isles-Spain-Portugal (Buckland et al. 1992b), and the East Greenland/Iceland (Buckland et al. 1992a). The International Whaling Commission divides North Atlantic fin whales into the following seven stocks: Nova Scotia, Newfoundland-Labrador, West Greenland, East Greenland-Iceland, British Isles-Spain-Portugal, West Norway-Faroe Islands, and North Norway (Donovan, 1991). Fin whales in the Mediterranean Sea display genetic differentiation from fin whales in coastal waters of Canada, Greenland, Iceland, and Spain (Berube et al. 1998), and it is predicted that further research will show that fin whales are resident in the Mediterranean Sea (Palsboll et al. 2004).

Fin whales are usually found inshore of the 2,000 m (6561 ft) contour. This species feeds on krill, planktonic crustaceans, and schooling fish such as herring and capelin. The best available abundance estimate for the western North Atlantic stock is for the region from Georges Bank to the mouth of the Gulf of St. Lawrence. A ship and aircraft line transect sighting survey conducted between 28 July to 31 August 1999 estimated 2,814 (CV=0.21) fin whales (Waring et al. 2006). The best estimate for the British Isles-Spain-Portugal stock is 17,000 (95% CI 10,400-28,900) (Buckland et al. 1992b). A study of the western Mediterranean basin estimated 3,583 fin whales (S.E. 967, 95% C.I. 2,130-6,027) in that region (Forcada et al. 1996), whereas a more detailed study of the Coriscan-Ligurian-Provencal basin estimated 901 fin whales (S.E. 196.1, 95% C.I. 591-1,374) (Forcada et al. 1995). This species is listed as endangered under the ESA and is listed in Appendix I of CITES.

Sei Whale (*Balaenoptera borealis*)
Stocks: Nova Scotia, eastern North Atlantic

Very little is known about the stock structure and abundance of sei whales in the North Atlantic. Donovan (1991) concluded that the stock identity of sei whales in the North Atlantic is an unresolved research question, but the International Whaling Commission did recognize a Nova Scotia stock that extends from the U.S. east coast north to Cape Breton, Nova Scotia then east to 42°W. The U.S. National Marine Fisheries Service provisionally adopted this stock definition, but admitted that little data exist to assess the status of the stock. Mitchell and Chapman (1977) estimated the Nova Scotia, stock to contain between 1,393 and 2,248 sei whales. An abundance of 280 sei whales was estimated from an aerial survey program conducted from 1978 to 1982 on the continental shelf and shelf edge waters between Cape Hatteras, North Carolina and Nova Scotia (CETAP 1982). Even less is known about sei whales in the eastern North Atlantic and Mediterranean. A handful of occurrences have been documented in the Mediterranean Sea (Reeves and Notarbartolo di Sciara 2006). A limited catch of sei whales occurred off Spain and northwestern Africa (Horwood 1987). This species is listed as endangered under the ESA and is listed in Appendix I of CITES.

Bryde's Whale (*Balaenoptera edeni*)
Stocks: northern Gulf of Mexico, North Atlantic

Bryde's whales are distributed worldwide in tropical and sub-tropical waters, typically south of 35°N and north of 35°S. Bryde's whales are the most common baleen whale in the Gulf of Mexico, and, although there are no data to differentiate them from animals in the North Atlantic, they are provisionally considered a separate stock (Waring et al. 2006). Bryde's whales are not known to occur in the Mediterranean Sea (Reeves and Notarbartolo di Sciara 2006). The best available abundance estimate for the northern Gulf of Mexico stock is 40 animals (CV=0.61) (Mullin and Fulling 2004). Limited data are available for the North Atlantic, though vocalizations from Bryde's whales have been documented in the Caribbean (Barlow et al. 2000, Oleson et al. 2003). This species is listed in Appendix I of CITES.

Minke Whale (*Balaenoptera acutorostrata*)
Stocks: Canadian East Coast, northeastern North Atlantic

Minke whales have a widespread distribution in polar, temperate, and tropical waters, with sightings typically within the 200 m (656 ft) depth contour. There are four recognized minke whale stocks in the North Atlantic, including the Canadian East Coast, west Greenland, central North Atlantic, and northeastern North Atlantic, though the data for stock differentiation are limited (Donovan 1991). The best available abundance estimate for the Canadian East Coast stock is 3,618 (CV=0.186) minke whales, the sum of the 1999 Georges Bank to Gulf of St. Lawrence survey estimate (2,998 (CV=0.19)) and the 1996 northern Gulf of St. Lawrence estimate (620 (CV=0.52)) (Waring et al. 2006). The IWC estimates the remainder of the North Atlantic contains approximately 149,000 (95% C.I. 120,000-182,000) minke whales. During summer, minke whales are relatively widespread and abundant in northern waters, whereas during winter, the species appears to migrate to warm temperate or tropical waters (Waring et al. 2006). Preferred prey includes herring, cod, salmon, capelin, squid, and shrimp (Leatherwood et al., 1976; Ridgway and Harrison, 1985). It is believed that this species is more solitary, though large groups have been observed. This species is listed in Appendix I of CITES.

Humpback Whale (*Megaptera novaeangliae*)
Stocks: Gulf of Maine, North Atlantic

Humpback whales have a global distribution, migrating from high latitude feeding grounds to low latitude breeding grounds. In the North Atlantic, they are found during the spring, summer, and fall in at least six feeding grounds, including the Gulf of Maine, the Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, Iceland, and Norway. Animals mix on the main winter breeding ground in the West Indies, and some animals are also seen off the Cape Verde Islands. It is also becoming apparent that significant numbers of animals do not migrate to the winter breeding grounds and are found in mid and high latitude regions during winter months (Barco et al. 2002, Swingle et al. 1993). The stock definition in the North Atlantic is currently under revision since recent genetic data show likely separation between the mitochondrial DNA of the western North Atlantic feeding grounds to suggest separate populations (Clapham et al. 2003). Accordingly, NMFS recognizes a Gulf of Maine stock (Waring et al. 2006), though humpback whales have also been considered as a single stock in the North Atlantic in the past. The best estimate of abundance for the North Atlantic is 11,570 (CV=0.068) animals from photographic mark-recapture work conducted during 1992-1993 as part of the Years of the North Atlantic Humpback Whale (YoNAH) Project (Stevick et al. 2003). A 1999 line transect survey from Georges Bank to the mouth of the Gulf of St. Lawrence estimated 902 (CV=0.41) animals in the Gulf of Maine stock (Waring et al. 2006). Humpback whales are classified as a “visitor” species to the Mediterranean Sea, with 13 documented sightings in the region (Reeves and Notarbartolo di Sciara 2006). This species is listed as endangered under the ESA and is listed in Appendix I of CITES.

Northern Right Whale (*Eubalaena glacialis*)
Stocks: western North Atlantic

Northern right whales migrate from winter calving grounds off the southeastern United States to summer feeding grounds off New England, including the Gulf of Maine, Bay of Fundy, and the Scotian Shelf. Recently, sightings to the north and east of this traditional range have been documented, including Newfoundland, Greenland, Iceland, and arctic Norway (Waring et al. 2006). A minimum population estimate of 299 animals is the best estimate currently available. Right whales are considered vagrants in the Gulf of Mexico, Caribbean, and Mediterranean Sea, and it is unlikely they would occur in any of the proposed experimental regions. This species is listed as endangered under the ESA and is listed in Appendix I of CITES.

Toothed Whales

Sperm Whale (*Physeter macrocephalus*)

Stocks: North Atlantic, northern Gulf of Mexico, Mediterranean

Sperm whales are the largest of the toothed whales and are known for their ability to make prolonged deep dives, with average dive times of approximately 30-60 minutes (Waring et al., 2006). According to the Sperm Whale Seismic Study (SWSS), the average dive lasted 46 minutes, with 95 percent of dives lasting 30-57 minutes (USDOI, MMS, 2006). During SWSS, sperm whales in the Gulf of Mexico and the North Atlantic Ocean had two categories of dive depths: dives less than 150 m (492 ft) and dives greater than 300 m (984 ft). In the Atlantic, sperm whales dove to an average 966 m (3, 169 ft), with a maximum depth of 1, 202 m (3,944 ft). In the Gulf of Mexico, sperm whales dove to an average of 659 m (2,162 ft) (USDOI, MMS, 2006). Sperm whales are distributed in deep, oceanic waters around the world. Their distribution off the U.S. is seasonal, with summer concentrations east of Delaware and Virginia, throughout the mid-Atlantic Bight, and around Georges Bank and into the Northeast Channel region. In the fall, sperm whales are found on the continental shelf south of New England and in the mid-Atlantic Bight. Sperm whales have been documented in the Gulf of Mexico in all seasons. Because of the year-round occurrence of sightings, strandings, and whaling catches, animals in the Gulf of Mexico are considered a separate stock for management purposes (Waring et al., 2004 in USDOI, MMS, 2006; Waring et al., 2006). Also, the preliminary results of the SWSS survey indicate that sperm whales in the Gulf of Mexico are different from other populations, which is supported by genetic analyses, coda vocalizations, and population structure data (USDOI, MMS, 2006). In the eastern North Atlantic, sperm whales occur from Norwegian waters to the equator, with a major breeding area around the Azores (Reid et al. 2003). They are distributed throughout the Mediterranean Sea, with concentrations over steep-sloped and deep water areas. The best available abundance estimate for the North Atlantic stock is 4,804 animals (CV=0.38), resulting from combining the survey estimates from Maryland to the Bay of Fundy (2,607 animals (CV=0.57)) and from Florida to Maryland (2,197 animals (CV=0.47)). The best estimate for the Gulf of Mexico stock is 1,349 (CV=0.23) animals (Waring et al. 2006). No population estimates exist for the Mediterranean Sea, but based on encounter rates, it is suspected that the number of sperm whales in the western basin is in the low to mid hundreds (Reeves and Notarbartolo di Sciara 2006). This species is listed as endangered under the ESA and is listed in Appendix I of CITES.

Pygmy Sperm Whales (*Kogia breviceps*)
Dwarf Sperm Whales (*Kogia simus*)
Stocks: western North Atlantic, northern Gulf of Mexico, eastern North Atlantic

Pygmy sperm whales and dwarf sperm whales are distributed worldwide in temperate to tropical waters along the continental shelf edge and continental slope. The species are difficult to differentiate in the field and sightings of either are typically categorized as *Kogia* spp. *Kogia* are rarely seen alive at sea, but they are among the most frequently stranded small whales in some areas (Jefferson et al., 1993). Pygmy sperm whales have stranded from Nova Scotia south to Texas and Cuba; however, the dwarf sperm whale is typically not found north of Virginia (Leatherwood and Reeves, 1983). In addition, it is thought dwarf sperm whales are either distributed further offshore or dive deeper during feeding bouts (Waring et al. 2006). *Kogia* are best known from U.S. waters, though a few strandings of *Kogia breviceps* have been documented off Spain and western Ireland, for example, with sightings mainly in the Bay of Biscay and off western Ireland(Reid et al. 2003). The best available abundance estimate for the western North Atlantic stock is 395 animals (CV=0.40), representing the sum of the estimates from the two 2004 U.S. Atlantic surveys in which the estimate from the northern U.S. Atlantic was 358 (CV=0.44) and the southern U.S. Atlantic was 37 (CV=0.75). The best estimate of the Gulf of Mexico stock is 742 (CV=0.29) animals (Waring et al. 2006). Dwarf sperm whales have not been seen during surveys of the Tongue of the Ocean (Claridge, pers comm.); only pygmy sperm whales have been sighted there. However, during surveys taking place from 1997-2002 off the southern end of Great Abaco Island, which includes the northern margin of the Northwest Providence Channel branch of the Great Bahamas Canyon, 133 dwarf sperm whales and 8 pygmy sperm whales were sighted (Claridge, 2006; Claridge, pers comm.). These species are listed in Appendix I of CITES.

Northern Bottlenose Whale (*Hyperoodon ampullatus*)
Stocks: western North Atlantic, Scotian Shelf, eastern North Atlantic

Northern bottlenose whales occur only in temperate, subpolar, and polar waters of the North Atlantic. Only one reputable sighting of northern bottlenose whales has been recorded in the Mediterranean Sea in recent history (Reeves and Notarbartolo di Sciara 2006), and no record of northern bottlenose whales exists for the Caribbean. Northern bottlenose whales are rare in U.S. waters, though a western North Atlantic stock is recognized for management purposes (Waring et al. 2006). No population estimates exist for the western North Atlantic stock. North Atlantic Sighting Surveys in 1987 and 1989 suggested a population numbering about 40,000 animals (Reid et al. 2003). Northern bottlenose whales are known to be locally abundant south and east of Iceland and in the Gully off Nova Scotia. The Gully population is considered resident and has been listed as endangered under Canada's Species at Risk Act (SARA). This species is listed in Appendix I of CITES.

Cuvier's Beaked Whale (*Ziphius cavirostris*)
Stocks: western North Atlantic, northern Gulf of Mexico, eastern North Atlantic, Mediterranean

Cuvier's beaked whale may have the widest distribution of any beaked whale, probably found from 60° N to 50° S. Strandings of *Ziphius* along the east coast of the North America have ranged from Nova Scotia to Florida, the Gulf of Mexico, and the Caribbean, with sightings primarily occurring along the continental shelf edge in the mid-Atlantic (Waring et al. 2006). In the Mediterranean Sea, Cuvier's beaked whales are found in the eastern and western basins (Reeves and Notarbartolo di Sciara 2006). They appear to be relatively abundant in the eastern Ligurian Sea and off southwestern Crete, especially over and around canyons. Cuvier's beaked whale are also recorded frequently off the Iberian Peninsula and in the Bay of Biscay, where the species may be resident year-round (Reid et al. 2003). There are no data on abundance or population trends for this species in either the eastern North Atlantic or the Mediterranean. In the western

North Atlantic, the undifferentiated complex of beaked whales (*Ziphius* and *Mesoplodon* spp.) is estimated to number 3,513 (CV=0.63) animals (Waring et al. 2006), whereas in the northern Gulf of Mexico, the best estimate of abundance for *Ziphius* is 95 (CV=0.47) animals (Mullin and Fulling 2004). It is noted, however, that the estimate of unidentified beaked whales in the northern Gulf of Mexico is 146 (CV=0.46) animals, and that some of these animals are likely to be Cuvier's beaked whales (Waring et al. 2006). This species is listed in Appendix II of CITES. Cuvier's beaked whales have had dives of up to 85 minutes documented (WHOI team, pers comm.). They are most commonly seen in small groups of 1-10 individuals, but it is not uncommon to see them alone, which are usually old males (Carwardine, 2000).

Beaked Whales (*Mesoplodon* spp.)
Stocks: western North Atlantic, northern Gulf of Mexico, eastern North Atlantic

Species of *Mesoplodon* are difficult to distinguish at sea; therefore, most field identifications are made at the generic level at best. In the western and eastern North Atlantic, four species are known to occur, including Sowerby's beaked whale (*M. bidens*), Blainville's beaked whale (*M. densirostris*), Gervais' beaked whale (*M. europaeus*), and True's beaked whale (*M. mirus*). Only Blainville's and Gervais' are known to occur in the northern Gulf of Mexico. *Mesoplodon* are considered vagrants in the Mediterranean Sea with only three possible occurrences ever documented (Reeves and Notarbartolo di Sciara 2006). Sowerby's beaked whale has the most northerly distribution of all species of *Mesoplodon* in the Atlantic and is the most frequently seen and stranded species in the eastern North Atlantic (Reid et al. 2003). Its occurrence in the Gulf of Mexico is considered extralimital since only 1 stranding has been documented (Waring et al. 2006). True's beaked whales inhabit warm temperate waters, with few documented occurrences in the eastern North Atlantic and off Canada (Reid et al. 2003, Waring et al. 2006). They have been documented from Nova Scotia to the Bahamas in the western North Atlantic (Waring et al. 2006). Gervais' beaked whales inhabit warm temperate to tropical waters, with the majority of records coming from the western North Atlantic. Blainville's beaked whale is the most widely distributed species of *Mesoplodon*, occurring in all temperate and tropical oceans worldwide. There are no estimates of population size or structure for the eastern North Atlantic. In the western North Atlantic, the undifferentiated complex of beaked whales (*Ziphius* and *Mesoplodon* spp.) is estimated to number 3,513 (CV=0.63) animals (Waring et al. 2006), whereas in the northern Gulf of Mexico, the best estimate of abundance for *Mesoplodon* spp. (including Blainville's and Gervais') is 106 (CV=0.41) animals (Mullin and Fulling 2004). It is noted, however, that the estimate of unidentified beaked whales in the northern Gulf of Mexico is 146 (CV=0.46) animals, and that some of these animals are likely to be Blainville's and Gervais' beaked whales (Waring et al. 2006). These species are listed in Appendix II of CITES. *Mesoplodon* dive characteristics from tagged animals are: 1) average dive duration 46 min; 2) maximum dive duration 57 min; 3) vocal interval 26 min; 4) average dive depth 835 m; and 5) maximum measured dive depth 878 m.

Killer Whale (*Orcinus orca*)
Stocks: western North Atlantic, northern Gulf of Mexico, eastern North Atlantic

The killer whale is distributed worldwide from tropical to polar regions, though numbers appear to be greatest in sub-Arctic and Arctic waters of the north Atlantic (Reid et al. 2003). Considering historical whaling records, killer whales should be considered in oceanic waters of the western North Atlantic, northern Gulf of Mexico, and eastern North Atlantic, though limited occurrences have been documented in recent years (Waring et al. 2006). The best abundance estimate for the northern Gulf of Mexico is 133 (CV=0.49) animals (Mullin and Fulling 2004). No current population estimates exist for the western North Atlantic or eastern North Atlantic stocks (Waring et al. 2006). Sighting surveys between Iceland and the Faroe Islands indicate a population ranging between 3,500 and 12,500 animals (Gunnlaugsson and Sigurjonsson 1990). This species is listed in Appendix II of CITES.

False Killer Whale (*Pseudorca crassidens*)
Stocks: northern Gulf of Mexico, eastern North Atlantic

The false killer whale has a global distribution in warm temperate and tropical waters. This species appears to be highly social, with groups of 10-50 animals common and larger pods of 600-800 having been reported (Reid et al. 2003). They are commonly seen in oceanic waters, offshore of the continental shelf break. False killer whales have a diverse diet that includes many species of fishes and squid. In the eastern North Atlantic, most sightings occur from the Bay of Biscay south to the Canary Islands, though no estimates of population size exist. The best estimate of population size in the northern Gulf of Mexico is 1,038 (CV=0.71) animals (Mullin and Fulling 2004). This species is listed in Appendix II of CITES.

Pygmy Killer Whale (*Feresa attenuata*)
Stocks: western North Atlantic, northern Gulf of Mexico, eastern North Atlantic

The pygmy killer whale is widely distributed in subtropical and tropical waters. It can be difficult to differentiate from melon-headed whales under normal sighting conditions. Pygmy killer whales are commonly seen in oceanic waters, offshore of the continental shelf break. They are not common in either the western or eastern North Atlantic, but they have been seen in the Gulf of Mexico in all seasons (Waring et al. 2006). There are no data for population estimates in either the western or eastern North Atlantic. The best estimate of abundance for the Gulf of Mexico is 408 (CV=0.60) animals (Mullin and Fulling 2004). This species is listed in Appendix II of CITES.

