Updated: 04/06/07

I. APPLICATION FOR A PERMIT FOR SCIENTIFIC RESEARCH UNDER THE MARINE MAMMAL PROTECTION ACT

II. DATE OF APPLICATION: 6 April 2007

III. APPLICANT AND PERSONNEL
A. <u>Applicant/Permit Holder</u>: Dr. John Boreman Director, Office of Science and Technology National Oceanic and Atmospheric Administration National Marine Fisheries Service Office of Science and Technology 1315 East-West Highway Silver Spring, MD 20910-6233

A. <u>Principal Investigator (PI)</u>: Dr. Brandon Southall Director, NOAA Ocean Acoustics Program National Marine Fisheries Service Office of Science and Technology 1315 East-West Highway Silver Spring, MD 20910-6233 Tel: 301-713-2363 x163

A. <u>Co-Investigators (CI)</u>: Dr. Ian Boyd, University of St. Andrews Dr. Christopher W. Clark, Cornell University Dr. Darlene Ketten, Woods Hole Oceanographic Institution Dr. Peter Tyack, Woods Hole Oceanographic Institution Dr. Adam S. Frankel, Marine Acoustics, Inc. Diane Claridge, Bahamas Marine Mammal Research Organization

A. <u>Primary contact for correspondence during permit review process</u>: Mr. Clayton H. Spikes Chief Engineer, Marine Acoustics, Inc. 4100 N. Fairfax Drive, Suite 730, Arlington, VA 22203 Tel: 703-465-8404; Fax: 703-465-8420; E-mail: clay.spikes@marineacoustics.com

Table of Contents

List of Tables

III.B. APPLICANT AND PERSONNEL QUALIFICATIONS AND EXPERIENCE

Dr. John Boreman (Applicant):

Director, Office of Science and Techology
National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)
Office of Science and Technology, Director
1315 East-West Hwy, SSMC3 12450
Silver Spring, MD 20910
phone: 301-713-2367 x171 fax: 301-713-0376
email: John.Boreman@noaa.gov

Education:

- **B.Sc.** (1970) - State University of New York College of Forestry (now SUNY College of Environmental Science and Forestry) and Syracuse University, Syracuse, NY 13210
- **M.Sc.** (1972) - Cornell University (major - Fishery Biology), Ithaca, NY 14853
- **Ph.D.** (1978) - Cornell University (major - Fishery Science), Ithaca, NY 14853

Awards and Honors:

- Certified Fisheries Scientist, American Fisheries Society (No. 2108)
- Alpha Xi Sigma - National Forestry Honorary (Elected 1969)
- Who's Who in American Colleges and Universities (1970)
- Letter of Commendation from EPA Region IV Administrator for Scientific Contributions to the Brunswick Power Plant Case (1976)
- Quality Performance Award - US Fish and Wildlife Service (1979)
- Letter of Commendation from EPA Region II Administrator for Scientific Contributions to the Hudson River Power Plant Case (1981)
- Unit Citation (as member of the National Power Plant Team) from Secretary of the Interior Watt (1982)
- NOAA Administrator's Award for Developing Scientific Information and Serving as the NOAA Spokesperson for Conservation of East Coast Striped Bass (1984)
- Letter of Commendation from Commerce Secretary Baldridge for Scientific Contributions to the Conservation of East Coast Striped Bass (1984)
- Listed in American Men and Women of Science (since 1979)
- NMFS Assistant Administrator's Award for Unusually Outstanding Performance (1988)
- Dwight A. Webster Award of Merit, Northeastern Division, American Fisheries Society (1999)
- Meritorious Service Award of the American Fisheries Society (1999)
- Certificate of Appreciation for Leadership, American Fisheries Society (2000)
- NMFS Employee of the Year (2001)
- Department of Commerce Bronze Medal (2003)

Employment History (last 20 yr):