Melon-headed Whale (*Peponocephala electra*)
Stocks: western North Atlantic, northern Gulf of Mexico, eastern North Atlantic

The melon-headed whale is widely distributed in pelagic tropical waters, usually observed in large pods ranging from 50 to 1,500 animals. They are not common in either the western or eastern North Atlantic, but they have been seen in the Gulf of Mexico year-round (Waring et al. 2006). There are no data for population estimates in either the western or eastern North Atlantic. The best estimate of abundance for the Gulf of Mexico is 3,451 (CV=0.55) animals (Mullin and Fulling 2004). This species is listed in Appendix II of CITES.

Pilot Whales (*Globicephala* spp.)
Stocks: western North Atlantic, northern Gulf of Mexico, eastern North Atlantic, Mediterranean

The two species of pilot whales are difficult to identify to the species level at sea. It is believed that long-finned pilot whales (*Globicephala melas*) are found in cold temperate to polar waters and short-finned pilot whales (*Globicephala macrorhynchus*) are found in warm temperate to tropical waters. In the western North Atlantic, the species boundary is believed to be between New Jersey and Cape Hatteras (Waring et al. 2006). Pilot whales typically occur in groups of 5-20 individuals in oceanic waters. They are found almost exclusively along the continental shelf edge and slope regions, and tend to concentrate in areas of high bathymetric relief or strong thermal fronts. The best available abundance estimate for *Globicephala* spp. in the western North Atlantic is 31,139 animals (CV=0.27) as estimated from the two 2004 line transect surveys (Waring et al. 2006). Sightings of short-finned pilot whales in the Gulf of Mexico have occurred in all seasons, primarily over the continental slope (Mullin and Fulling 2004). The best estimate of abundance for short-finned pilot whales in the Gulf of Mexico is 2,388 (CV=0.48) animals. In the eastern North Atlantic, long-finned pilot whales have primarily been documented in the Bay of Biscay (Reid et al. 2003). Surveys covering a large portion of their range estimated 778,000 (CV=0.30) animals. Long-finned pilot whales are regularly found in the western section of the Ligurian Sea; however, abundance estimates are only available for the Strait of Gibraltar, where 249 to 270 animals have been identified through mark-recapture studies (Reid et al. 2003). These species are listed in Appendix II of CITES**.**

Risso's Dolphin (*Grampus griseus*)
Stocks: western North Atlantic, northern Gulf of Mexico, eastern North Atlantic, Mediterranean

Risso's dolphins occur in virtually all tropical to temperate waters of the world between 60° N and 60° S. In the western North Atlantic, they range from eastern Newfoundland to the Lesser Antilles and Gulf of Mexico. It is believed that Risso's dolphins undergo north-south, summer-winter migrations. Surveys in offshore waters found Risso's dolphins associated with strong bathymetric features, Gulf Stream warm-core rings, and the Gulf Stream north wall (Waring et al. 2006). Typically, this species occupies the continental shelf edge and slope year-round, feeding mainly on squid. Risso's dolphins are found in groups of 3 to 30 individuals, although groups of up to several hundred have been reported. The best available abundance estimate in the western North Atlantic is 20,479 animals (CV=0.59), representing the sum of the estimates from the two 2004 U.S. Atlantic surveys in which the estimate from the northern U.S. Atlantic was 15,053 (CV=00.78) and the southern U.S. Atlantic was 5,426 (CV=0.54) (Waring et al. 2006). In the northern Gulf of Mexico, the best estimate of abundance is 2,169 (CV=0.32) animals

(Mullin and Fulling 2004). In the eastern North Atlantic, Risso's dolphins are considered an uncommon species and no studies have attempted to estimate abundance (Reid et al. 2003). In the Mediterranean Sea, Risso's dolphins are genetically distinct from those in the eastern Atlantic (Reeves and Notarbartolo di Sciara 2006). They are found year-round in the Ligurian-Corso-Provencal basin. Line-transect surveys in the western central Mediterranean estimated 493 (95% C.I. 162-1,498) animals (Reeves and Notarbartolo di Sciara 2006). This species is listed in Appendix II of CITES.

Common Dolphin (*Delphinus delphis*)
Stocks: western North Atlantic, eastern North Atlantic, Mediterranean

The common dolphin is one of the most abundant cetaceans throughout the world's warm temperate and tropical oceans. They are found along the coast over the continental shelf and slope and near pelagic regions with sharp bathymetric relief. Common dolphins are gregarious and are often found in aggregations of many hundreds, sometimes more than a thousand (Leatherwood and Reeves 1983). Their diet consists primarily of fish and squid. The best available abundance estimate for common dolphins in the western North Atlantic is 120,743 animals (CV=0.23), derived from combining the two 2004 line transect surveys (Waring et al. 2006). There are two estimates of abundance in the eastern North Atlantic. The SCANS survey in July 1994 estimated 75,500 animals (95% CI: 23,000-249,000) in the region around the Celtic Sea (Reid et al. 2003). The MICA survey, covering a region south and west of the SCAN survey, estimated 62,000 animals (95% CI: 35,000-108,000) (Reid et al. 2003). Common dolphins in the Mediterranean Sea have experienced a significant decline in numbers since the late 1960s (Bearzi et al. 2003). Besides a few scattered areas such as the Alboran Sea, common dolphins are rare to non-existent in the Mediterranean. This species is listed in Appendix II of CITES.

Rough-toothed Dolphin (*Steno bredanensis*)
Stocks: northern Gulf of Mexico, eastern North Atlantic

The rough-toothed dolphin occurs in warm temperate and tropical waters around the world. They are found in all seasons in the Gulf of Mexico in oceanic and continental shelf waters (Waring et al. 2006). In the eastern North Atlantic, their distribution is believed to extend north to approximately the Azores and the Canary Islands (Reeves et al. 2002). No population estimates exist for the eastern North Atlantic. The Gulf of Mexico population is provisionally considered distinct from sightings in the western North Atlantic (Waring et al. 2006). The best estimate of abundance in the Gulf of Mexico is 2,223 (CV=0.41) animals. This species is listed in Appendix II of CITES.

Striped Dolphin (*Stenella coeruleoalba*)
Stocks: western North Atlantic, northern Gulf of Mexico, eastern North Atlantic, Mediterranean

Striped dolphins are distributed worldwide in temperate and tropical waters. This species is found from Nova Scotia south to at least Jamaica and into the Gulf of Mexico and appears to prefer continental slope waters offshore to the Gulf Stream (Waring et al.

2006). Striped dolphins are often found in groups numbering in the hundreds, but can sometimes contain many more animals. The best available abundance estimate for the western North Atlantic is 94,462 animals (CV=0.40), representing the sum of the estimates from the two 2004 U.S. Atlantic surveys in which the estimate from the northern U.S. Atlantic was 52,055 (CV=0.57) and the southern U.S. Atlantic was 42,407 (CV=0.53) (Waring et al. 2006). In the northern Gulf of Mexico, the best estimate of abundance is 6,505 animals (CV=0.43) (Mullin and Fulling 2004). The only striped dolphin population estimate for the eastern North Atlantic is 73,843 animals (95% CI: 36,113-150,990) for an area southwest of Ireland to France and northwest Spain, excluding the Bay of Biscay (Reid et al. 2003). The striped dolphin is the most abundant cetacean in the Mediterranean (Reid et al. 2003). The best abundance estimate for the western basin of the Mediterranean Sea is 117,880 animals (95% CI: 68,379-214,800) (Forcada et al. 1994). This species is listed in Appendix II of CITES.

Short-snouted Spinner Dolphin or Clymene Dolphin (*Stenella clymene*)
Stocks: western North Atlantic, northern Gulf of Mexico, eastern North Atlantic

The Clymene dolphin is endemic to tropical and sub-tropical waters of the Atlantic. Sightings in the western North Atlantic are limited, but observations in the Gulf of Mexico have primarily occurred off the continental shelf over deeper waters (Waring et al. 2006). These dolphins eat small fishes and squid and appear to feed at night or in mid-water depths. The best estimate of abundance for the western North Atlantic is 6,086 animals (CV=0.93) (Mullin and Fulling 2003). The best estimate for the northern Gulf of Mexico is 17,355 animals (CV=0.65) (Mullin and Fulling 2004). In the eastern North Atlantic, their distribution is believed to extend north to approximately the Azores and the Canary Islands (Reeves et al. 2002). No population estimates exist for the eastern North Atlantic. This species is listed in Appendix II of CITES.

Long-snouted Spinner Dolphin (*Stenella longirostris*)
Stocks: western North Atlantic, northern Gulf of Mexico

The spinner dolphin is found in warm temperate and tropical waters throughout the world. In the northern Gulf of Mexico, they are seen year-round, primarily in oceanic waters (Mullin and Fulling 2004). They are very rarely sighted in the western North Atlantic, and no data are available from which an abundance estimate could be calculated. The best estimate of abundance for the northern Gulf of Mexico population is 11,971 animals (CV=0.71) (Mullin and Fulling 2004). This species is listed in Appendix II of CITES.

Pantropical Spotted Dolphin (*Stenella attenuata*)
Stocks: western North Atlantic, northern Gulf of Mexico

The pantropical spotted dolphin is distributed worldwide in tropical and subtropical waters. They often occur in oceanic waters in the Gulf of Mexico, rarely being seen on the continental shelf or shelf edge (Waring et al. 2006). Pantropical spotted dolphins have been observed year-round in the Gulf of Mexico and in the winter off the southeastern

United States. The best available abundance estimate is 4,439 animals (CV=0.49), representing the sum of the estimates from the two 2004 U.S. Atlantic surveys in which the estimate from the northern U.S. Atlantic was 0 and the southern U.S. Atlantic was 4,439 (Waring et al. 2006). The best estimate of abundance for the northern Gulf of Mexico is 91,321 animals (CV=0.16) (Mullin and Fulling 2004). This species is listed in Appendix II of CITES.

Atlantic Spotted Dolphin (*Stenella frontalis*)
Stocks: western North Atlantic, northern Gulf of Mexico, eastern North Atlantic

Atlantic spotted dolphins are endemic to the tropical and warm-temperate of the Atlantic, ranging from Maine to Venezuela in the west and the Iberian Peninsula to southwestern Africa in the east. There are two forms that may represent subspecies, a larger, heavily spotted form that is found inside or near the 200 m isobath and a smaller, less spotted, offshore form that is commonly found off the east coast of Florida and is difficult to distinguish from the pantropical spotted dolphin. Limited information is available for the eastern North Atlantic, but observations have been reported infrequently from the Azores and the Canary Islands. Sightings of Atlantic spotted dolphins north of Cape Hatteras are concentrated in slope waters, whereas south of Cape Hatteras, animals are observed in continental shelf, slope, and offshore waters. Favored prey includes herrings, anchovies, and carangid fish. Atlantic spotted dolphins often occur in groups of up to 50 individuals. The best available abundance estimate for the Atlantic spotted dolphin in the western North Atlantic is the sum of the estimates from the two 2004 vessel surveys, 50,978 animals (CV=0.42), where the northern estimate is 3,578 and the southern estimate is 47,400 (Waring et al. 2006). The best estimate of abundance in the northern Gulf of Mexico is 30,947 animals (CV=0.27) (Mullin and Fulling 2004). This species is listed in Appendix II of CITES.

Bottlenose Dolphin (*Tursiops truncatus*)
Stocks: Gulf of Mexico Continental Shelf, Gulf of Mexico Outer Continental Shelf, western North Atlantic coastal, western North Atlantic offshore, eastern North Atlantic, Mediterranean

Bottlenose dolphins are distributed worldwide in temperate and tropical waters in a diverse range of habitats. Thirty-eight stocks are defined for the Gulf of Mexico (Waring et al. 2006). The Bay, Sound, and Estuarine Stocks consist of 33 enclosed or semi-enclosed regions, each representing a distinct community of bottlenose dolphins. The coastal waters (depths less than 20 m) are divided into the western, northern, and eastern stocks. None of these 36 stocks are expected to be encountered during the proposed experiment. Animals from the Continental Shelf and Slope Stock (animals in water depths of 20-200 m) and the Outer Continental Shelf Stock (animals in water depths greater than 200 m), however, may be encountered. These stocks represent a mix of the "coastal" and "offshore" ecotypes (Waring et al. 2006). In the western North Atlantic, the offshore form extends along the entire shelf-break and into offshore waters from Georges Bank to Cape Hatteras during the spring and summer (CETAP 1982). During the fall, this distribution is compressed toward the south, with fewer sightings in winter. During winter months and south of Cape Hatteras, the offshore form is found exclusively seaward of 34 km and in waters deeper than 34 m (Torres et al. 2003). The coastal form of bottlenose dolphin is found within 7.5 km of shore. In between these two habitats, the coastal and offshore forms intermingle. The coastal stock is listed as “depleted” in the mid-Atlantic region under the MMPA. The best available current abundance estimate for offshore bottlenose dolphins in the western North Atlantic is 81,588 animals (CV=0.17), the sum of the estimates from the 2002 aerial survey and the two 2004 vessel surveys (Waring et al. 2006). The coastal bottlenose dolphin is divided into several management units in the western North Atlantic. The central Florida management unit could possibly be encountered during the proposed experiment. The best estimate of abundance for this population is 10,652 animals (CV=0.46) (Waring et al. 2006). The best estimate for the Continental Shelf and Slope Stock in the Gulf of Mexico is 25,320 animals (CV=0.26) (Fulling et al. 2003). The best estimate of abundance for the Outer Continental Shelf Stock is 2,239 animals (CV=0.41) (Mullin and Fulling 2004). Estimates of abundance in the eastern North Atlantic only exist for distinct coastal populations (Reid et al. 2003). Bottlenose dolphins in the Mediterranean are considered coastal species, however they are regularly found in deep waters near the continental slope. Anecdotal reports exist for many regions, but data on abundance and distribution are limited. It is estimated that the total population size in the Mediterranean is in the low 10,000s (Reid et al. 2003). This species is listed in Appendix II of CITES.

Fraser’s Dolphin (*Lagenodelphis hosei*)
Stocks: northern Gulf of Mexico, eastern North Atlantic

The Fraser’s dolphin is distributed worldwide in tropical waters, often in oceanic waters. They swim quickly in large pods of 100 to 1000 individuals. The limited number of sightings in the western North Atlantic makes it impossible to estimate a population size. Fraser’s dolphins have been sighted more often in the Gulf of Mexico, but they are still considered uncommon (Waring et al. 2006). The best estimate of abundance in the Gulf of Mexico is 726 animals (CV=0.70). Fraser’s dolphins are believed to range to about 20° N in the eastern North Atlantic, though no data exist to estimate abundance. This species is listed in Appendix II of CITES.

Harbor Porpoise (*Phocoena phocoena*)
Stocks: Gulf of Maine/Bay of Fundy, eastern North Atlantic

The harbor porpoise ranges between 1.4 and 1.8 m (4.6 and 5.9 ft) in length and is distributed throughout the northern hemisphere in temperate and sub-Arctic coastal waters. Harbor porpoises eat a wide variety of fish and cephalopods. Most groups are small, consisting of less than 8 individuals, but when feeding or migrating, they can expand to loose groups of 50 to several hundred animals. During the summer (July through September), harbor porpoise are concentrated in Canadian waters and the Gulf of Maine in the western North Atlantic. In the fall (October to December) and spring (April to June), they move farther south and are widely distributed from Maine to South Carolina (Waring et al. 2006). The best estimate of abundance for the Gulf of Maine/Bay of Fundy stock is 89,700 animals based on 1999 survey results. In the eastern Atlantic, harbor porpoises range from the Russian White Sea south to Senegal (15° S) (Reid et al. 2003). The best estimate of abundance is based on the SCANS survey in July 1994 with about 28,000 animals estimated in the North Sea, 36,000 in the Skagerrak and Belt Seas, and 36,000 animals between Ireland and Brittany. This species is listed in Appendix II of CITES.

Pinnipeds

Harbor Seal (*Phoca vitulina*)
Stocks: western North Atlantic, eastern North Atlantic

Harbor seals are found in temperate, subarctic, and arctic waters of the North Atlantic and North Pacific oceans. They are year-round inhabitants of the coastal waters of eastern Canada and Maine, and they occur seasonally along the southern New England, New York, and New Jersey coasts from September through late May. Scattered harbor seal sightings and strandings have been recorded as far south as Florida. Breeding and pupping normally occur in waters north of the New Hampshire/Maine border (Waring et al. 2006). In the eastern North Atlantic, they exhibit a similar distribution, with a year-round occurrence south to about the Iberian Peninsula. Aerial surveys along the Maine coast during the pupping season were conducted between 1981 and 2001; the observed count in 2001 was 38,011 animals. Additional studies provided a correction factor for animals not hauled out, resulting in a best available abundance estimate of 99,340 animals (CV=0.097) (Waring et al. 2006). No data exist for an abundance estimate for the eastern North Atlantic stock, though it is suggested that the population may number up to 100,000 individuals. This species is not listed by CITES.

Mediterranean Monk Seal (*Monachus monachus*)
Stocks: eastern North Atlantic, Mediterranean

The Mediterranean monk seal has been virtually eliminated from much of its original habitat by human encroachment. It was originally distributed throughout the Mediterranean, along the western coast of Africa, and on the islands of the Cape Verdes, Azores, and the Canaries. The species now only occurs in the eastern Mediterranean and at Côte des Phoques, Africa where females pup in caves in remote and relatively undisturbed areas (Gucu et al. 2004). Extremely sensitive to human disturbance, today the Mediterranean monk seal numbers between 300- 500 animals. The Mediterranean monk seal is listed as critically endangered by the IUCN and the U.S. Endangered Species Act. This species is also listed in Appendix I of CITES.

Marine mammal auditory capabilities

Mysticetes
All mysticetes produce low frequency sounds, although no direct measurements of auditory (hearing) thresholds have been made (Clark, 1990; Richardson et al., 1995; Edds-Walton, 1997;Tyack, 2000; Evans and Raga, 2001). A few species vocalizations are

known to be communication signals. However, it is not known if mysticete low-frequency sounds are used for other functions such as orientation, navigation, or detection of predators and prey.

Based on a study of the morphology of cetacean auditory mechanisms, Ketten (1994) hypothesized that mysticete hearing is in the low to infrasonic range. It is generally believed that baleen whales have frequencies of best hearing where their calls have the greatest energy—below 1,000 Hz (Ketten, 2000).

Blue Whales

There is no direct measurement of auditory threshold for the hearing sensitivity of blue whales (Ketten, 2000; Thewissen, 2002). In one of the only studies to date, no change in blue whale vocalization pattern or movement relative to an LFA sound source was observed for RLs of 70 to 85 dB (Aburto et al., 1997).

Blue whales produce a variety of LF sounds in a 10 to 200 Hz band (Edds, 1982; Thompson and Friedl, 1982; Alling and Payne, 1991; Clark and Fristrup, 1997; Rivers, 1997; Stafford et al., 1998, 1999a, 1999b; Stafford et al., 2001; Frankel, 2002). These low frequency calls may be used as communicative signals, as it is difficult to determine actual demonstrations of communication in the strict sense of the term (McDonald et al., 1995). Short sequences of rapid frequency-modulated (FM) calls below 90 Hz are associated with animals in social groups (Moore et al., 1999; Mellinger and Clark, 2003). The most typical signals are very long, patterned sequences of tonal infrasonic sounds in the 15 to 20 Hz range. The seasonality and structure of the sounds suggest that these are male song displays for attracting females and/or competing with other males.

Blue whales produce long, patterned hierarchically organized sequences of sounds (song). These occur throughout most of the year with peak period of singing overlapping with the general period of functional breeding. Blue whales also produce a variety of transient sound (that is, they do not occur in predictable patterns or have much interdependence of probability) in the 30 to 100 Hz band (sometimes referred to as “D” calls). These usually sweep down in frequency or are inflected (up-over-down), which occur throughout the year, and are assumed to be associated with socializing when animals are in close proximity (Mellinger and Clark, 2003; Clark and Ellison, 2004).

Croll et al. (2001) studied the effects of anthropogenic low-frequency noise on the foraging ecology of blue and fin whales off San Nicolas Island, California. Blue and fin whales produce long, intense patterned sequences of signals in the band of 10 to 100 Hz. These signals have been recorded over ranges of hundreds of miles. This study examined the response of blue and fin whales to human-produced low-frequency sounds at RLs greater than 120 dB produced by SURTASS LFA sonar. The blue and fin whale sightings did not appear to be randomly distributed and did not appear to be related to the sound source. No clear trends appeared in vocalization rates. There was no significant change in vocal activity in the study area or obvious responses of blue or fin whales in the presence of low frequency sound. It is possible that the brief interruption of normal behavior or short-term physiological responses to LF noise at RLs of approximately 140 dB have few implications on survival and reproductive success. Long-term effects, however, could have more significant effects, but these effects are harder to identify and quantify (Croll et al.,2001).

The call characteristics of blue whales vary geographically and seasonally (Stafford et al., 2001). In temperate waters, intense bouts of long, patterned sounds are very common from fall through spring, but these also occur to a lesser extent during the summer in high latitude feeding areas. The blue whale is one of the loudest baleen whales with estimated SLs as high as 180 to 190 dB (Cummings and Thompson, 1971; Aroyan et al., 2000).

Fin Whales

There is no direct measurement of auditory threshold for the hearing sensitivity of fin whales (Ketten, 2000; Thewissen, 2002).

Fin whales produce a variety of LF sounds in the 10 to 200 Hz band (Watkins, 1981; Watkins et al., 1987; Edds, 1988; Thompson et al., 1992). Short sequences of rapid FM calls in the 20-70 Hz band are associated with animals in social groups (Watkins, 1981; Edds, 1988; McDonald et al., 1995). The most typical signals are long, patterned sequences of low and infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton, 1964; Watkins et al., 1987; Clark et al., 2002). This sound is referred to as a “20-Hz pulse.” The seasonality of the pattern of bouts suggests that these are male reproductive displays or displays associated with food resources (Watkins et al., 1987; Clark et al., 2002; Croll et al., 2002) while the individual counter-calling sounds suggest that the more variable calls are contact calls (McDonald et al., 1995).

Croll et al. (2001) studied the effects of anthropogenic low-frequency noise on the foraging ecology of blue and fin whales off San Nicolas Island, California. This study is described above in the blue whale section.

Regional differences in vocalization production and structure have been found between the Gulf of California and several Atlantic and Pacific Ocean regions. The 20-Hz signal is very common from fall through spring in most regions, but also occurs to a lesser extent during the summer in high-latitude feeding areas (Clark and Charif, 1998; Clark et al., 2002). In the Atlantic region, 20-Hz signals are produced regularly throughout the year. Atlantic fins also produce higher frequency down sweeps ranging from 100 to 30 Hz (Frankel, 2002). Estimated SLs are as high as 180 to 190 dB (Patterson and Hamilton, 1964; Watkins et al., 1987; Thompson et al., 1992; McDonald et al., 1995; Charif et al., 2002; Croll et al., 2002).

Sei Whale

There is no direct measurement of auditory threshold for the hearing sensitivity of sei whales (Ketten, 2000; Thewisson, 2002).

Few sounds have been recorded from sei whales. Knowlton et al. (1991) and Thompson et al. (1979) recorded rapid sequences of FM pulses in the 1.5 to 3.0 kHz range near groups of feeding sei whales during the summer off eastern Canada. Seasonal and geographical differences and sound level range have not been identified for sei whales.

Bryde's Whale
There is no direct measurement of auditory threshold for the hearing sensitivity of Bryde's whales.

Bryde's whales are known to produce a variety of LF sounds in the 20 to 900 Hz band (Cummings, 1985; Edds et al., 1993; Olson et al., 2003), and animals off California produce moaning sounds concentrated at 124 to 250 Hz. A pulsed moan has also been recorded in frequencies ranging from 100 to 900 Hz. Olson et al. (2003) reported call types with a fundamental frequency below 60 Hz. These lower frequency call types have been recorded from Bryde's whales in the Caribbean, eastern tropical Pacific, and off the coast of New Zealand. Calves produce discrete pulses at 700-900 Hz (Edds et al., 1993). The function of these sounds is unknown, but is assumed to be used for communication. SLs range between 152 and 174 dB (Frankel, 2002).

Minke Whale
There is no direct measurement of auditory threshold for the hearing sensitivity of Minke whales (Ketten, 2000; Thewisson, 2002).

Minke whales produce a variety of sounds, primarily moans, clicks, downsweeps, ratchets, thump trains, and grunts in the 80 Hz to 20 kHz range (Winn and Perkins, 1976; Thompson et al., 1979; Edds-Walton, 2000; Mellinger and Clark, 2000; Frankel, 2002). The signal features of their vocalizations consistently include low frequency, short-duration downsweeps from 250 to 50 Hz. Thump trains may contain signature information, and most of the energy of thump trains is concentrated in the 100 to 200 Hz band (Winn and Perkins, 1976). Complex vocalizations recorded from Australian minke whales involved pulses ranging between 50 and 9,400 Hz, followed by pulsed tones at 1,800 Hz and tonal calls shifting between 80 and 140 Hz (Gedamke et al., 2001).

Both geographical and seasonal differences have been found among the sounds recorded from minke whales. Sounds recorded in the Northern Hemisphere, include "grunts," "thumps," and "ratchets" from 80 to 850 Hz, and pings and clicks from 3.3 to 20 kHz. Most sounds recorded during the winter consist of 10 to 60-second sequences of short 100 to 300-microsecond LF pulse trains (Winn and Perkins, 1976; Thompson et al., 1979; Mellinger and Clark, 2000), while Edds-Walton (2000) reported LF grunts recorded during the summer.

Recordings in mid- to high-latitudes in the Ross Sea, Antarctica have short sounds, sweeping down in frequency from 130 to 60 Hz over 0.2 to 0.3 seconds. Similar sounds with a frequency range from 396 to 42 Hz have been recorded in the St. Lawrence Estuary (Edds-Walton, 2000 *in* Gedamke et al., 2001).

Short, MF clicks with energy between 3 and 12 kHz for 1 to 20 ms were recorded in the presence of one animal south of Newfoundland (Beamish and Mitchell, 1973 *in* Gedamke et al., 2001); however, these sound may have been produced by an unseen species (Gedamke et al., 2001).

The function of the sounds produced by minke whales is unknown, but they are assumed to be used for communication such as maintaining space among individuals (Richardson et al., 1995).

Humpback Whale

There is no direct measurement of auditory threshold for the hearing sensitivity of humpback whales (Ketten, 2000; Thewissen 2002). Because of this lack of auditory sensitivity information, Houser et al. (2001) developed a mathematical function to describe the frequency sensitivity by integrating position along the humpback basilar membrane with know mammalian data. The results predicted the typical U-shaped audiogram with sensitivity to frequencies from 700 Hz to 10 kHz with maximum sensitivity between 2 to 6 kHz. Humpback whales have been observed reacting to LF industrial noises at estimated RLs of 115-124 dB (Malme et al., 1985). They have also been observed to react to conspecific calls at RLs as low as 102 dB (Frankel et al., 1995).

Humpbacks produce a great variety of sounds that fall into three main groups: 1) sounds associated with feeding, 2) sounds made within groups on winter grounds, and 3) songs associated with reproduction. These vocalizations range in frequency from 20 to 10,000 Hz. Feeding groups produce distinct repeated sounds ranging from 20 to 2,000 Hz, with dominant frequencies near 500 Hz (Thompson et al., 1986; Frankel, 2002). These sounds are attractive and appear to rally animals to the feeding activity (D'Vincent et al., 1985; Sharpe and Dill, 1997). Feeding sounds were found to have SLs in excess of 175 dB (Thompson et al., 1986; Richardson et al., 1995).

Social sounds in the winter breeding areas are produced by males and extend from 50 Hz to more than 10,000 Hz with most energy below 3000 Hz (Tyack and Whitehead, 1983; Richardson et al., 1995). These sounds are associated with agonistic behaviors from males competing for dominance and proximity to females. They have shown to elicit reactions from animals up to 9 km (4.9 nm) away (Tyack and Whitehead, 1983).

During the breeding season, males sing long, complex songs with frequencies between 25 and 5,000 Hz. Mean SLs are 165 dB (broadband), with a range of 144 to 174 dB (Payne and Payne, 1971; Frankel et al., 1994; Richardson et al., 1995; Tyack and Clark 2000). The songs vary geographically among humpback populations and appear to have an effective range of approximately 10 to 20 km (5.4 to 10.8 nm) (Au et al., 2000). Singing males are typically solitary and maintain spacing of 5 to 6 km (2.7 to 3.2 nm) (Tyack, 1981; Frankel, 1994). Songs have been recorded on the wintering ground, along migration routes, and less often on northern feeding grounds (Richardson et al., 1995).

Gabriele and Frankel (2002) reported that underwater acoustic monitoring in Glacier Bay National Park in Alaska has shown that humpback whales sing more frequently in the late summer and early fall than previously thought. A song is a series of sounds in a predictable order. The humpback songs are typically about 15 min long and are believed to be a mating-related display performed only by males. This study showed that humpback whales frequently sing while they are in Glacier Bay in August through November. Songs were not heard earlier than August, despite the presence or whales, or later than November, possibly because the whales started to migrate. It is possible that song is not as prevalent in the spring as it is in the late summer and fall; however, whales still vocalize at this time. The longest song session was recorded in November and lasted almost continuously for 4.5 hours, but most other song sessions were shorter. The songs in Hawaii and Alaska were similar within a single year. The occurrence of songs possibly correlates to seasonal hormonal activity in the male humpback whales prior to the migration to the winter grounds (Gabriele and Frankel, 2002).

Humpback whale songs have also been recorded off of Cape Cod, Massachusetts. Clark and Clapham (2004) have studied singing on an almost daily basis by humpback whales between May and June in the Georges Bank off of Cape Cod, Massachusetts. Song occurrence decreased in the late spring. There was, however, no pronounced diurnal pattern in the occurrence of singing. Portions of the songs were detectable in the band of 80 to 400 Hz. It is possible that these songs represent an advertisement of males as well as an assessment by females of males. Males may establish a bond in the summer at the feeding grounds which may have a possible pay-off on the breeding grounds in the winter. The songs may also be an intra-sexual display between the males. There is a hypothesis that singing is driven by elevated testosterone levels and, therefore, song would be rare in the mid-summer. Since the detection of songs declined in June, this study is consistent with the hypothesis (Clark and Clapham, 2004).

Northern Right Whale

There is no direct measurement of auditory threshold for the hearing sensitivity of right whales (Ketten, 2000; Thewissen, 2002). However, based on the thickness or width measurements of the basilar membrane from slide samples, their frequency range is estimated to be 10 Hz to 22 kHz, based on established marine mammal models (Parks et al., 2001).

North Atlantic right whales produce LF moans with frequencies ranging from 70 to 600 Hz (Clark, 1982; Matthews et al., 2001; Vanderlaan et al., 2003). Lower frequency sounds characterized as calls are near 70 Hz. Broadband sounds have been recorded during surface activity and are termed “gunshot slaps” (Clark, 1982; Matthews et al., 2001). SLs for North Pacific right whales were not available from these studies.

Parks and Tyack (2005) describe North Atlantic right whale vocalizations from SAGs. Recordings were made of surface active groups (SAGs) in the Bay of Fundy, Canada. The call-types defined in this study included screams, gunshots, blows, up calls, warbles, and down calls and were from 59 whale sounds measured at ranges between 40 and 200 m (31 to 656 ft), with an average distance of 88 m (289 ft). The SLs for the sounds ranged from 137 to 162 dB for tonal calls and 174 to 192 dB for broadband gunshot sounds.

Odontocetes

Odontocetes have a broad acoustic range with recent hearing thresholds measuring between 400 Hz and 100 kHz (Richardson et al., 1995; Finneran et al., 2002). Many odontocetes produce a variety of click and tonal sounds for communication and echolocation purposes (Au, 1993). It is generally believed that odontocetes communicate mainly above 1,000 Hz and echolocate above 20 to 30 kHz (Wursig and Richardson, 2002). Little is known about the details of most sound production and auditory thresholds for many species (Frankel, 2002).

Sperm Whales

Recent audiograms measured from a sperm whale calf resulted in an auditory range of 2.5 to 60 kHz, best hearing sensitivity between 5 and 20 kHz (Ridgway and Carder, 2001). Measurements of evoked response data from one stranded sperm whale have shown a lower limit of hearing near 100 Hz (Gordon et al., 1996).

Sperm whales produce broadband clicks with energy from less than 100 Hz to 30 kHz (Watkins and Schevill, 1977; Watkins et al., 1985; Goold and Jones, 1995; Weilgart and Whitehead, 1997; Mohl et al., 2000; Madsen et al., 2002; Thode et al., 2002). Regular click trains and creaks have been recorded from foraging sperm whales and may be produced as a function of echolocation (Whitehead and Weilgart, 1991; Jaquet et al., 2001; Madsen et al., 2002; Thode et al., 2002). A series of short clicks, termed “codas,” have been associated with social interactions and are thought to play a role in communication (Weilgart and Whitehead, 1993; Pavan et al., 2000). Distinctive coda repertoires have shown evidence of geographical variation among female sperm whales (Weilgart and Whitehead, 1997; Whitehead, 2002). SELs of clicks have been measured between 202 and 236 dB (Madsen and Møhl, 2000; Mohl et al., 2000; Thode et al., 2002; Mohl et al., 2003).

Mohl et al., (2000) reported results from recordings of sperm whales at high latitudes with a large-aperture array that were interpreted to show high directionality in their clicks, with maximum recorded SLs greater than 220 dB (Mohl et al. 2000). Mohl et al. (2003) further described the directionality of the clicks and that clicks differ significantly with aspect angle. This is dependent on the direction that the click is projected and the point where the click is received. The maximum SL for any click in these recordings was 236 dB with other independent events ranging from 226 to 234 dB (Mohl et al., 2003).

Thode et al. (2002) reported on depth-dependent acoustic features of diving sperm whales in the Gulf of Mexico. The correlation between the sperm whale’s depth and inter-click interval is a characteristic behavioral pattern of other echolocating animals when they are getting close to a target. The returns were always detected when the animal was descending toward the ocean bottom, but were never detected once the animal initiated what was presumed to be foraging behavior. Even during the initial descent phase, the detection of bottom returns was sporadic. After long periods during which only direct and surface-reflection paths were recorded, the bottom returns often faded within seconds, with a 10-dB increase in signal energy that is typically accompanied by energy variation in the direct signal arrival of less than 3 dB. These observations suggest that sperm whale signals have directional properties (Thode et al., 2002).

Zimmer et al. (2005b) discuss the three-dimensional beam pattern of regular sperm whale clicks. Regular clicks have several components by which the whale produces a narrow, high-frequency sonar beam to search for prey, a less-directional backward pulse which provides orientation cues, and a low-frequency component of low directionality which conveys sound to a large part of the surrounding water column with a potential for reception by conspecifics at large ranges. The click travel time was used to estimate the acoustic range of the whale during its dives. In this study, the SL of the high-frequency sonar beam in the click was 229 dB (peak value). The backward pulse had a SL of 200 dB (peak value). The low-frequency component immediately followed the backward pulse and had a long duration, with peak frequencies that are depth dependent to over 500 m (1640 ft). Zimmer et al. (2005b) propose that the initial backward pulse is produced by the phonic lip and activates air volumes connected to the phonic lips, which generates the low-frequency component. The two dominant frequencies in the low-frequency component indicate either one resonator with aspect-dependent radiation patterns or that two resonators exist with similar volumes at the surface but different rates at which the volumes are reduced by increasing static pressure. Most of the energy of the initial backward-directed pulse reflects forward off the frontal sac into the junk and leaves the junk as a narrow, forward-directed pulse A fraction of that energy is reflected by the frontal sac back into the spermaceti organ to generate higher-order pulses. This forward-directed pulse is well-suited for echolocation.

Pygmy and Dwarf Sperm Whales

There are sparse data on the hearing sensitivity for pygmy sperm whales. An auditory brainstem response study on a rehabilitating pygmy sperm whale indicated that this species has an underwater hearing range that is most sensitive between 90 and 150 kHz (Carder et al., 1995; Ridgway and Carder, 2001).

Recent recordings from captive pygmy sperm whales indicate that they produce sounds between 60 and 200 kHz with peak frequencies at 120-130 kHz (Santoro et al., 1989; Carder et al., 1995; Ridgway and Carder, 2001). Echolocation pulses were documented with peak frequencies at 125 to 130 kHz (Ridgway and Carder, 2001). Thomas et al. (1990) recorded a LF sweep between 1,300 and 1,500 Hz from a captive pygmy sperm whale in Hawaii. Richardson et al. (1995) reported pygmy sperm whale frequency ranges for clicks to be between 60 and 200 kHz with the dominant frequency at 120 kHz. No geographical or seasonal differences in sounds have been documented. Estimated SLs were not available.

Cuvier's Beaked Whale

There is no direct measurement of auditory threshold for the hearing sensitivity of Cuvier's beaked whales (Ketten, 2000; Thewissen, 2002).

Cuvier's beaked whales have been recorded producing HF clicks between 13 and 17 kHz (Frantzis et al., 2002). These sounds were recorded during diving activity and may be associated with echolocation purposes. There is no available data regarding seasonal or geographical variation in the sound production of Cuvier's beaked whales. Beaked whales are capable of producing SLs of 200 to 220 dB (peak-to-peak) (Johnson et al., 2004).

Studies on Cuvier's beaked whales and Blainville's beaked whales conducted by Johnson et al. (2004) concluded that no vocalizations were detected from any tagged beaked whales when they were within 200 m (656.2 ft) of the surface. The Cuvier's beaked whale started clicking at an average depth of 475 m (1,558.4 ft), ranging from 450 to 525 m (1,476 to 1,722 ft), and stopped clicking when they started their ascent at an average depth of 850 m (2,789 ft), with a range of 770 to 1,150 m (2,526 to 3,773 ft). The intervals between regular clicks were approximately 0.4 second. Trains of clicks often end in a rapid increase in the click rate, which is also called a buzz. According to these studies, both the Cuvier's beaked whale and the Blainville's beaked whale have a somewhat flat spectrum that was accurately sampled by Johnson et al. (2004) between 30 and 48 kHz. There may be a slight decrease in the spectrum above 40 kHz, but the 96 kHz sampling rate was not sufficient to sample the full frequency range of clicks from either of the species (Johnson et al., 2004).

Zimmer et al. (2005a) also studied Cuvier's beaked whales and their echolocation clicks. The highest measured SL was 214 dB (peak-to-peak). It is recognized in this study that it is possible that Cuvier's beaked whales cannot produce any higher SLs, but it is more likely that the full capabilities of the Cuvier's beaked whales are underestimated by this study. Therefore, the maximum SL shown in this study may be the result of the whale's reducing the volume when ensonifying at each other (Zimmer et al., 2005a).

Mesoplodon Spp.

There is no direct measurement of auditory threshold for the hearing sensitivity of *Mesoplodon* species (Ketten, 2000; Thewissen, 2002). There are sparse data available on the sound production of *Mesoplodon* species. Sowerby's beaked whales have been documented to occur in the Bahamas.