2006 – Present	Director, Office of Science and Technology, National Marine Fisheries Service, Silver Spring, MD
2004 - 2006	Director, Northeast Fisheries Science Center, National Marine Fisheries Service, Woods Hole, MA
2005 - Present	Adjunct Professor of Fisheries Oceanography, School of marine Science and Technology, University of Massachusetts - Dartmouth
2002 - 2004	Acting Director, Northeast Fisheries Science Center, National Marine Fisheries Service, Woods Hole, MA
1997 - 2002	Deputy Director, Northeast Fisheries Science Center, National Marine Fisheries Service, Woods Hole, MA
1989 - Present	Adjunct Professor of Fisheries, Dept. Natural Resources Conservation, Univ. of Massachusetts - Amherst
1989 - 1997	Director, UMass/NOAA Cooperative Marine Education and Research Program, University of Massachusetts - Amherst
1985 -1989	Chief, Research Coordination Section, Research Planning and Coordination Staff, Northeast Fisheries Science Center, NMFS, Woods Hole, MA

Special Activities (last 20 yr):

- Advisor to U.S. Fish and Wildlife Service, LaCrosse Fisheries Center, and U.S. Army Corps of Engineers (St. Louis District) on techniques for determining long-term impacts of navigation on fish populations in the upper Mississippi River (1989 - present)
- Consultant to VERSAR, Inc., on development of indicators for fish and shellfish in coastal communities for the EPA EMAP Program (1990)
- Advisor to Hudson River Foundation on potential impacts of development projects in New York Harbor on resident and transient fish populations (1990)
- Member, Technical Review Panel for the Hudson River Foundation (1989 - 2004)
- Chair, Scientific Advisory Committee to the North Carolina Striped Bass Management Board (1990 - 1991)
- Chair, Technical Working Group, Hudson River Power Case permit re-negotiations (1992 - 1997)
- Member, Board of Directors, Hudson River Foundation (1993 - 2004)
- Member, Monitoring Advisory Committee, Public Service Gas and Electric of New Jersey (1994 - 2001)
- Chair, Program Committee, Hudson River Foundation (1996 - 2004)
- Consultant, Ministry of Fisheries, Ukraine (1997)
- Member, External Advisory Board, Department of Natural Resources Conservation, UMass-Amherst (1999 - present)
- US Delegate, Advisory Committee on the Marine Environment, ICES (2000)
- Vice Chair, Northeast Area Monitoring and Assessment Program (NEAMAP), Atlantic States Marine Fisheries Commission (2000 - 2004)
- Advisor, Research and Education Subcommittee, Hudson River Institute Rivers and Estuaries Project (2001 - 2003)Member, NMFS Advisory Board on Ecosystem-Based

Approach to Marine Resource Management (2001 - 2003)
- Member, Mount Hope Bay Natural Laboratory Advisory Committee, UMass-Dartmouth (2002 - present)
- Invited Lecturer, SUNY College of Environmental Science and Forestry (2001)
- Invited Lecturer, Rutgers University (2002)
- Co-Chair, NOAA Fisheries Intra-agency Task Force on Employee Training (2002 - 2004)
- Invited lecturer, Marine Resources Education Program (MREP), University of New Hampshire (2002 - present)
- Member, scientific program review panel for the Cooperative Institute for Marine and Atmospheric Sciences (CIMAS), University of Miami (2003)
- NOAA representative, Northeast Regional Ocean Council (2005 - present)

Professional Affiliations (last 20 yr):

- Chair, Northeastern Division Newsletter Committee (1985 - 1988)
- Member, Best Student Paper and Poster Awards Committee, Ann. Mtg. (1986, 1994, 1995, 1996)
- Chair, NE Symposium Program Committee, (1990 - 1992)
- Secretary/Treasurer, Northeastern Division (1992 - 1993) *elected position*
- President-Elect, Marine Fisheries Section (1992 - 1994) *elected position*
- Chair, Special Committee on Reauthorization of the Magnuson Act (1992-1994)
- President, Marine Fisheries Section (1994 - 1996) *elected position*
- Chair, Groundfish Steering Committee (1994 - present)
- Member, AFS Special Management Committee (1995 - 1996) *elected position*
- Member, Northeastern Division Audit Committee (1996 - 1997)
- Bycatch Symposium Steering Committee (1994 - 1996)
- Chair, AFS Meritorious Service Award Committee (2001 - 2002)
- Chair, Special AFS Symposium on large-scale fishery independent surveys (for AFS 2003 annual meeting)

Oral Presentations (last 20 yr):

Boreman, J., and R. Lewis. 1986. Atlantic coastal migration of striped bass. International Symposium on Common Strategies of Anadromous and Catadromous Fishes, Boston, MA.

Appeared in PBS-TV Special "Striped Bass - The Mysterious Disappearance" shown in 1987.

Boreman, J. 1988. Stock Assessment and Fishery Evaluation Reports - A Proposed Requirement under the Magnuson Act. 7th Stock Assessment Workshop. Woods Hole, MA.

Boreman, J. 1990. Equating ichthyoplankton mortality to fishing opportunity foregone. Workshop on Navigation Impacts to Ichthyoplankton, U.S. Fish and Wildlife Service, St. Paul, MN.

Boreman, J. 1990. Developing standards for measuring restoration of coastal habitats. Northeast Fish and Wildlife Conference, Nashua, NH.

Boreman, J. 1992. Eggs per recruit modelling. Winter Flounder Modelling Workshop. Milford, CT.

Boreman, J. 1992. Improving habitat quality vs reducing fishing mortality to restore depleted populations of winter flounder. Northeast Fish and Wildlife Conference, Norfolk, VA.

Boreman, J., S. Correia, and D. Witherell. 1992. Population-level effects of changes in age 0 survival of winter flounder in the Gulf of Maine. 16th Larval Fish Conference, Kingston, RI.

Boreman, J. 1992. Fishery-level impacts of changes in survival rates of three estuarine fish species induced by fluxes in habitat quality. Joint ESCA-ERF Estuarine Conference: Changes in Fluxes in Estuaries - Implications from Science to Management, Plymouth, UK.

Boreman, J. 1993. The technical working group for re-settlement of the Hudson River Power Case. Annual Meeting, Estuarine Research Federation, Hilton Head, SC.

Boreman, J. 1994. Sensitivity of North American sturgeon and paddlefish populations to fishing mortality. International Symposium on Sturgeon Biodiversity and Conservation, New York, NY.

Boreman, J., and R.I. Fletcher. 1994. Using egg survey data to determine spawning patterns of fishes. 124th Annual Meeting of the American Fisheries Society, Halifax, NS.

Boreman, J. 1995. Pollution versus overfishing: finding a cause for declining abundance of fish. Conference on Pollution and Fisheries, Baltimore, MD.

Boreman, J. 1996. Challenges and opportunities in natural resources research, education, and management in the 21st century. Department of Forestry and Wildlife Management, University of Massachusetts, Amherst, MA.

Brady, S., and **J. Boreman**. 1996. Bycatch of sea turtles in the longline fishery off the northeast US coast. Special Symposium on Fishery Bycatch, Annual Meeting, American Fisheries Society, Dearborn, MI.

Grogan, C., and **J. Boreman**. 1996. Determining the probability that historical fish populations are extirpated. Southern New England Chapter, American Fisheries Society, Storrs, CT.

Boreman, J. 1999. Surplus production is a myth. Electric Power Research Institute, Atlanta, Georgia.

Boreman, J., and K. Friedland. 2001. Relative sensitivity of American shad to fishing mortality. International Shad Symposium, Baltimore, MD.

<u>Workshop and Symposium Involvement (last 20 yr):</u>

1987	Development of valid stock abundance indices for white perch in the Choptank and York rivers. CBSAC Working Group on Data Set Identification and Interpretation. Annapolis, MD (Organizer and Chair).
1987	Role of Dominant Year Classes in Fishery Science and Management. Special Marine Fisheries Section Session, Annual Meeting, Northeastern Division, AFS, Boston, MA (Organizer and Moderator).
1988	Use of historical data sets to determine causes of variability and long-term trends in the abundance of white perch in the York and Choptank rivers. CBSAC Working Group on Data Set Identification and Interpretation. Pennsylvania State University, State College, PA (Organizer and Chair).
1991	Fisheries Management: Dealing with Development in the Watershed. Northeastern Division AFS Symposium, Newport, RI (Chair, Program Committee).
1992	Workshop on Atlantic Sturgeon in the Hudson River. Hudson River Foundation, New York, NY (Chair)
1994	Workshop on American shad in the Hudson River. Hudson River Foundation, New York, NY (Chair)
1994	Workshop on Atlantic mackerel research in the Northeast US. NMFS, Gloucester, MA (Co-chair)
1995	Workshop on bay anchovy in the Hudson River. Hudson River Foundation, New York, NY (Chair)
1996	Special Session on Northwest Atlantic Groundfish, NE Fish and Wildlife Conference, Farmington, CT (Organizer and Moderator)
2003	Large Scale Fishery Independent Surveys: Looking to the Future by Learning from the Past (In Planning), 2003 Annual Meeting of the American Fisheries Society (Chair)
2003	NOAA Fisheries Training Workshop, Boulder, Colorado (Co-chair)