A stranded Blainville's beaked whale in Florida produced chirps and whistles below 1 kHz up to 6 kHz (Caldwell and Caldwell, 1971a). There are no available data regarding seasonal or geographical variation in the sound production of *Mesoplodon* species.

Studies on Cuvier's beaked whales and Blainville's beaked whales conducted by Johnson et al. (2004) concluded that no vocalizations were detected from any tagged beaked whales when they were within 200 m (656.2 ft) of the surface. The Blainville's beaked whale started clicking at an average depth of 400 m (1312.3 ft), ranging from 200 to 570 m (656.2 to 1870.1 ft), and stopped clicking when they started their ascent at an average depth of 720 m (2362.2 ft), with a range of 500 to 790 m (1640.4 to 2591.9 ft). The intervals between regular clicks were approximately 0.4 second. Trains of clicks often end in a rapid increase in the click rate, which is also called a buzz. Both the Cuvier's beaked whale and the Blainville's beaked whale have a somewhat flat spectrum that was accurately sampled by Johnson et al. (2004) between 30 and 48 kHz. There may be a slight decrease in the spectrum above 40 kHz, but the 96 kHz sampling rate was not sufficient to sample the full frequency range of clicks from either of the species (Johnson et al., 2004).

Killer Whale

Killer whales hear underwater sounds in the range of <500 Hz to 120 kHz (Bain et al., 1993; Szymanski et al 1999). Their best underwater hearing occurs between 15 and 42 kHz, where the threshold level is near 34 to 36 dB RL (Hall and Johnson, 1972; Szymanski et al 1999).

Killer whales produce sounds as low as 80 Hz and as high as 85 kHz with dominant frequencies at 1-20 kHz (Schevill and Watkins, 1966; Diercks et al., 1971, 1973; Evans, 1973; Steiner et al., 1979; Awbrey et al., 1982; Ford and Fisher, 1983; Ford, 1989; Miller and Bain, 2000). An average of 12 different call types (range 7 to 17), mostly repetitive discrete calls, exist for each pod (Ford, 2002). Pulsed calls and whistles, called dialects, carry information hypothesized as geographic origin, individual identity, pod membership, and activity level. Vocalizations tend to be in the range between 500 Hz and 10 kHz and may be used for group cohesion and identity (Ford, 2002; Frankel, 2002). Whistles and echolocation clicks are also included in killer whale repertoires, but are not a dominant signal type of the vocal repertoire in comparison to pulsed calls (Miller and Bain, 2000). Erbe (2002) recorded received broadband SPLs of orca burst-pulse calls ranging between 105 and 124 dB RL at an estimated distance of 100 m (328 ft).

False Killer Whale

False killer whales hear underwater sounds in the range of <1 to 115 kHz (Johnson, 1967; Awbrey et al., 1988; Au, 1993). Their best underwater hearing occurs at 17 kHz, where the threshold level ranges between 39 to 49 dB RL (Sauerland and Dehnhardt, 1998).

Au et al. (1997) conducted a survey on the effects of the Acoustic Thermometry of Ocean Climate (ATOC) program on false killer whales and on Risso's dolphins, which will be discussed later. The ATOC program broadcast a low-frequency 75-Hz phase modulated, 195 dB SL signal through ocean basin-sized water masses to study ocean temperatures on a global scale. The hearing sensitivity was measured for false killer whales. The hearing thresholds for false killer whales were 140.7 dB RL, plus or minus 1.2 dB for the 75-Hz pure tone signal and 139.0 dB RL plus or minus 1.1 dB for the ATOC signal. The results of this study concluded that small cetaceans, such as false killer whales and Risso's dolphins, swimming directly over the ATOC source do not seem to hear the transmitted sound unless the animals dove to a depth of approximately 400 m (1312 ft). If these animals were at a horizontal range greater than 0.5 km (0.3 mi), the level of the ATOC signal would be below their hearing threshold at any depth. Also, this study indicates that for ranges greater than 0.5 km (0.3 mi), the maximum sound-pressure level above a depth of 560 m (1837.3 ft) is approximately 130 dB RL. As the range increases beyond 2 km (1.2 mi), the sound-pressure level becomes progressively lower (Au et al., 1997).

False killer whales produce a wide variety of sounds from 4 to 130 kHz, with dominant frequencies between 25 to 30 kHz and 95 to 130 kHz (Busnel and Dziedzic, 1968; Kamminga and van Velden, 1987; Thomas and Turl, 1990; Murray et al., 1998). Most signal types vary between whistles, burst-pulse sounds and click trains (Murray et al. 1998). Whistles generally range between 4.7 and 6.1 kHz. False killer whales echolocate highly directional clicks ranging between 20 and 60 kHz and 100 and 130 kHz (Kamminga and van Velden, 1987; Thomas and Turl, 1990). There is no available data regarding seasonal or geographical variation in the sound production of false killer whales. Estimated SL of clicks are near 228 dB (Thomas and Turl, 1990).

Pygmy Killer Whale
There is no direct measurement of auditory threshold for the hearing sensitivity of pygmy killer whales (Ketten, 2000; Thewissen, 2002). Little is known of the sound production of this species. One documentation describes pygmy killer whales producing LF “growl” sounds (Pryor et al., 1965).

Melon-Headed Whale
There is no direct measurement of auditory threshold for the hearing sensitivity of melon-headed whales (Ketten, 2000; Thewissen, 2002).

Melon-headed whales produce sounds between 8 and 40 kHz. Individual click bursts have frequency emphases between 20 and 40 kHz. Dominant frequencies of whistles are 8-12 kHz, with both upsweeps and downsweeps in frequency modulation (Watkins et al., 1997). There are no available data regarding seasonal or geographical variation in the sound production of this species. Maximum SLs are estimated at 155 dB for whistles and 165 dB for click bursts (Watkins et al., 1997).

Pilot Whales
There is no direct measurement of auditory threshold for the hearing sensitivity of either long- or short-finned pilot whales (Ketten, 2000; Thewissen, 2002). Long-finned pilot whales have not been documented to occur in the Bahamas.

Pilot whales echolocate with a precision similar to bottlenose dolphins and also vocalize with other school members (Olson and Reilly, 2002). Long-finned pilot whales produce sounds as low as 500 Hz and as high as 18 kHz, with dominant frequencies between 1 to 11 kHz (Schevill, 1964; Busnel and Dziedzic, 1966; Taruski, 1979; Steiner, 1981; McLeod, 1986). These sounds include double clicks and whistles with a mean frequency common among this species at 4,480 Hz (Olson and Reilly, 2002; Frankel, 2002). Sound production of long-finned pilot whales are correlated with behavioral state and environmental context (Taruski, 1979; Weilgart and Whitehead, 1990; Frankel, 2002). For example, signal types described as non-wavering whistles are associated with resting long-finned pilot whales. The whistles become more complex in structure as more social interactions take place (Frankel, 2002). There is no available data regarding seasonal or geographical variation in the sound production of the long-finned pilot whale. Estimated SLs were not available.

Short-finned pilot whales produce sounds as low as 280 Hz and as high as 100 kHz, with dominant frequencies between 2 to 14 kHz and 30 to 60 kHz (Caldwell and Caldwell, 1969; Fish and Turl, 1976; Scheer et al., 1998). Sounds produced by this species average near 7,870 Hz, higher than that of a long-finned pilot whale (Olson and Reilly, 2002). Echolocation abilities have been demonstrated during click production (Evans, 1973). SLs of clicks have been measured as high as 180 dB (Fish and Turl 1976; Richardson et al., 1995). There are little available data regarding seasonal or geographical variation in the sound production of the short-finned pilot whale, although there is evidence of group specific call repertoires (Olson and Reilly, 2002).

Risso's Dolphins

Audiograms for Risso's dolphins indicate their hearing SLs equal to or less than approximately 125 dB in frequencies ranging from 1.6 to 110 kHz (Nachtigal et al, 1995 *in* Nedwell et al., 2004). Phillips et al. (2003) reports that Risso's dolphins are capable of hearing frequencies up to 80 kHz. Best underwater hearing occurs between 4 and 80 kHz with hearing threshold levels from 63.6 to 74.3 dB RL. Hearing thresholds from this study were tested between 1.6 and 110 kHz and were approximately 125 dB down to approximately 65 dB RL (Nachtigall et al., 1995 *in* Croll et al., 1999 and Nedwell et al., 2004). Other audiograms obtained on Risso's dolphin (Au et al., 1997) confirm previous measurements and demonstrate hearing thresholds of 140 dB RL for a one-second 75 Hz signal (Au et al., 1997; Croll et al., 1999).

Au et al. (1997) conducted a survey on the effects of the ATOC program on false killer whales and on Risso's dolphins, which will be discussed later. The ATOC program broadcasted a low-frequency 75-Hz phase modulated, 195 dB SL acoustic signal over ocean basins to study ocean temperatures on a global scale. The hearing sensitivity was measured for Risso's dolphins and their thresholds were found to be 142.2 dB RL, plus or minus 1.7 dB for the 75-Hz pure tone signal and 140.8 dB RL plus or minus 1.1 dB for the ATOC signal (Au et al., 1997).

Risso's dolphins produce sounds as low as 0.1 kHz and as high as 65 kHz. Their dominant frequencies are between at 2 to 5 kHz and at 65 kHz. (Watkins, 1967; Au, 1993; Croll et al., 1999; Phillips et al., 2003). The maximum peak-to-peak SL, with dominant frequencies at 2 to 5 kHz , is about 120 dB (Au, 1993 *in* Croll et al., 1999). In one experiment conducted by Phillips et al. (2003), clicks were found to have a peak frequency of 65 kHz, with 3-dB bandwidths at 72 kHz and durations ranging from 40 to 100 microsec. In a second experiment, Phillips et al. (2003) recorded clicks with peak frequencies up to 50 kHz, 3-dB bandwidth at 35 kHz with durations ranging from 35 to 75 microsec. SLs were up to 208 dB. The behavioral and acoustical results from these experiments provided evidence that Risso's dolphins use echolocation. Estimated SLs of echolocation clicks can reach up to 216 dB (Phillips et al., 2003). Bark vocalizations consisted of highly variable burst pulses and have a frequency range of 2 to 20 kHz. Buzzes consisted of a short burst pulse of sound around 2 seconds in duration with a frequency range of 2.1 to 22 kHz. Low frequency, narrowband grunt vocalizations ranged between 400 and 800 Hz. Chirp vocalizations were slightly higher in frequency than the grunt vocalizations, ranging in frequency from 2 to 4 kHz. There are no available data regarding seasonal or geographical variation in the sound production of Risso's dolphin.

Common Dolphins

Common dolphins produce sounds as low as 0.2 kHz and as high as 150 kHz, with dominant frequencies at 0.5 to 18 kHz and 30 to 60 kHz (Caldwell and Caldwell, 1968; Popper, 1980; Au, 1993; Moore and Ridgway, 1995 *in* Croll et al., 1999). Signal types consist of clicks, squeals, whistles, and creaks (Evans 1994 *in* Croll et al., 1999). Whistles of short-beaked common dolphins range between 7.4 and 13.6 kHz, while long-beaked common dolphins have a frequency range of 7.7 and 15.5 kHz for their whistle production (Oswald et al., 2003). Most of the energy of echolocation clicks is concentrated between 15 and 100 kHz (Croll et al., 1999). The maximum peak-to-peak SL of common dolphins is 180 dB. In the North Atlantic, the mean SL was approximately 143 dB with a maximum of 154 dB (Croll et al., 1999). There are no available data regarding seasonal or geographical variation in the sound production of common dolphins.

Rough-Toothed Dolphins

There is no direct measurement of auditory threshold for the hearing sensitivity of rough-toothed dolphins (Ketten, 2000; Thewissen, 2002).

Rough-toothed dolphins produce sounds ranging from 0.1 kHz up to 200 kHz (Popper, 1980; Miyazaki and Perrin, 1994; Richardson et al., 1995). Clicks have peak energy at 25 kHz, while whistles have a maximum energy between 2 to 14 kHz and at 4 to 7 kHz (Norris and Evans, 1967; Norris, 1969; Popper, 1980). There is no available data regarding seasonal or geographical variation in the sound production of this species.

Stenella Spp.

Based on auditory brainstem responses, striped dolphins hear SLs equal to or louder than 120 dB in the range of less than 10 to greater than 100 kHz (Popper, 1980). The behavioral audiogram developed by Kastelein and Hagedoorn (2003) shows hearing capabilities from 0.5 to 160 kHz. The best underwater hearing of the species appears to be at from 29 to 123 kHz (Kastelein and Hagedoorn, 2003). They have relatively less hearing sensitivity below 32 kHz and above 120 kHz. There is no direct measurement of auditory threshold for the hearing sensitivity of the remaining *Stenella* dolphins (Ketten, 2000; Thewissen, 2002).

Dolphins of the genus *Stenella* produce sounds as low as 0.1 kHz and as high as 160 kHz with tri-modal dominant frequencies at 5 to 60 kHz, 40 to 50 kHz, and 130 to 140 kHz (Caldwell and Caldwell, 1971b; Popper, 1980; Steiner, 1981; Norris et al., 1994; Richardson et al., 1995; Au et al., 1998; Croll et al., 1999; Oswald et al., 2003). The amount and variety of signal types generally increases with increasing social activity (Frankel, 2002). Spinner dolphins produce burst pulse calls, echolocation clicks, whistles and screams (Norris et al., 1994; Bazua-Duran and Au, 2002). The results of a study on spotted and spinner dolphins conducted by Lammers et al. (2003) revealed that the whistles and burst pulses of the two species span a broader frequency range than is traditionally reported for delphinids. The fundamental frequency contours of whistles occur in the human hearing range, but the harmonics typically reach 50 kHz and beyond. Additionally, the burst pulse signals are predominantly ultrasonic, often with little or no energy below 20 kHz (Lammers et al., 2003).

Atlantic spotted dolphins produce a variety of sounds, including whistles, whistle-squawks, buzzes, burst-pulses, synch pulses, barks, screams, squawks, tail slaps, and echolocation clicks. Like other odontocetes, they produce broadband, short duration echolocation signals. Most of these signals have a bimodal frequency distribution. They project relatively high-amplitude signals with a maximum SL of about 223 dB (Au and Herzing, 2003). Their broadband clicks have peak frequencies between 60 and 120 kHz.. Dolphins produce whistles with frequencies generally in the human audible range, below 20 kHz. These whistles often have harmonics which occur at integer multiples of the fundamental and extend beyond the range of human hearing. Atlantic spotted dolphins have also been recorded making burst pulse squeals and squawks, along with bi-modal echolocation clicks with a low-frequency peak between 40 and 50 kHz and a high-frequency peak between 110 and 130 kHz. Many of the vocalizations from Atlantic spotted dolphins have been associated with foraging behavior (Herzing, 1996). There is no available data regarding seasonal variation in the sound production of *Stenella* dolphins, although geographic variation is evident. Peak-to-peak SLs as high as 210 dB have been measured (Au et al., 1998; Au and Herzing, 2003).

Bottlenose Dolphins

Bottlenose dolphins hear underwater sounds in the range of 150 Hz to 135 kHz (Johnson, 1967; Ljungblad et al., 1982). Their best underwater hearing occurs at 15 kHz, where the threshold level range is 42 to 52 dB RL (Sauerland and Dehnhardt, 1998). Bottlenose dolphins also have good sound location abilities and are most sensitive when sounds arrive from the front (Richardson et al., 1995).

Bottlenose dolphins produce sounds as low as 0.05 kHz and as high as 150 kHz with dominant frequencies at 0.3 to 14.5 kHz, 25 to 30 kHz, and 95 to 130 kHz (Johnson, 1967; Popper, 1980; McCowan and Reiss, 1995; Schultz et al., 1995; Croll et al., 1999; Oswald et al., 2003). The maximum SL is 228 dB (Croll et al., 1999). Bottlenose dolphins produce a variety of whistles, echolocation clicks and burst-pulse sounds. Echolocation clicks with peak frequencies from 40 to 130 kHz are hypothesized to be used in navigation, foraging, and predator detection (Au, 1993; Houser et al., 1999 *in* Helweg et al., 2003; Jones and Sayigh, 2002). According to Au (1993), sonar clicks are broadband, ranging in frequency from a few kHz to more than 150 kHz, with a 3-dB bandwidth of 30 to 60 kHz (Croll et al., 1999). The echolocation signals usually have a 50 to 100 microsec duration with peak frequencies ranging from 30 to 100 kHz and fractional bandwidths between 10 and 90 percent of the peak frequency (Houser et al., 1999 both *in* Helweg et al., 2003).

Burst-pulses, or squawks, are commonly produced during social interactions. These sounds are broadband vocalizations that consist of rapid sequences of clicks with inter-click intervals less than 5 milliseconds. Burst-pulse sounds are typically used during escalations of aggression.

Each individual bottlenose dolphin has a fixed, unique FM pattern, or contour whistle called a signature whistle. These signal types have been well studied and are presumably used for recognition, but may have other social contexts (Frankel, 2002; Sayigh, 2002). Maximum sound levels can reach 228 dB. Stereotypically, signature whistles have a narrow-band sound with the frequency commonly between 4 and 20 kHz, duration between 0.1 and 3.6 seconds, and a SL of 125 to 140 dB (3.3 ft) (Croll et al., 1999).

McCowan et al. (1999) discusses bottlenose dolphins and their structure and organization of communication mathematically. They apply Zipf's law, which examines the first-order entropic relation and evaluates the signal composition of a repertoire by examining the frequency of use of signals in a relationship to their ranks. It measures the potential capacity for information transfer at the repertoire level by examining the optimal amount of diversity and redundancy necessary for communication transfer across a noisy channel. The results from this experiment suggest that Zipf's statistic can be applied to animal vocal repertoires, specifically in this case, dolphin whistle repertoires, and their development. Zipf's statistic may be an important comparative measure of repertoire complexity both inter-species and as an indicator for vocal acquisition or learning of vocal repertoire structure within a species. The results also suggest that dolphin whistles contain some higher-order internal structure, enough to begin to predict statistically what whistle types might immediately follow the same or another whistle type. A greater knowledge of the higher-order entropic structures could allow the reconstruction of dolphins whistle sequence structure, independent of additional data inputs such as actions and non-vocal signaling (McCowan et al., 1999).

In contrast to the signature whistle theory, McCowan et al. (2001) stated that predominant whistle types produced by isolated dolphins were the same whistle types that were predominant for all adult subjects and for infant subjects by the end of their first year in both socially interactive and separation contexts. No evidence for individually distinctive signature whistle contours was found in the bottlenose dolphins studied. Ten of 12 individuals produced one shared whistle type as their most predominant whistle during contexts of isolation. The two other individuals produced two other predominant whistle types that could not be considered signature whistles because both whistle types were shared among many different individuals within and across independent captive social groups (McCowan et al., 2001).

Jones and Sayih (2002) reported geographic variations in behavior and in the rates of vocal production. Both whistles and echolocation varied between Southport, North Carolina, the Wilmington North Carolina Intracoastal Waterway (ICW), the Wilmington, North Carolina coastline, and Sarasota, Florida. Dolphins at the Southport site whistled more than the dolphins at the Wilmington site, which whistled more than the dolphins at the ICW site, which whistled more than the dolphins at the Sarasota site. Echolocation production was higher at the ICW site than all of the other sites. Dolphins in all three of the North Carolina sites spent more time in large groups than the dolphins at the Sarasota site. Echolocation occurred most often when dolphins were socializing (Jones and Sayigh, 2002).

Fraser's Dolphin

There is no direct measurement of auditory threshold for the hearing sensitivity of Fraser's dolphins (Ketten, 2000; Thewissen, 2002).

Fraser's dolphins produce sounds ranging from 4.3 to over 40 kHz (Leatherwood et al., 1993; Watkins et al., 1994). Echolocation clicks are described as short broadband sounds without emphasis at frequencies below 40 kHz, while whistles were frequency-modulated tones concentrated between 4.3 and 24 kHz. Whistles have been suggested as communicative signals during social activity (Watkins et al., 1994). There are no available data regarding seasonal or geographical variation in the sound production of Fraser's dolphins. SLs were not available.

Discussion

As shown above, the BRS may affect several marine mammal species, which have varied auditory thresholds and sound production frequencies. The purpose of the BRS 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. It is therefore necessary to expose a range of marine mammals, most of which have an auditory threshold within the desired range, to the sound sources.

A number of mitigation measures would be taken to minimize to a negligible level the potential for any stress, pain or suffering of marine animals. The BRS is designed to not expose any animals to sound levels high enough to cause any MMPA Level A harassment, such as PTS. The BRS goal is to elicit identifiable behavioral reaction from underwater MF coherent sound exposure—if no identifiable behavioral reaction after 5 full PBs, the most probable option would be to move to another stimulus signal, while minimizing the potential for Level B harassment. It is important to note that the goal of the BRS is not to cause TTS. However, due to the nature of BRSs, this potential effect cannot be ruled out. Hence, Level B harassment takes are requested, as per Tables 2 and 3. Animals can avoid exposure during the PB experiments by swimming away, and if any such avoidance reactions are observed, subsequent exposures would be carefully designed to take this into account. Stress from playbacks could possibly involve playback of vocalizations of predator species (e.g., orca calls [Yurk, 2002]) for all subject species. If the subject reacts to the playback as if it were a predator, it may experience some stress as it prepares for an anti-predator response. However, these natural sound playbacks are important for understanding whether marine mammals may respond to any anthropogenic signals in a similar way to these natural sounds. Each CA for tagging only lasts a few minutes, and we do not approach any individual more than three times a day. The FF and acoustic exposures are designed only to last several hours maximum, so are unlikely to have any longer term impacts. The scientific research team would follow the PB subjects after exposure to monitor for return to baseline behavior, and would modify the PB protocol if there is any evidence of longer term changes.

The BRS is designed in such a way as to minimize exposure of animals to sounds louder than is required to elicit identifiable behavioral reactions in this range of RLs. The primary feature controlled in the proposed experiments is the RL of sound at the test subject, and the scientific research team would model and measure underwater sound propagation to predict and control exposure at the animal. In the past few years, researchers listed in the permit application and operating under Permit No. 875-1401 started each PB with a SL yielding a relatively low RL at the indicator animal; e.g., a level of 120 dB SPL. After they had time to monitor for potential disturbance, the RL was increased in a ramp-up procedure to the target exposure level. The RL at the animal would be increased either by increasing the SL or by having the PB vessel slowly approach the subject.

Acoustic monitors at AUTEC would follow the location of vocal intervals of beaked whale groups on the range. Any time that underwater MF coherent sound sources are transmitting on the range, they would record the RLs near the whales. The movement and vocal behavior of beaked whales exposed to underwater MF coherent sound sources would be compared to silent control conditions, and this comparison would be used to help establish minimum exposures associated with detectable reactions, and also with typical high levels of exposure not associated with risk. This would minimize the potential of any unexpected effects of experimental exposures during PBs on the AUTEC range.

The primary features the scientific research team would control in the PB experiments are the duration and RL (SPL) of sound at the test subject. They would establish a maximum RL above which we would not expose animals in order to avoid exposures that might enter the range of possible harm to the auditory system (170 dB SPL). One important feature used to help set this level involves the duration and duty cycle of the signals. For exposure to brief impulses from underwater short coherent sounds with low duty cycles of the sort to be tested in these studies, the TTS studies above suggest that a maximum SEL of 190 dB is conservative. Ridgway et al. (1997) and Schlundt et al. (2000) found no sign of TTS in dolphins exposed to RLs of single 1-sec signals above 190 dB SEL for sounds at frequencies of best hearing for the dolphins that were longer in duration and narrower in bandwidth. The onset of TTS started at received levels above 190 dB SEL for these sounds lasting one second.

Given that exposures would be below the level indicating a potential for injury, they also take into account the regulatory situation. The SURTASS LFA FOEIS/EIS (Department of the Navy 2001) assumes a continuum of risk from low near 120 dB to high near 180 dB SPL, with an assumed MMPA Level A injury take for all exposures above 180 dB SPL. In this policy context, NMFS in its cover letter of 25 July 2001 for the first amendment to permit no. 981-1578, quoted comments from the Marine Mammal Commission pointing out how important it is to test whether exposures to RLs up to 180 dB SPL may cause disturbance:

> The experimental protocol uses a maximum received level for all sounds except airguns of 160 dB SPL. However, this upper limit is not consistent with that proposed by the Navy (i.e. 180 dB SPL). The difference in these limits seems significant (a hundred-fold change in the intensity) and an informed judgment on the effects of SURTASS LFA or similar systems requires a measure of response to these levels. If a received sound level of 160 dB SPL or

> less is sufficient to cause significant behavioral changes, then the need to increase the received level to 180 dB SPL is not apparent. However, if changes observed at a received level of 160 dB SPL are deemed insignificant, **then further testing at higher levels seems necessary**.

The scientific research team would establish a maximum RL above which they would not expose animals in order to avoid exposures that might enter the range of possible harm to the auditory system. For the relatively short Phase I (2007) underwater MF coherent sound transmissions proposed, with low duty cycles, it is believed that a maximum exposure level of 170 dB SPL is conservative based upon TTS data, as long as the animals do not receive >10 pings at levels near 170 dB. Given the diversity of responses of marine mammals to coherent sounds, and given the extensive data researchers still need to collect in the 140-160 dB region, the permit applicant propose a maximum RL of 170 dB for PB signals from underwater coherent MF acoustic sources. The permit applicant would also add a margin of error for safety in each experiment to account for the possibility that the acoustic models used to predict RL at the animal are not always correct. This margin of error would be validated by comparison of estimated levels with those measured initially, and during the course of the PB by RLs measured at the animal by the tag.

Acoustic monitors at AUTEC would follow the location of vocal intervals of beaked whale groups on the range. Any time that underwater MF coherent sound sources are transmitting on the range, they would record the RLs near the whales. The movement and vocal behavior of beaked whales exposed to underwater coherent sounds would be compared to silent control conditions, and this comparison would be used to help establish minimum exposures associated with detectable reactions. This would minimize the potential of any unexpected effects of experimental exposures during BRS activities on the AUTEC range.

The RL at the animal would be increased either by increasing the SL or by having the PB vessel slowly approach the subject. The time devoted to the period for each RL must be a compromise between giving the animal time to exhibit an identifiable behavioral reaction and for us to detect it, while allowing the PB, which would typically last 1-3 hr, to complete the range of exposures up to the RL goal should no response be observed.

As mentioned above, the U.S. Marine Mammal Commission strongly urged setting the upper threshold for exposures up to the level treated by policymakers as likely to disturb. If disturbance is detected and verified at levels below this, the series of PB experiments probably need not go to higher RLs, but only document the level at which disturbance starts. Hence, the appropriate maximum level for PBs may need to go higher if no disturbance is detected within the regulated range, assuming that there is minimal potential for physiological effects, or permanent effects on hearing. However, for the Phase I SRP application and evaluated in this draft EA, the scientific research team proposes not to expose animals to levels above those treated as safe by regulatory agencies (in this case, 170 dB SPL).

PBs of a specific signal to a focal animal would occur at the lowest RLs thought to pose a potential for an identifiable behavioral reaction. Researchers would only increase the exposure after determining whether there is a change in behavior at the lower level. The design of these studies--to test whether specific acoustic exposures cause behavioral disruption--does not necessarily mean that researchers must continue increasing exposure until significant disturbance of a biologically important behavior is detected. Even if such a response is not detected, researchers would limit exposure to levels below those thought to pose a risk of injury (in this case, 170 dB SPL). In addition, as discussed previously, the permit applicant plans to limit maximum exposure to within the range that is currently mitigated or treated as safe by regulatory agencies. The maximum exposure level proposed for Phase I PBs is a RL at the animal of 170 dB SPL for underwater MF coherent sounds. Playbacks are planned to last on the order of 1-3 hours to test whether normal behavior may soon resume, even during exposure, and follow post-exposure behavior carefully to monitor for how long it may take to return to baseline. In the past few years, researchers operating under other permits have increasingly succeeded with 16 hr tag attachments, a duration that would allow for a 4 hour pre-exposure period, 6+ hour exposure and up to 4 hours post-exposure.

During CAs for tagging, some animals may show avoidance or other reactions. 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 would break off the CA and select a different subject. If after three CAs, researchers are not able to attach a tag, they would also select a different subject for tagging. The purpose of the PB 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 researchers obtain evidence of an identifiable behavioral reaction during a PB, they would not increase the RL 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 + surface sequence). After exposure and assuming researchers can identify and move the OV close enough, they would continue to follow the focal animal and would monitor how long it takes it to return to baseline behavior. If there is any sign of prolonged responses that might pose a risk of injury (e.g., panicked flight toward shallow water), researchers would suspend PBs, and communicate with NMFS to develop a protocol to ensure that future PBs would limit exposure to levels below those likely to expose animals to any such risk.

Observers would carefully monitor for changes in behavior during PBs. Visual observation of the movement patterns of animals with relatively short dive times, such as most delphinids, can serve as a useful indicator of avoidance reactions or changes in surface/dive behavior during a PB. For animals such as sperm and beaked whales with potentially long dive times, passive acoustic tracking of vocalizing animals serves as a good criterion of disturbance. Disturbance of beaked or sperm whales can be judged during a dive if they cease vocalizing in response to a PB or if passive tracking indicates disturbance of normal dive behavior. It has proved possible at AUTEC to conduct combined acoustic/visual follows of beaked whales in which a small observation vessel is sent by acoustic monitors to a location where beaked whales are heard. The monitors radio the OV when the whales stop clicking and start ascent, and the OV often sights the whales after their ascent. Then, when the whales start their descent, the OV radios the acoustic monitors, who pick up the clicks as the whales start to echolocate at the start of a foraging dive. This kind of visual/acoustic follow can be used for real-time monitoring. Animal disturbance indicators would include, but not be limited to: 1) click cessation for more than 2 min during a foraging dive; 2) premature ascent and/or changes in ascent rate; 3) abnormally short or long surface time period; 4) abnormal number and/or frequency of hard tail flicks/slaps or trumpet blows; 5) continuous surges or tail slashes; and 6) panicked flight. After each PB is completed, the primary criteria for disturbance from the acoustic stimuli would come from data from the DTAG2. The researchers would compare the pre-exposure baseline for each individual subject to the exposure condition using data on vocalizations, dive pattern, fluke strokes, orientation, and acceleration. The DTAG2 would provide more detailed data on potential disturbance reactions than has been possible for cetaceans in the past.

Acoustic Recording Tag

An acoustic recording tag offers a direct means to measure acoustic and motor behavior. By simultaneously recording the sound at the animal, together with behavioral signals, the connection between sound and response or other behavior can be made directly. Specific advantages of an acoustic tag are:

1. The sound level at the animal (i.e., RL) is measured directly. There is no reliance on transmission loss models alone to estimate RL.
2. There are no time alignment errors when correlating sound exposure and behavioral response.
3. It is possible (with the DTAG2) to measure subtle and short-duration responses; e.g., fluke stroke frequency and amplitude, ensuring that almost any potential response would be documented.

An acoustic recording tag also provides information on the vocalization rate and types of vocalizations produced by individuals, often of known age/sex/species. Acoustic recording tags have been demonstrated on such diverse species as elephant seals, dolphins, and right whales. The elephant seal tag used a hard drive to record low-bandwidth sound and pressure (Burgess et al., 1998; Costa et al., 2003). A major discovery made with this tag was that the ventilation and heart rate of the host animal can be recorded acoustically (Le Boeuf et al., 2000), obtaining a response measure familiar from its wide use on terrestrial species. This result has been duplicated using the DTAG with dolphins, and demonstrated heart rate responses to noise (Miksis et al. 2001). Similar acoustic records from DTAGs on beaked whales have been able to record heart rate when the whale is at the surface, but unfortunately, to date it has not been possible to sample heart rate continuously throughout the dive cycle.

Masking

There is a small possibility of short-term masking incidental to the behavioral response study. Many marine mammal species have a large range of frequencies in which they vocalize and hear. For example, as discussed previously, all mysticetes produce low frequency sounds, although no direct measurements of auditory (hearing) thresholds have been made (Clark, 1990; Richardson et al., 1995; Edds-Walton, 1997;Tyack, 2000; Evans and Raga, 2001). A few species' vocalizations are known to be communication signals. However, it is not known if mysticete low-frequency sounds are used for other functions such as orientation, navigation, or detection of predators and prey. Minke whales have a large frequency range in their vocalizations. Complex vocalizations recorded from Australian minke whales involved pulses ranging between 50 and 9,400 Hz, followed by pulsed tones at 1,800 Hz and tonal calls shifting between 80 and 140 Hz (Gedamke et al., 2001).

Also, as stated previously, odontocetes have a broad acoustic range, with recent hearing thresholds measuring between 400 Hz and 100 kHz (Richardson et al., 1995; Finneran et al., 2002). Many odontocetes produce a variety of click and tonal sounds for communication and echolocation purposes (Au, 1993). It is generally believed that odontocetes communicate mainly above 1,000 Hz and echolocate above 20 to 30 kHz (Wursig and Richardson, 2002). Little is known about the details of most sound production and auditory thresholds for many species (Frankel, 2002).

However, the chance of masking during the BRS is small. First, the source must be operating in the same frequency and at the same time as a marine mammal is either vocalizing or listening. Based on existing MF sonars, it is believed that most signals are probably contained in a single one-third octave frequency band, or possibly two one-third frequency bands at the most. Since many marine mammals are able to hear and vocalize in a large range of frequencies, this leaves many other frequency bands for a marine mammal to shift if need be. Additionally, the playbacks are planned to last on the order of 1-3 hours to test whether normal behavior may soon resume, even during exposure, and the permit applicant plans to follow post-exposure behavior carefully to monitor for how long it may take to return to baseline, with no greater than 10 pings at the maximum 170 dB RL. Since the tests would be conducted in a relatively short time, if masking were to occur, it is unlikely that it would be for a significant amount of time, and no long-term effects on any animal that may experience any masking are anticipated.

CHAPTER 4 ENVIRONMENTAL CONSEQUENCES

This chapter represents the scientific and analytic basis for comparison of the direct, indirect, and cumulative effects of the alternatives. Regulations for implementing the provisions of NEPA require consideration of both the context and intensity of a proposed action (40 CFR Parts 1500-1508). Thus, the significance must be analyzed in several contexts, such as society as a whole, the affected resources and regions, and the affected interests. Intensity refers to the severity of the impact and the following 10 specific aspects that must be considered: (1) beneficial and adverse effects; (2) effects on public health and safety; (3) unique characteristics of the geographic area (*e.g.*, proximity to historic or cultural resources, park lands, and ecologically critical areas); (4) degree to which possible effects are likely to be highly controversial; (5) degree to which possible effects are highly uncertain or involve unique or unknown risks; (6) precedent-setting actions; (7) whether the action is related to other actions with individually insignificant but cumulatively significant impacts; (8) loss or destruction of significant scientific, cultural, or historical resources (including adverse effects on sites listed in the National Register of Historic Places); (9) degree to which action may adversely affect an endangered or threatened species or designated critical habitats; and (10) violation of Federal, state, or local laws imposed for protection of the environment.

NMFS has, through NAO 216-6, established agency procedures for complying with NEPA and the implementing regulations issued by the Council on Environmental Quality. NAO 216-6 specifies that issuance of scientific research permits under the MMPA and ESA is among a category of actions that are generally exempted (categorically excluded) from further environmental review, except under extraordinary circumstances. Specifically, when a proposed action that would otherwise be categorically excluded is the subject of public controversy based on potential environmental consequences, has uncertain environmental impacts or unknown risks, establishes a precedent or decision in principle about future proposals, may result in cumulatively significant impacts, or may have an adverse effect upon endangered or threatened species or their habitats, preparation of an EA or EIS is required.

Issuance of a scientific research permit under the MMPA and ESA authorizes “takes” of marine mammals and threatened or endangered species, respectively. Given the definitions of take, harassment, and harm under the MMPA and ESA, a “take” as authorized under a permit issued pursuant to the MMPA or ESA could be considered an “adverse effect” on the affected individual animal under NAO 216-6.

In the case of the proposed action, the most likely avenue for “take” is via Level B harassment related to short-term disruption of behavioral patterns. Since the proposed action would occur within the range of various marine mammal species, some individual marine mammals may be “taken” through harassment. However, it should be noted that an adverse effect upon an individual animal does not necessarily equate to an adverse effect upon the entire species to which that animal belongs. Since NEPA does not define what an adverse effect on a threatened or endangered species is, NMFS will rely upon the following to examine the degree to which a proposed action will result in adverse effects on a listed species.

An adverse effect on an individual marine mammal does not necessarily translate into an adverse effect on the population or the environment. In order for an adverse effect on an individual member or some number of individuals of a species to result in an adverse effect on the species as a whole, the effects on the individuals must result in reduced reproduction or survival of the individual that would consequently result in an appreciable reduction in the likelihood of survival or recovery for the species. Therefore, in order for the proposed action to have an adverse effect on a species, the exposure of individual animals of a given species to the sound source would first have to result in the disruption of essential behaviors of the exposed individual, such as feeding, mating, or nursing, to a degree that the individual's likelihood of successful reproduction or survival was substantially reduced. Second, the substantial reduction in the individual's likelihood of successful reproduction or survival would have to result in a net reduction in the number of individuals of its species. In other words, the loss of the individual or its future offspring would not be offset by the addition, through birth or emigration, of other individuals into the population. Third, that net loss to the species would have to be reasonably expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the listed species in the wild. The effects of the proposed action on threatened and endangered species are further evaluated through the interagency consultation process pursuant to Section 7 of the ESA, as described in Subchapter 4.4.

Whether or not a marine organism may be affected by the proposed action is dependent on two factors. The first factor is whether or not the organism is only in the action area at certain times of the year, others may only be present at certain times of day. The second factor is whether or not the organism can detect (hear) the sounds produced by the source. Whether or not an organism can detect the sound is dependent on its auditory threshold at a given frequency. Auditory threshold is the audibility limit of discriminating sound intensity and pitch. In other words, auditory threshold is a measurement of the weakest sound of a given frequency that an individual can detect. As an example, humans are capable of hearing 32 kHz sounds, but only when they are extraordinarily loud because our ears are not as sensitive at detecting sounds in this frequency range compared to lower frequencies.

For those organisms that are present and can detect the sounds, whether or not they would be adversely affected is a function of their exposure as well as their response. Exposure is a function of the frequency and energy level of the source (which determine how far the sound will travel and how "loud" it will be at a given distance), proximity to the source (which also determines "loudness"), and duration of the sound over a given time interval. For a given organism, response is likely to be a function of a variety of biological factors. For example, whether or not a dolphin that hears the sound deviates from its course or otherwise alters its behavior could depend on its age, sex, reproductive condition, the time of year or day, the behavior of other dolphins in its vicinity, the specific behavior in which it was engaged at the time of exposure, or some combination of the above.

At any given distance from the source, only those marine organisms with hearing sensitivity at the received sound level and in the frequency range of the sonar would be "exposed" during the proposed research. Available information on the hearing sensitivity of invertebrates, sea turtles, sea birds, and most fish (as summarized in Chapter 3) suggests they are not likely to be "exposed" at any time during the proposed action. For the cetacean species within the action area, "exposure" would be up to a maximum of 170 dB. Therefore, the estimates of incidental harassment takes for the non-target species, while lower than for some of the other species, are likely over-estimated.

Other permits that have been issued and involved tagging and/or introducing sound into the marine environment include:

- Permit no. 223 and 576 involved natural sound playbacks to baleen whales (1981 and 1991, respectively).
- Permit no. 369-1440-01 involved tagging sperm whales in the Gulf of Mexico during the spring and summer of 2001.
- Permit no. 765 involved tagging and playback experiments with sperm whales, ended 31 December 1997.
- Permit no. 875-1401 was for the SURTASS LFA sonar SRP which involved playback experiments to baleen whales in 1997-98.
- Permit no. 917 also involved tagging sperm whales in the Gulf of Mexico during the summer of 2001.
- Permit no. 981-1578 involved research similar to that covered by the permit application.
- Permit no. 1048-1717 involved research to develop, validate and improve low-power and high frequency sonar systems designed to detect marine mammals (2003).

As discussed in Subchapter 1.2, NMFS has previously prepared EAs on active acoustics research permits because of "public controversy" (*i.e.*, Tyack EA; NMFS 2000) or uncertain environmental impacts (*i.e.*, Tyack EA; NMFS 2003). Virtually any activity involving acoustics and marine mammals has been perceived by some members of the public as "controversial," including the use of sonars (also the use of airguns). The purpose of this proposed research, though, is to detect disturbance reactions and to determine how exposure may affect the ability of exposed animals to achieve the goals of their activities. The results of this study would be used in order to develop an understanding to strive for the development of a safe response that can be used to indicate risk and test whether other man-made sounds elicit the indicator response in beaked whales and other deep-diving odontocetes, and attempt to define dose:response relationships for MF sonar and other man-made sounds. Based on the proposed mitigation measures, the exposures would be controlled to ensure the safest possible method of exposure and the knowledge gained from this study would help to prevent future marine mammal biologically significant behavioral change incidents and aid NMFS in the permitting and regulatory process by providing these data. Thus, the results of the proposed action would facilitate the formulation or modification of regulations for improving the protection of ESA or MMPA species from noise exposure, which would help the stocks benefit as individual animals are protected by monitoring and mitigation measures and as acoustic habitat degradation is reversed.

4.1 Effects of Alternative 1 – No Action

Under this alternative, which is the "no action" alternative, a new permit for scientific research to conduct a behavioral response study on deep diving odontocetes would not be issued at this time.

Although the action area for the proposed study encompasses a very small portion of ocean, the behavioral response study, if proven reliable, could have a much wider geographic application. Increasing evidence suggests the potential for exposure to intense underwater sounds in some settings to cause beaked whales to strand, and some of the stranded animals may die (Simmonds and Lopez-Jurado, 1991; Frantzis, 1998, Cox et al. 2006). Some reports on this problem correlate the strandings with military sonars at source levels of 226+ dB that are operated intermittently for many hours in the mid frequency band (SACLANTCEN, 1998; DOC and DON, 2001). The dominant species in these strandings is Cuvier's beaked whale, *Ziphius cavirostris*, but the genus *Mesoplodon* is also involved. Thus, most marine mammal strandings that are coincident with MF sonar exercises have involved beaked whales. Until the causes of these strandings can be identified, (and possibly dose:response relationships defined) it will remain difficult to discriminate an actual hazard from random coincidences of human activities and natural strandings. One of the most direct and precise ways to test whether MF sonar sounds could pose a risk of stranding is to conduct BRSs, including a combination of observational studies and carefully controlled experiments on safe and early indicators of responses that may be linked to a causal chain of events leading to stranding.

Factors such as research activities and the use of sonar would continue to have an impact under the No Action Alternative. The existing baseline condition is that the ocean in general is a very noisy place, particularly in developed coastal regions like that of the action area. Although there would not be the noise contribution of the sound source during the BRS, if this study is not conducted, scientific information that could be used by NMFS for the formulation of protective regulations would not be collected. Also, there would be no collection of empirical data on the behavioral effects of these sounds on marine mammals, particularly deep diving odontocetes, and on possible causes for strandings.

4.2 Effects of Alternative 2 – Proposed Action

Under the Proposed Action alternative, a one-year scientific research permit would be issued to NMFS Office of Science and Technology authorizing takes of marine mammals by Level B harassment during exposure to the sound sources and by close approaches for photo-identification, attachment of scientific instruments, and behavioral observations. Visual and passive acoustic monitoring would be implemented to ensure there would be no Level A takes of marine mammals; and there would be clear source shutdown criteria to limit exposure to Level B harassment. Sloughed skin samples collected from detached tags would be imported into the US for analysis.

Under the Proposed Action alternative, a permit would authorize the intentional exposure of sperm whales, Cuvier's beaked whales, Mesoplodon spp., short-finned pilot whales, Risso's dolphins, and melon-headed whales to controlled coherent/incoherent sound source transmissions. A permit would also authorize unintentional exposure of a number of other marine mammals under NMFS jurisdiction to the source, as outlined in Table 1.

The most likely effect of the source sounds on marine mammals is avoidance. Some behavioral indicators of disturbance, or "Level B" harassment, are avoidance (moving away from the sound), increased vigilance, cessation of an activity, or changes in swim speed or surfacing interval. Avoidance reactions are the most obvious indicators of disturbance. Avoidance reactions can be strong or mild and can have varying effects on individuals. For example, migrating gray whales were observed to alter their course by 30 deg as they approached an industrial sound source, which allowed them to pass well to the side of the source without making a large change in their course or the length of their migration (Richardson *et al*., 1995). In addition to avoidance reactions, marine mammals may respond to underwater sounds by changing their activity. For example, cetaceans that are resting or socializing at the surface may dive or start to travel slowly at the onset of man-made noise.

The proposed mitigation measures would minimize exposure of animals to sounds louder than is required to elicit indicator responses in this range of RLs. The primary feature the scientific research team would control in the BRS experiments is the RL of sound at the test subject, and they would model and measure sound propagation in order to predict and control exposure at the animal. The RL at the whale would be increased either by increasing the SL or by having the PB vessel approach the subject.

4.3 Comparison of Alternatives

The proposed Phase I BRS field research activity is planned as a pilot experiment of approximately 6 weeks in the summer/fall of 2007. Based upon their experience tagging beaked and pilot whales with the DTAG, the permit applicant assumes a 20 percent success rate (# successful attachments/touch) for attachment to beaked whales and 40 percent for pilot whales. Beaked whales are not just difficult to tag, but they are also difficult to sight and approach. Based upon previously conducted field work, the applicant estimates four CAs are required for one chance to touch an animal with a tag. During previous field work with *Ziphius* in the Ligurian Sea, researchers listed in the permit application followed groups that grew to up to 7 individuals. However, animals are often sighted alone. For this BRS, the permit applicant assumed a beaked whale group size of five for *Mesoplodon spp*. And 3 for *Ziphius*. On average a CA to a beaked whale for tag attachment may actually involve CA to two or more whales in addition to the tagging subject. Claridge (2006) identifies average group size of short-finned pilot whales for the AUTEC region to be 6, which is used in the permit applicant's calculations.

The sensitivity and responsiveness of animals is likely to vary within a population. This means that it is essential to conduct PBs to a sample of animals. On the other hand, there is a limit to the number of animals that can be tagged and followed within a 6 week experiment. For most of the species to be studied by tagging individuals for PBs, the permit applicant hopes for a sample size of 40 focal tagged individuals (with an estimated 4 occurring outside Bahamian territorial seas) for this Phase I (BRS).

The permit applicant proposes to conduct initial PBs with beaked whales, such that maximum RL at the subject is no greater than the levels associated with behavioral responses (e.g., cessation of vocalization and/or movement away from the source), in initial observational work with beaked whales, with the source at a range from the animal such that any potential behavioral reaction by the animal would not be caused by detecting any aspect of the source other than the playback acoustic stimulus. That is, researchers would attempt to remove the potential for contextual response by the animal so as to focus on behavioral reactions caused solely by its response to the RL from the sound source to which it is exposed. Researchers would continue to increase the RL until an identifiable behavioral reaction was observed. Thereupon, the exposure would be maintained for an interval of time sufficient to define the response in terms of diving and surfacing behavior. Only after careful study of the identifiable behavioral reaction would researchers propose increasing animal exposure levels. The maximum RL researchers would expose any animal to would be 170 dB SPL RL for underwater MF coherent sounds. NMFS (2003) currently suggests an exposure above 160 dB SPL in order to estimate MMPA Level B harassment takes.

All of the potential PB subjects are social and are likely to be sighted in groups. Researchers would obtain as much data as possible from other animals within the group, but the primary unit for statistical analysis would remain the PB of a specific stimulus type to focal subjects that have been tagged or are being followed by a small observation vessel (McGregor, 1992). As was discussed previously, the number of animals exposed to a PB would be estimated by counting all animals within the group of the focal animal as exposed. Researchers would use a nominal group size of 6 to estimate the number of PB takes for sperm and pilot whales; and a nominal group size of 5 for beaked whales (*Mesoplodon spp.)*, 3 for beaked whales (*Ziphius*), 232 for melon-headed whales, and 14 for Risso's dolphins. These are conservative estimates, given that the PB protocols are designed to minimize the chances that non-focal animals would be exposed to higher levels than the focals, even if the focal animal is exposed to a level that evokes behavioral reaction, the potential is very low that this many other animals in the area would have exposures that are as high.

Estimating the number of intentional PB takes to proposed target species and unintentional (incidental) PB takes for other species requires estimating the number of PB events. This is complicated by the ability to tag multiple sperm, beaked or pilot whales, or melon headed whales or Risso's dolphins. It has been difficult to attempt to tag multiple animals simultaneously, but researchers listed in the permit application have succeeded in doing this for both beaked and sperm whales. However, responses of several animals to the same exposure may not be statistically independent. Therefore, for this experiment the permit applicant assumed only one animal subject per PB, so that a goal sample size of 20 animal PB subjects could be achieved by conducting 20 PBs (with an estimated 2 occurring outside of Bahamian territorial seas).

For unintentional (incidental) PB takes, the permit applicant used the same group sizes for sperm, beaked, melon-headed and pilot whales, and Risso's dolphins as those estimated above. For the incidental takes of other marine mammals, the permit applicant used reasonable estimates of animal distribution, abundance and density data, coupled with number of PBs. Both sets of the numbers, derived using 220 dB SL, 5 km/hr relative speed of animal and PB vessel, and 12 hr duration of PB, are presented in Table 5. For the Phase I 2007 research, the permit applicant has erred on the conservative side with this calculation methodology. Revised calculations would be done for the proposed Phase II 2008 research.

The entire exposure series is designed to last up to 1-3 hr (although our calculations assume 12 hr to maximize the conservative estimations of the BRS). The experiments are designed to be able to detect identifiable behavioral reactions during this exposure, and to monitor return of behavior to baseline after the exposure stops. Over a series of PB events, the following nominal beaked whale PB sequence is proposed:

- Monitor at least one pre-exposure dive + surface sequence;
- After animal starts next foraging dive, commence PB signals soon after animal starts clicking (average vocal time 26 min);
- Start animal RL at minimum (e.g., ambient, ambient +10 dB), and slowly ramp up over 10-20 min until identifiable behavioral reaction is elicited or maximum exposure level of 170 dB SPL is attained;
- If animal ceases clicking during PB, maintain exposure level to ascertain if/when clicking resumes;
- After 30 min (nominally) of PB, terminate source transmissions;
- If animal ceases clicking during PB and some other identifiable behavioral reaction is noted during the dive + surface sequence, monitor at least one post-exposure dive + surface sequence to ensure return to baseline behavior;
- If an animal ceases clicking during PB 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, PBs would be temporarily suspended to re-evaluate research protocols;
- If animal did not cease clicking, execute next PB same as the first;
- Goal is to elicit identifiable behavioral reaction from underwater MF coherent sound exposure—if no identifiable behavioral reaction after 5 full PBs, most probable option would be to move to another stimulus signal.

Thus, it is unlikely, given the design, that individual animals involved in the experiments would have their activities disrupted by more than a few hours. These experiments are designed to evaluate unknown risks of relatively uncontrolled MF sonar exposure, but the careful controls built into the BRS experimental design would minimize the risks of the controlled sound exposures. The tagging and PB experiments use standard experimental techniques that have been used safely with many species over the past decade under NMFS Scientific Research Permits. Given the large scale of these studies, the proposed combination of close approach, focal follow, tagging and PB is not likely to be adopted by many other researchers.

Compared to the baseline noise level or harassment of marine mammals of the No Action alternative, this does not represent a substantial increase in exposure to noise or by MMPA Level B harassment from tagging for any marine mammals in the BRS action area. The duration of any exposure would be brief and behavioral responses to detection of the source sounds would be short-lived. The potential for adverse impacts on the human environment is not greater under the Proposed Action compared to the No Action alternative.

As mentioned previously, the existing baseline condition is that the ocean in general is a very noisy place, particularly developed coastal regions like that of the BRS action area. Although there would not be the noise contribution of source transmissions, if this study is not conducted, scientific information that could be used by NMFS for the formulation of protective regulations would not be collected. Also, there would be no collection of empirical data on the behavioral effects of these sounds on marine mammals, particularly deep diving odontocetes, and on possible causes for strandings.

4.4 Compliance With ESA

This section will summarize conclusions of biological opinions resulting from formal consultation to ensure that these proposed permit is not likely to jeopardize the continued existence of any species listed as threatened or endangered or result in the destruction or adverse modification of critical habitat that has been designated for these species as required by section 7(a)(2) of the ESA. The consultation process on the proposed permit cannot conclude until the comment period on the permit application has closed and NMFS has decided whether to revise the proposed permit in response to public comment. For the purpose of the consultation, the draft EA represents NMFS' assessment of the potential biological impacts.

4.5 Mitigation Measures

Effects

The tagging of animals may evoke short-term behavioral responses such as sudden movement, turning or rolling. The longest effect of tagging that has been detected comes from tagging sperm whales that are breathing at the surface following a foraging dive. Once a tag has been attached to a sperm whale, it may stop its blow sequence and dive earlier than it would otherwise have done. The subsequent foraging dive involves normal diving, foraging, and vocalization behavior, but may be somewhat shorter than the previous or following dives, when the animal blows at the surface for as long as it wants. This change in dive duration does not appear to have an effect beyond an hour, and appears to have minimal effect on foraging. The tag is able to monitor for other reactions. None have been defined in previous tests, other than possible orienting responses (Malakoff, 2001), and the permit applicant does not anticipate any effects on individual animals beyond this kind of short orienting response.

As previously mentioned, the the entire exposure series is designed to last up to 1-3 hr (although our calculations assume 12 hr to maximize the conservative estimations of the BRS). The experiments are designed to be able to detect identifiable behavioral reactions during this exposure, and to monitor return of behavior to baseline after the exposure stops. It cannot be assumed that an animal will surface after a dive at or near the vicinity of where it commenced the dive, but the AUTEC range monitors can usually help vector the PB support vessels to the vicinity of the animal's surfacing location. If reactions are detected that do not return to baseline within the post-playback tagging duration, then they would suspend PBs and reevaluate the design. Thus, it is unlikely, given the design, that individual animals involved in the experiments would have their activities disrupted by more than a few hours. These experiments are designed to evaluate unknown risks of uncontrolled sound exposure, but the careful controls built into the experimental design would minimize the risks of the controlled sound exposures. The tagging and PB experiments would use standard experimental techniques that have been used safely with many species over the past decade under NMFS Scientific Research Permits.

Effects of Incidental Harassment

It is possible that CAs of one animal for tagging might affect the behavior of other animals nearby. In previous tagging experience, researchers have seen few responses other than animals in the same group as the tagged one following the tagged animal if it turns or dives after tagging. The permit applicant does not anticipate reactions lasting more than a minute to these incidental approaches. Similarly, when researchers conduct a FF with a tagged whale, the FF vessel would also follow other animals nearby. The protocols for FF are designed so that the FF vessel has no effect on the behavior of either the focal animal or its companions, so no harassment is anticipated from this activity.

The primary activity that might cause incidental harassment involves the PB experiments. These experiments are designed so that the FF animal would eventually be exposed to a higher RL than other animals that may be present. However, it is possible that other animals might come close enough to exhibit disruption of behavior. Not every species has been studied with the signals proposed for the PBs, but enough is known tomake some predictions. Captive bottlenose dolphins do not show aversive reactions to 1-sec tonal signals until they are above 180 dB SPL (Schlundt et al. 2000). Rendell and Gordon (1999) recorded pilot whales in the presence of 0.17 sec pings from a 4-5 kHz sonar. The pilot whales vocalized more often during transmissions, but did not avoid the area during several hours of exposure. Humpback, fin, and right whales have been reported to respond to sonar sounds in the 15 Hz – 28 kHz range (Watkins, 1986), and Maybaum (1993) reports that humpback whales responded to pings from a 3.3 kHz sonar by swimming away with increased speed and linearity (i.e., in a straight line), but the sounds did not consistently affect vocalizations or diving behavior.

The observed responses of odontocetes other than beaked whales to underwater MF coherent sounds appear to be limited to a range of between 100-1000 m (328-3,281 ft), a range within which they can be monitored visually by the acoustic monitors and visual observers who are on watch before, during and after transmissions. Any changes of vocal behavior, such as that reported for pilot whales, can be detected by the acoustic monitors. Little measured data have been collected on the responses of beaked whales to underwater MF coherent sounds. The location and vocal behavior of beaked whales would be monitored, along with any underwater MF coherent sound transmissions on the AUTEC range. Beaked whale detections can usually be associated with a RL of the underwater MF sound, if present. The vocal and movement behavior of the beaked whales can be compared in exposure and control conditions, and the acoustic exposure associated with changes in vocal behavior can be quantified. This would help estimate the potential for incidental harassment at this site.

The permit applicant requests takes under the Phase I (BRS) SRP application by incidental harassment for any of the species that may be present in the Tongue of the Ocean, and outside the Bahamian territorial seas, where PBs are proposed, and would use visual and acoustic monitoring to document any incidental disturbance reactions. Transmissions would be suspended, however, if any marine mammals are detected to have the potential to approach within the 170 dB SPL isopleth for underwater MF coherent sounds.

Effects on Stocks

The proposed research would have only minor short-term effects on the individual subjects. The PB experiments would only be detectable over a tiny portion of the seasonal range of the species present in the study area. Therefore, the proposed research would have little direct impact on the relevant species or stock. Since most of these species have been exposed to underwater coherent sounds, any information verifying safe exposure levels will be critical for ensuring adequate protection of these stocks from impacts of human-made noise. If the proposed carefully controlled sound exposures do indicate any effects, the data would be critical for establishing evidence for exposure criteria for possible regulation that may cause a cumulative decrease in exposure from existing activities, which are not currently effectively regulated.

Stress, Pain, and Suffering

This project is designed to minimize to a negligible level the potential of any stress, pain or suffering. The tags are non-invasive, using soft suction cups, and there is no indication that they cause any pain. An animal can easily dislodge the tag with rolling or shaking movements. A minority of tagged animals do this, usually within a few minutes of tagging. The ease and speed with which they can remove the tag, indicates little chance for stress from attachments. Regarding effects of playbacks, in humans, the threshold for pain from acoustic exposure is above the level that can cause hearing damage. This project is designed not to expose any animals to sound levels high enough to cause any hearing damage (e.g., PTS). Animals can avoid exposure during the PB experiments by swimming away, and if any such avoidance reactions are observed, subsequent exposures would be carefully designed to take this into account. Stress from playbacks could possibly involve playback of vocalizations of predator species (e.g., orca calls [Yurk, 2002]) for all subject species. If the subject reacts to the playback as if it were a predator, it may experience some stress as it prepares for an anti-predator response. However, these natural sound playbacks are important for understanding whether marine mammals may respond to any anthropogenic signals in a similar way to these natural sounds. Each CA for tagging only lasts a few minutes, and they do not approach any individual more than three times a day. The FF and acoustic exposures are designed only to last several hours maximum, so are unlikely to have any longer term impacts. The PB subjects would be followed after exposure to monitor for return to baseline behavior, and the scientific research team would modify the PB protocol if there is any evidence of longer term changes.

Measures to Minimize Effects

The basic goal of the PBs covered in the permit application is to determine the lowest exposure of transient transmissions of underwater sound that predictably elicit selected indicator responses from subjects. The studies are designed in such a way as to minimize exposure of animals to sounds louder than is required to elicit identifiable behavioral reactions in this range of RLs. The primary feature controlled in the experiments is the RL of sound at the test subject, and the scientific research team would model and measure underwater sound propagation to predict and control exposure at the animal. In the past few years, researchers have started each PB with a SL yielding a relatively low RL at the indicator animal; e.g., a level of 120 dB SPL. After they had time to monitor for potential disturbance, the RL was increased in a ramp-up procedure to the target exposure level. The RL at the animal would be increased either by increasing the SL or by having the PB vessel slowly approach the subject.

Also, acoustic monitors at AUTEC would follow the location of vocal intervals of beaked whale groups on the range. Any time that underwater MF coherent sound sources are transmitting on the range, they would record the RLs near the whales. The movement and vocal behavior of beaked whales exposed to underwater MF coherent sound sources would be compared to silent control conditions, and this comparison would be used to help establish minimum exposures associated with detectable reactions, and also with typical high levels of exposure not associated with risk. This would minimize the potential of any unexpected effects of experimental exposures during PBs on the AUTEC range.

Maximum received level for controlled exposures of noise

The plan for the PB experiments is to determine behavioral responses of whales exposed to received sound levels well below those thought to pose a potential for injury. The range of sound exposures has been selected to include those that are currently viewed by regulatory policy as unlikely to pose an adverse impact. The PB research is designed to test these assumptions.

The most important criterion for selection of a maximum exposure level involves the concern not to expose animals to sounds that might cause physiological harm or injury. The permit applicant recognizes that there may be some circumstances where animals would remain in areas with no obvious sign of behavioral disruption, even though the sound exposure may affect their hearing. Therefore, one cannot always rely upon wild animals to swim away from a source to avoid potentially harmful exposures. Over the past few years there have been several successful experiments defining sound exposures that cause TTS in captive dolphins and seals (Ridgway et al., 1997; Kastak et al., 1999; Schlundt et al., 2000) using SEL as the criterion for evaluating exposure in terms of auditory injury.

A maximum RL would be established above which researchers would not expose animals in order to avoid exposures that might enter the range of possible harm to the auditory system (170 dB SPL). One important feature used to help set this level involves the duration and duty cycle of the signals. For exposure to brief impulses from underwater short coherent sounds with low duty cycles of the sort to be tested in these studies, the TTS studies above suggest that a maximum SEL of 190 dB is conservative. Ridgway et al. (1997) and Schlundt et al. (2000) found no sign of TTS in dolphins exposed to RLs of single 1-sec signals above 190 dB SEL for sounds at frequencies of best hearing for the dolphins that were longer in duration and narrower in bandwidth. The onset of TTS started at received levels above 190 dB SEL for these sounds lasting one second.

Given that exposures would be below the level indicating a potential for injury, the permit applicant would also take into account the regulatory situation. The SURTASS LFA FOEIS/EIS (Department of the Navy 2001) assumes a continuum of risk from low near 120 dB to high near 180 dB SPL, with an assumed MMPA Level A injury take for all exposures above 180 dB SPL. In this policy context, NMFS in its cover letter of 25 July 2001 for the first amendment to permit no. 981-1578, quoted comments from the Marine Mammal Commission pointing out how important it is to test whether exposures to RLs up to 180 dB SPL may cause disturbance:

> The experimental protocol uses a maximum received level for all sounds except airguns of 160 dB SPL. However, this upper limit is not consistent with that proposed by the Navy (i.e. 180 dB SPL). The difference in these limits seems significant (a hundred-fold change in the intensity) and an informed judgment on the effects of SURTASS LFA or similar systems requires a measure of response to these levels. If a received sound level of 160 dB SPL or less is sufficient to cause significant behavioral changes, then the need to increase the received level to 180 dB SPL is not apparent. However, if changes observed at a received level of 160 dB SPL are deemed insignificant, **then further testing at higher levels seems necessary**.

The permit applicant would establish a maximum RL above which animals would not be exposed in order to avoid exposures that might enter the range of possible harm to the auditory system. For the relatively short Phase I (2007) underwater MF coherent sound transmissions proposed, with low duty cycles, the permit applicant believes that a maximum exposure level of 170 dB SPL is conservative based upon TTS data, as long as the animals do not receive >10 pings at levels near 170 dB. Given the diversity of responses of marine mammals to coherent sounds, and given the extensive data we still need to collect in the 140-160 dB region, the permit applicant proposes a maximum RL of 170 dB for PB signals from underwater coherent MF acoustic sources. The permit applicant would also add a margin of error for safety in each experiment to account for the possibility that the acoustic models used to predict RL at the animal are not always correct. This margin of error would be validated by comparison of estimated levels with those measured initially, and during the course of the PB by RLs measured at the animal by the tag.

Acoustic monitors at AUTEC would follow the location of vocal intervals of beaked whale groups on the range. Any time that underwater MF coherent sound sources are transmitting on the range, they would record the RLs near the whales. The movement and vocal behavior of beaked whales exposed to underwater coherent sounds would be compared to silent control conditions, and this comparison would be used to help establish minimum exposures associated with detectable reactions. This would minimize the potential of any unexpected effects of experimental exposures during BRS activities on the AUTEC range.

The RL at the animal would be increased either by increasing the SL or by having the PB vessel slowly approach the subject. The time devoted to the period for each RL must be a compromise between giving the animal time to exhibit an identifiable behavioral reaction and for us to detect it, while allowing the PB, which would typically last 1-3 hr, to complete the range of exposures up to the RL goal should no response be observed.

Necessary vs. unnecessary disturbance

The proposed research uses tags that, while attached, continuously monitor the behavior of cetaceans. This technique requires CA for photo-identification and for tag attachment, and these CAs and tag attachments may require some brief and necessary disturbance, but the tagging reduces the potential for disturbance during the subsequent FF. FFs of tagged animals can be conducted farther from the focal whale than would otherwise be required to monitor the behavior of untagged animals. The goal of the FFs is to operate the OV in such a way that it has no effect on the subjects.

The PB studies are designed to determine what kinds of sound exposure may cause behavioral responses in odontocete marine mammals that are indicative of early safe effects that may pose a risk of stranding for much longer and/or more intense exposures. Marine mammals are exposed to an increasing number of loud underwater sound sources. One of the main obstacles to minimizing the risk of adverse impacts of these exposures concerns ignorance of sound levels that may cause disturbance. The key for the proposed work is to develop a safe indicator response; this disturbance level would be necessary to inform policy-makers to protect these species. The researchers would therefore intentionally expose animals to underwater MF coherent sound in order to test whether the exposure stimulates the indicator response. All of this field research takes place in a broader policy context, in which interest and concern may focus on specific exposure ranges for specific taxonomic groups and for specific sound sources. As mentioned above, the U.S. Marine Mammal Commission strongly urged setting the upper threshold for exposures up to the level treated by policymakers as likely to disturb. If disturbance is detected and verified at levels below this, the series of PB experiments probably need not go to higher RLs, but only document the level at which disturbance starts. Hence, the appropriate maximum level for PBs may need to go higher if no disturbance is detected within the regulated range, assuming that there is minimal potential for physiological effects, or permanent effects on hearing. However, for the Phase I SRP application, the permit applicant proposes to not expose animals to levels above those treated as safe by regulatory agencies (in this case, 170 dB SPL).

What would be done to avoid or minimize disturbance?

PBs of a specific signal to a focal animal would be started at the lowest RLs thought to pose a potential for an identifiable behavioral reaction. Researchers would only increase the exposure after determining whether there is a change in behavior at the lower level. The design of these studies--to test whether specific acoustic exposures cause behavioral disruption--does not necessarily mean that they must continue increasing exposure until they detect significant disturbance of a biologically important behavior. Even if they have not detected such a response, they would limit exposure to levels below those thought to pose a risk of injury (in this case, 170 dB SPL). In addition, as discussed above, researchers plan to limit maximum exposure to within the range that is currently mitigated or treated as safe by regulatory agencies. The maximum exposure level they propose for the Phase I PBs is a RL at the animal of 170 dB SPL for underwater MF coherent sounds. The permit applicant plans playbacks to last on the order of 1-3 hours to test whether normal behavior may soon resume, even during exposure, and they plan to follow post-exposure behavior carefully to monitor for how long it may take to return to baseline. In the past few years, researchers have increasingly succeeded with 16 hr tag attachments, a duration that would allow for a 4 hour pre-exposure period, 6+ hour exposure and up to 4 hours post-exposure.

What would be done if evidence of disturbance is observed?

The plan is to start PBs of a specific signal to a focal animal at the lowest RLs thought to pose a potential for an identifiable behavioral reaction. The researchers would only increase the exposure after determining whether there is a change in behavior at the lower level. The design of these studies--to test whether specific acoustic exposures cause behavioral disruption--does not necessarily mean that they must continue increasing exposure until they detect significant disturbance of a biologically important behavior. Even if they have not detected such a response, they would limit exposure to levels below those thought to pose a risk of injury (in this case, 170 dB SPL). In addition, as discussed above, they plan to limit maximum exposure to within the range that is currently mitigated or treated as safe by regulatory agencies. The maximum exposure level proposed for Phase I PBs is a RL at the animal of 170 dB SPL for underwater MF coherent sounds. The researchers plan playbacks to last on the order of 1-3 hours to test whether normal behavior may soon resume, even during exposure, and they plan to follow post-exposure behavior carefully to monitor for how long it may take to return to baseline. In the past few years, researchers have increasingly succeeded with 16 hr tag attachments, a duration that would allow for a 4 hour pre-exposure period, 6+ hour exposure and up to 4 hours post-exposure.

4.6 Unavoidable Adverse Effects

The mitigation measures imposed by permit conditions are intended to reduce, to the maximum extent practical, the potential for adverse effects of the research on the targeted species as well as any other species that may be incidentally harassed. However, as discussed above, the proposed research would have only minor short-term effects on the individual subjects. The PB experiments would only be detectable over a tiny portion of the seasonal range of the species present in the study area. Therefore, the proposed research would have little direct impact on the relevant species or stock. Since most of these species are now routinely exposed to increasingly loud underwater sounds, any information verifying safe exposure levels would be critical for ensuring adequate protection of these stocks from impacts of human-made noise. If the proposed carefully controlled sound exposures do indicate any effects, the data would be critical for establishing evidence for exposure criteria for possible regulation that may cause a cumulative decrease in exposure from existing activities, which are not currently effectively regulated.

4.7 Cumulative Effects

4.7.1 Intentional lethal takes

Most species of baleen whales were the targets of commercial whaling. Commercial whaling is the reason most species of large whale were listed as endangered under the ESA. Only a small number of nations currently engage in commercial whaling of a few species of baleen whales. The most common targets of modern whalers are the minke whale and sperm whale. Shooting of small cetaceans and pinnipeds that were thought to be interfering with commercial fishing operations has occurred, but it is currently prohibited under the MMPA. Since the take prohibitions of the MMPA and ESA became effective, marine mammals in the U.S. have been protected from intentional lethal take with the exception of subsistence harvests of a few species in Washington and Alaska. Although harvests may have contributed to previous declines of some species of marine mammal in Bahamian waters, intentional lethal takes are not currently considered to be a factor affecting any of the stocks in the proposed action.

The tag attachments the permit holder proposes using have been used extensively with no evidence of injury or any problem other than temporary behavioral disruption to the tagged whale in some delphinid species (Schneider et al., 1998). Every effort would be made to ensure that PB exposures do not pose a risk to the subjects, and a primary effort of Phase I (2007) would be to define a safe behavioral indicator of risk of stranding; i.e., a response that, while safe in itself because of low intensity or short duration, can be related to a causal hypothesis for strandings that coincide with MF sonar sounds. The PBs are designed to define the minimum exposure required to elicit the behavioral responses to be used as an indicator. They would start with low levels of exposure at the subject(s) and would not increase the exposure level if identifiable behavioral reactions have been detected, until those reactions are fully analyzed. Previous research conducted under permit no. 981-1578 and other PB experiments using similar stimuli have been conducted with sperm whales with no problems (Gordon et al., 1996). The behavioral reaction most commonly reported for sperm whales exposed to brief man-made sounds is cessation of vocalization (Watkins et al., 1985; Bowles et al., 1994). This vocal behavior would be monitored in real-time, and RLs at the subject would not be increased if animals show an unusual cessation of vocalization so that researchers can determine how long it takes the animals to return to normal vocal behavior. The tags would allow researchers to follow individual whales after PB to verify return to normal behavior. The combination of careful SL selection, permanent monitor hydrophones at the research location, and monitoring and mitigation measures, reduce the potential for unintended lethal takes to as low a level as is scientifically possible within the framework of a viable BRS.

4.7.2 Entrapment and entanglement in fishing gear

For most marine mammal species listed in Table 1, incidental capture in fishing gear is not an issue of concern relative to their population abundance and productivity rates. Estimates of annual fishing-related mortality are well below Potential Biological Removal limits established for most stocks. With the exception of humpback whales, annual fishery-related mortality for the endangered species is zero. Actual numbers of observed and estimated fishery-related mortality by stock are provided for each species in the annual stock assessment reports, which are available from the NMFS website. Given the low numbers of interactions for most stocks, and that the effects of the proposed action would be limited to short term “Level B” harassment, the proposed action is not likely to result in cumulative impacts in combination with interactions with fisheries.

4.7.3 Vessel interactions

Collision with vessels is a cause of serious injury and mortality for large whales in some areas of the U.S., especially right whales in the North Atlantic. However, the exact number of these interactions is not known for other species, since most whales struck and killed by vessels would tend to sink, rather than come inshore where they would be found. The proposed action is not likely to increase the number of vessel interactions since the research vessels would move slowly and deliberately, and for the most part, have knowledge of the location of marine mammals in their vicinity.

Tag attachment vessel (TAV)

Tag delivery would be conducted to minimize the potential for disturbing the animal. The permit applciant proposes to use small maneuverable vessels for tag attachment. Researchers have successfully used 5-15 m vessels for attaching tags to animals in 1998 - 2006, with minimal signs of disturbance using a 12+ m long cantilevered pole or a 4-5 m handheld pole. The permit applicant proposes to attach tags using a pole deployed from a similar kind of vessel (e.g., 3-5 m RIB) by approaching them slowly.

Whale Observation/Tag tracking Vessel (OV or WTV)

The primary requirement for the whale tracking vessel (WTV) are:

- height for antenna placement and for visual observations;
- silent propulsion and ability to deploy hydrophone array;
- ability to deploy TAV;
- cabin and bunk space for tagging team, visual monitors, and a crew of acoustic monitors to operate around the clock, if required.

A large quiet research vessel is optimal for this task. One critical component of the PBs involves accurate assessment of range from the PB source to the focal animal. Researchers would measure the angle between a surfacing animal and the horizon or use laser range-finding binoculars to calculate range for animals visually sighted at the sea surface. In some circumstances, it is possible for the acoustic monitors to estimate the range to vocalizing animals as well (Thode et al. 2002). If the OV and PBV are separate vessels, researchers would have a data link between them to allow each platform to plot the locations of ships and animals in near-real-time. These data would be supplemented by the standard AUTEC platform reconstruction data, coupled with the best estimate of animal underwater location from the range hydrophone data.

Playback vessel (PBV)

The PB vessel would be used to deploy the sound source(s) and transmit the experimental stimuli signals. It must have hardware for deploying the sound source(s) and, in the case of a vessel, suitable deck and lab space for the source equipment and sound generation electronics (computer, power amplifiers, etc.). One critical component of the PBs involves accurate assessment of range from the PB source to the focal animal. The researchers would use laser range-finding binoculars or measure the angle between a surfacing animal and the horizon to calculate range for animals visually sighted at the sea surface. In some circumstances, it is possible for the acoustic monitors to estimate the range to vocalizing animals as well (Thode et al. 2002). This vessel should have a relatively quiet propulsion system to minimize potentially confounding vessel noise. These data would be supplemented by the standard AUTEC platform reconstruction data, coupled with the best estimate of animal underwater location from the range hydrophone data.

4.7.4 Other research permits

There are currently no other scientific research permits that authorize similar acoustic research. Other scientific research permits that have been issued for tagging and/or introducing sound to the marine environment are:

Permit no. 223 and 576 involved natural sound playbacks to baleen whales.
Permit no. 369-1440-01 involved tagging sperm whales in the Gulf of Mexico during the spring and summer of 2001.

Permit no. 765 involved tagging and playback experiments with sperm whales, ended 31 December 1997.
Permit no. 875-1401 was for the SURTASS LFA sonar SRP which involved playback experiments to baleen whales in 1997-98.
Permit no. 917 involved tagging sperm whales in the Gulf of Mexico during the summer of 2001.
Permit no. 981-1578 involved research similar to that covered by this permit application.
Permit no. 1048-1717 involved research to develop, validate and improve low-power and high frequency sonar systems designed to detect marine mammals.

The majority of "takes" under these permits are by "Level B" harassment. Under these permits, a limited number of cetaceans are also "taken" by remote biopsy sampling for genetic and contaminant studies and attachment of scientific instruments such as VHF or satellite tags to track their movements at sea. A small percentage of some pinniped species are also captured, have scientific instruments attached, and blood and tissue samples collected for health assessments and studies of foraging behavior. NMFS does not anticipate cumulative impacts from these permits in conjunction with the proposed action for a number of reasons. First, there is not likely to be direct overlap in time and space among any permits. All NMFS permits require permit holders to coordinate their field activities with other permit holders who may be conducting research in the same area or on the same species. The second reason cumulative impacts are not anticipated from research permits is that the duration of the proposed action is very brief and any effects on exposed marine mammals are expected to be short term. The same is also true of individual studies under other permits that authorize research on the same species or stocks. Last, the location of the proposed action for BRS is not near the other research activities.

4.7.5 Habitat degradation

Loss of habitat is a primary cause of the decline of many species worldwide. Habitat loss does not have to result from physical exclusion from an area (as can occur with some construction activities). Marine mammals may be indirectly affected by a variety of other human activities, including discharges from wastewater systems, dredging, ocean dumping and disposal, and aquaculture. In the North Pacific, undersea exploitation and development of mineral deposits, as well as dredging of major shipping channels pose a continued threat to the coastal habitat of right whales. Point-source pollutants from coastal runoff, offshore mineral and gravel mining, at-sea disposal of dredged materials and sewage effluent, potential oil spills, as well as substantial commercial vessel traffic, and the impact of trawling and other fishing gear on the ocean floor are continued threats to right whales in the North Atlantic. None of these habitat degradation causes relate to the proposed BRS-07 field research.

The impacts from these activities are difficult to measure. However, some researchers have correlated contaminant exposure to possible adverse health effects in marine mammals. Studies of captive harbor seals have demonstrated a link between exposure to organochlorines (*e.g.*, dichloro-diphenyl-trichloroethane [DDT], polychlorinated biphenyls (PCBs), and polyaromatic hydrocarbons) and immunosuppression (Ross *et al*.

1995, Harder *et al.* 1992, De Swart *et al.* 1996). The impact of ocean contamination on the health of marine mammal populations has been investigated with increasing interest, with particular focus on chemicals that persist in the environment, such as the organochlorines. These chemicals tend to bioaccumulate through the food chain, thereby increasing the potential of indirect exposure to a marine mammal via its food source. During pregnancy and nursing, some of these contaminants can be passed from the mother to developing offspring. Contaminants like organochlorines do not tend to accumulate in significant amounts in invertebrates, but do accumulate in fish and fish-eating animals. Thus, contaminant levels in planktivorous mysticetes have been reported to be one to two orders of magnitude lower compared to piscivorous odontocetes (Borell, 1993; O'Shea and Brownell, 1994; O'Hara and Rice, 1996; O'Hara *et al.*, 1999). None of these habitat degradation causes relate to the proposed BRS-07 field research.

Given that the BRS target species at AUTEC have been exposed to sonar transmissions on numerous occasions over the past few decades, and their abundance and densities have not measurably decreased, it is safe to conclude that the introduction of sound source transmissions during the short-term proposed BRS field research would not cause habitat degradation.

4.7.6 Noise

Animals inhabiting the marine environment are continually exposed to many sources of sound. Naturally occurring sounds such as lightning, rain, subsea earthquakes, and animal vocalizations (*e.g.*, whale songs) occur regularly. The noise from airplanes and helicopters, recreational boating and commercial shipping, is a source of potential disturbance. Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson *et al*., 1995). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Baker *et al.* 1983; Bauer and Herman 1986; Hall 1982; Krieger and Wing 1984), but the long-term effects, if any, are unclear or not detectable. Marine mammals can be found in areas of intense human activity, suggesting that some individuals or populations may tolerate, or have become habituated to, certain levels of exposure to noise (Richardson *et al*., 1995). For example, baleen whales, including right whales, are consistently found within the shipping lanes of the St. Lawrence estuary and off Cape Cod despite frequent exposure to vessels. Such tolerance is likely related to the importance of the area to feeding and/or migrating whales and a certain degree of habituation. It is not clear whether such chronic exposure to anthropogenic noise has adverse physiological effects or whether potential masking of communication sounds is having negative impacts on social behaviors.

There is evidence that anthropogenic noise has increased the ambient level of sound in the ocean over the last 50 years. Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage. Commercial fishing vessels, cruise ships, transport boats, and recreational boats all contribute sound into the ocean. The military uses sound to test the construction of new vessels as well as for naval operations.

In areas such as the Gulf of Mexico where oil and gas production takes place, noise originates from the drilling and production platforms, tankers, vessel and aircraft support, seismic surveys, and the explosive removal of platforms. Currently 155 seismic survey vessels operate throughout the world with airgun array SLs of up 260 dB re 1 μPa at 1 m (far field estimate) or more. Hundreds of naval vessels operate high power sonars with SLs of 240 dB. Sonars used for depth sounding and bottom profiling often operate in the 1-12 kHz frequency band with SLs similar to that of the whale-finding sonar (Richardson *et al*.,1995). Most ships operate depth sounding sonars continuously while at sea and bottom profilers are a commonly used research tool.

In regards to this proposed study, introducing natural sounds, novel synthetic sounds, and coherent/incoherent sounds into the marine environment, the playback experiments involve controlled exposures that are less frequent and lower in level than many of these species may face from certain incidental commercial sources. The maximum level of exposure is lower than or equal to the exposures restricted by regulation due to the likelihood of physical injury. If this research, as anticipated, helps in the formulation/modifications of regulations improving the protection of ESA or MMPA species from noise exposure, then this would help the stocks, as individual animals are protected by monitoring and mitigation measures and as acoustic habitat degradation is reversed. In this context, it is essential to work with those species thought to be most sensitive.

4.7.7 Conclusion

Given the information provided in Subchapter 4.7, the potential for cumulative impacts from the BRS is considered to be extremely small. The BRS would introduce natural and artificial underwater sounds into the marine environment. However, due to the short duration of the BRS, it would not add appreciably to the underwater sounds that fish, sea turtles, and marine mammals are already exposed to. Even though the BRS would produce additional noise, this research is considered to be beneficial to the species in that it would provide data on the behavioral effects of sources on marine mammals, which can then lead to the formulation/modifications of regulations improving the protection of ESA or MMPA species from noise exposure and thus benefiting stocks of marine animals around the world. Finally, the BRS would cause no lethal takes of marine mammals.

APPENDIX A: BRIEF OVERVIEW OF THE PROCESS FOR OBTAINING A NMFS SCIENTIFIC RESEARCH PERMIT UNDER MMPA AND ESA

Persons seeking a special exception permit for scientific research must submit a properly formatted and signed application to the Office Director. The applicant must describe the species to be taken, the manner and duration of the takes, the qualifications of the researchers to conduct the proposed activities, as well as provide justification for such taking. Upon receipt, applications are reviewed for completeness according to the specified format and for compliance with regulations specified at 50 CFR §216.33. At this time, an initial determination is made as to whether the proposed activity is categorically excluded from the need to prepare an EA or EIS. A Notice of Receipt of complete applications must be published in the Federal Register. This Notice invites interested parties to submit written comments concerning the application within 30 days of the date of the Notice. At the same time, the application is forwarded to the MMC and other reviewers for comment. In addition, if endangered species are likely to be affected by the proposed activities, the Permits Division must consult with NMFS Endangered Species Division (or the U.S. Fish and Wildlife Service if species under their jurisdiction are involved). At the close of the comment period, the applicant may need to respond to requests for additional information or clarification from reviewers. If the proposed activities do not meet the criteria for a categorical exclusion, the appropriate environmental documentation (EA or EIS) must be prepared and is subject to public comment. If all concerns can be satisfactorily addressed and the proposed activity is determined to be in compliance with all relevant issuance criteria (see sections 1.5.2 and 1.5.3), the Office Director will issue a permit.

MMPA regulations regarding issuance of Scientific Research Permits (SRPs)

The regulations promulgated at 50 CFR §216.33, §216.34, and §216.41 specify criteria to be considered by the Office Director in making a decision regarding issuance of a permit or an amendment to a permit. Specifically, §216.33(c) requires that the Office Director (a) make an initial determination under NEPA as to whether the proposed activity is categorically excluded from preparation of further environmental documentation, or whether the preparation of an environmental assessment (EA) or environmental impact statement (EIS) is appropriate or necessary; and (b) prepare an EA or EIS if an initial determination is made that the activity proposed is not categorically excluded from such requirements. The permit issuance criteria listed at §216.34 require that the applicant demonstrate that:

> (1) The proposed activity is humane and does not present any unnecessary risks to the health and welfare of marine mammals.
> (2) The proposed activity is consistent with all restrictions set forth at §216.35 and any purpose-specific restrictions as appropriate set forth at §216.41, §216.42, and §216.43.
> (3) The proposed activity, if it involves endangered or threatened marine mammals, will be conducted consistent with the purposes and policies set forth in section 2 of the ESA.

(4) The proposed activity by itself or in combination with other activities will not likely have a significant adverse impact on the species or stock.
(5) The applicant's expertise, facilities, and resources are adequate to accomplish successfully the objectives and activities stated in the application.
(6) If a live animal will be held captive or transported, the applicant's qualifications, facilities, and resources are adequate for the proper care and maintenance of the marine mammal.
(7) Any requested import or export will not likely result in the taking of marine mammals or marine mammal parts, beyond those authorized by the permit.

In addition to these requirements, the issuance criteria at §216.41(b) requires that applicants for permits for scientific research and enhancement must demonstrate that:

(1) The proposed activity furthers a *bona fide* scientific or enhancement purpose.
(2) If the lethal taking of marine mammals is proposed:
(a) Non-lethal methods for conducting the research are not feasible; and
(b) For depleted, endangered, or threatened species, the results will directly benefit that species or stock, or will fulfill a critically important research need.
(3) Any permanent removal of a marine mammal from the wild is consistent with any applicable quota established by the Office Director.
(4) The proposed research will not likely have significant adverse effects on any other component of the marine ecosystem of which the affected species or stock is a part.
(5) For species or stocks designated or proposed to be designated as depleted or listed or proposed to be listed as endangered or threatened:
(a) The proposed research cannot be accomplished using a species or stock that is not designated or proposed to be designated as depleted, or listed or proposed to be listed as threatened or endangered;
(b) The proposed research, by itself or in combination with other activities will not likely have a long-term direct or indirect adverse impact on the species or stock;
(c) The proposed research will either:
(i) Contribute to fulfilling a research need or objective identified in a species recovery or conservation plan, or if there is no conservation or recovery plan in place, a research need or objective identified by the Office Director in stock assessments established under Section 117 of the MMPA;
(ii) Contribute significantly to understanding the basic biology or ecology of the species or stock, or to identifying, evaluating, or resolving conservation problems for the species or stock; or
(iii) Contribute significantly to fulfilling a critically important research need.

ESA regulations regarding issuance of SRPs

NMFS' regulations implementing the ESA at 50 CFR §222.308(b) provide that "Permits for marine mammals shall be issued in accordance with the provisions of part 216, subpart D of this chapter" as outlined in the previous subsection of this EA. In addition to these issuance criteria under the MMPA, NMFS' regulations implementing the ESA at 50 CFR §222.308(c) requires that the following criteria be considered in determining whether to issue a permit for scientific purposes for takes of endangered species:

(1) Whether the permit, if granted and exercised, will not operate to the disadvantage of the endangered species;

(2) Whether the permit would be consistent with the purposes and policy set forth in section 2 of the ESA;

(3) Whether the permit would further a *bona fide* and necessary or desirable scientific purpose or enhance the propagation or survival of the endangered species, taking into account the benefits anticipated to be derived on behalf of the endangered species;

(4) Whether alternative non-endangered species or population stocks can and should be used;

(5) Whether the expertise, facilities, or other resources available to the applicant appear adequate to successfully accomplish the objectives stated in the application; and

(6) Opinions or views of scientists or other persons or organizations knowledgeable about the species which is the subject of the application or of other matters germane to the application.

> Under section 7 of the ESA, the Permits Division, as a Federal action agency, is required to determine whether issuance of a permit may affect listed species or critical habitat. If it is determined that issuance of a permit may adversely affect listed species or adversely modify critical habitat, the Permits Division must formally consult with the Endangered Species Division. In requesting this consultation, the Permits Division is required to provide the best scientific and commercial data available for an adequate review of the effects of the proposed permit on listed species and critical habitat (50 CFR §402.14). Although both the MMPA and ESA definition of a "take" include harassment, the ESA does not define harassment. However, harassment has been defined in Biological Opinions prepared during consultations on issuance or marine mammal research permits, as injury to an individual animal or population of animals resulting from a human action that disrupts 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. Particular attention is given to the potential for injuries that may manifest themselves as an animal that fails to feed successfully, breed successfully (which can result from feeding failure), or complete its life history because of changes in its behavioral patterns. In the latter two of these examples, the injury to an individual animal could be injurious to a population because the individual's breeding success will have been reduced.

APPENDIX B: GLOSSARY OF ACOUSTICS TERMINOLOGY

Acoustic recording tag – Offers a direct means to measure acoustic and motor behavior.

Audiograms – Measures of hearing sensitivity. An audiogram plots auditory thresholds (minimum detectable levels) at different frequencies and depicts the hearing sensitivity of the species. It is difficult to interpret audiograms because it is not known whether sound pressure or particle motion is the appropriate stimulus and whether background noise determines threshold.

Auditory brainstem responses – A method in which recordings are made, non-invasively, of the brain response while the animal is presented with a sound. This is a method that is widely used to rapidly assess hearing in new-born humans, and which is being used more and more in studies of animal hearing, including hearing of marine mammals. The advantages of ABR are that the animal does not have to be trained to make a response (which can take days or weeks) and it can be done on an animal that is not able to move. It is also very rapid and results can be obtained within a few minutes of exposure to noise. The disadvantages are primarily that the ABR only reflects the signal that is in the brain and does not reflect effects of signal processing in the brain that may result in detection of lower signal levels than apparent from measures of ABR. In other words, in a behavioral study the investigator measures the hearing response of animals that have used their brains to process and analyze sounds, and therefore potentially extract more of the signal even in the presence of noise. With ABR, the measure is strictly of the sound that is detectable by the ear, without any of the sophisticated processing provided by the nervous system of any vertebrate. At the same time, ABR does give an excellent indication of basic hearing loss, and is an ideal method to quickly determine if there is TTS right after sound exposure when results are compared with those from controls.

Behavioral response studies (BRSs) – An experiment conducted in a controlled environment designed to examine the behavioral response of animals to a stimulus.

Close approach (CA) – A close approach is defined as any approach to a single focal animal or one of several animals within a group to within 10-15 m to allow for tag attachment and/or photo-identification.

Controlled experimental exposures – Controlled experimental exposures of sound have classically been called "playbacks" (McGregor, 1992), but controlled exposure experiments (CEEs per se) carefully control acoustic exposure at the subject in order to titrate what exposure evokes a behavioral response.

Critical Habitat –

1. Specific areas within a geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to conservation, and those features may require special management considerations or protections; and

2. Specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation.

DTAGs – The sampling method would be using electronic tags. The DTAG is the name given to a miniature solid-state acoustic recording tag. Two versions of the DTAG have been designed and fabricated. The first version (DTAG1) has worked very well for large whales such as sperm and baleen whales. The second version (DTAG2) is smaller, with capabilities for higher acoustic sampling rates, and the DTAG2 is proposed for the research to be conducted under this SRP. The DTAG2 uses solid-state non-volatile memory in place of magnetic media to overcome the limitations of hard drives which necessitate pressure housings. This has the advantage that the tag can be potted, eliminating the need for a pressure housing and enhancing the robustness of the device.

Essential Fish Habitat (EFH) –"those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. 1802(10))

Focal Follow (FF) – Following a single focal animal (typically, but not exclusively, the tagged animal) or several whales in a group including the focal animal during the tagging to relate data on the tag to observed surface behaviors, to relate acoustic data to observed surface behaviors, and for tagged animals, following for a period of time before the tag is attached and after the tag releases from the animal to determine any effects of tagging on behavior. Sometimes FFs can be conducted on individuals using natural markings, and behavioral data from this kind of follow can be useful, but many FFs in the permitted research would use the tag to facilitate the follow.

Hearing specialists – Bony fish with specializations that enhance their hearing sensitivity.

Hearing generalists (or non-specialists) – Fish that do not posses specializations that enhance their hearing sensitivity.

Hearing threshold –The level of sound that is barely audible in the absence of significant ambient noise is the absolute hearing threshold. It is the lowest sound level that is detected during a specific percentage of experimental trials. A statistical definition is necessary because, even for a single animal, the minimum detectable sound level varies over time (Richardson *et al*., 1995).

Low frequency – The band below 1,000 Hz.

Masking – Increases in noise levels can decrease the ability of an animal to detect biologically important sound when the increased noise level rises above the level of sound for which the animal is listening. This effect is commonly known as masking. Masking of significant sounds (*e.g.*, calls of other animals, predators, sounds of hazards, such as approaching boats, etc.) can occur when ambient noise levels increase. Marine mammals have evolved in the highly variable noise environment of the ocean, and presumably are well adapted for tolerating the natural variations in ocean noise that could at times cause masking. However, the determination of an animal's ability to tolerate changes in noise levels requires a better understanding of: 1) the functional importance of faint sound signals from the same species, predators, prey, and other natural sources; 2) signal detection abilities of marine mammals in the presence of background noise, including directional hearing abilities at frequencies where masking is an issue; and 3) abilities of marine mammals to adjust the intensities and perhaps frequencies and timing of emitted sounds to minimize masking effects.

Mid-frequency sonar – The band ranging from 1 to 10 kHz.

Neritic – The oceanic zone that spans from the low-tide line to the edge of the continental shelf.

Observations of opportunistic exposures – The most realistic circumstances for a 'natural' experiment but leave many factors uncontrolled.

Passive acoustic monitoring – A listening component which detects returning echoes from submerged objects through the use of hydrophones.

Permanent Threshold Shift (PTS) – An increase in the threshold of hearing that is permanent, not temporary. It is an unrecoverable deafening due to physiological damage to the hearing organs that does not diminish with time. PTS may occur as a result of long-term exposures and/or extremely loud noises. Repeated exposures that cause to temporary threshold shift (TTS) can induce PTS, as well. The mitigation measures proposed for implementation under the proposed research and discussed in the EA are designed to ensure that PTS does not occur from experiments under the proposed research.

Playbacks (PB) – The vessel-based playbacks may involve a stationary source of sound, or the source vessel may slowly approach the subject. The Phase I playback experiments would use underwater sound projectors capable of reproducing MF sonar and natural sounds (e.g., killer whale signals). The Phase II playback experiments would use underwater LF and MF sound projectors, and seismic survey (airgun) sound sources deployed from a vessel. The basic protocol for the playbacks involves a series of experiments, starting at a low exposure level, and only increasing exposure after no disruption of behavior has been observed at the lower level.

Received Level (RL) – The level of sound that arrives at the receiver, or listening device (hydrophone). It is measured in decibels referenced to 1 microPascal root-mean-square (rms). Put simply, the received level is the source level minus the transmission losses from the sound traveling through the water.

Sound Exposure Level (SEL) – The measure of sound energy flow per unit area expressed in dB and are assumed to be standardized at dB re 1 μPa^2-s, unless otherwise stated.

Sound Pressure Level (SPL) – Twenty times the logarithm to the base 10 of the ratio of the pressure to the reference pressure, in decibels at a specific point. The reference pressure shall be explicitly stated. SPL is usually measured in decibels referenced to 1 microPascal (rms).

Tagging – Attachment of the digital archival recording tag to a single focal animal via suction cup. The NMFS definition of a tagging take is that the tag touches the whale.

Temporary Threshold Shift (TTS) – a brief, transitory increase in an individual animal's hearing threshold in response to exposure to sound. All humans typically experience such shifts, such as the effect that occurs after leaving a noisy room for a quiet location. For a period of time, hearing sensitivity is decreased such that quiet sounds are not perceived. TTS recovers so that original hearing abilities return. Minor amounts of shift (3-5 dB) may recover in minutes; large shifts (40 dB) may recover overnight, and major shifts (>45 dB) may require days or weeks to recover. Above 65 dB the shift may not fully recover. TTS generally occurs in a limited or affected frequency band at sound intensities well above hearing threshold levels. Using NMFS interim guidance (based on human hearing data), the difference between the threshold of hearing and sound intensities that result in annoyance (or possibly TTS) in marine mammal is approximately 80 to 100 dB. For the experiments covered by this assessment, the more conservative value of 80 dB above threshold would be used throughout. NMFS nevertheless notes that at this time, exposures that cause PTS or TTS have not been measured for mysticetes or sperm whales.

APPENDIX C: LITERATURE CITED

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