<u>Publications (last 20 yr):</u>

Boreman, J., and R. Lewis. 1987. Atlantic coastal migration of striped bass. American Fisheries Society Symposium 1:331-339.

Boreman, J., and C.P. Goodyear. 1988. Entrainment impact estimates for seven fish species inhabiting the Hudson River estuary. American Fisheries Society Monograph 4: 152-160.

Barnthouse, L.W., **J. Boreman**, T.L. Englert, W.L. Kirk, and E.G. Horn. 1988. The Hudson River settlement agreement: technical rationale and cost considerations. American Fisheries Society Monograph 4: 267-273.

Boreman, J., and R.J. Klauda. 1988. Distributions of entrainable life stages of striped bass in the Hudson River, 1974-1979. American Fisheries Society Monograph 4: 53-58.

Englert, T.L., and **J. Boreman**. 1988. Historical review of entrainment impact estimates and the factors influencing them. American Fisheries Society Monograph 4: 143-151.

Englert, T.L., **J. Boreman**, and H.Y. Chen. 1988. Plant flow reductions and outages as mitigative measures. American Fisheries Society Monograph 4: 274-279.

Austin, H. A., E. Barth, C. Bonzek, **J. Boreman**, R. Hennemuth, E. Houde, M. Nammack, M. Prager, L. Rugolo, and C. Stagg. 1988. Chesapeake Bay Stock Assessment Plan. Report of the Chesapeake Bay Stock Assessment Committee to the Chesapeake Bay Program Living Resources Subcommittee. 59pp.

Barth, E., N. Bolgiano, **J. Boreman**, M. Boswell, J. Colvocoresses, G. P. Patil, M. Prager, and L. Rugolo. 1988. Use of historical data sets to determine causes of variability and long-term trends in the abundance of white perch in the York and Choptank rivers. Report of the Working Group on Data Set Identification and Interpretation, Chesapeake Bay Stock Assessment Committee.

Boreman, J. 1989. Fisheries research in the Hudson River (Book Review). Transactions of the American Fisheries Society 117: 517-518.

Boreman, J. 1990. Equating ichthyoplankton mortality to fishing opportunity foregone. Proceedings of a Workshop on Navigation Impacts to Ichthyoplankton. U.S. Fish and Wildlife Service, LaCrosse, Wisconsin.

Boreman, J. 1991. Improving habitat quality vs reducing fishing mortality to restore depleted populations of winter flounder. Report to the Atlantic States Marine Fisheries Commission, Winter Flounder Scientific and Statistical Committee. 17pp.

Brady, S., and **J. Boreman**. 1992. Preliminary review of data bases of sea turtles in the northeastern U.S. Proceedings of the Annual International Sea Turtle Conference, Jekyll Island, Georgia.

Boreman, J., S.C. Correia, and D.B. Witherell. 1993. Effects of changes in age 0 survival on egg production of winter flounder in Cape Cod Bay. American Fisheries Society Symposium 14:39-45.

Boreman, J., and R.I. Fletcher. 1993. Modelling egg deposition patterns. Bulletin of the Technical Working Group, Hudson River Monitoring Program 1(1):1-8.

Boreman, J. 1994. Fishery-level impacts of changes in survival rates of three estuarine fish species induced by fluxes in habitat quality. Pages 373-378. *In:* K. R. Dyer and R. J. Orth (eds), Proceedings of the Joint ESCA-ERF Estuarine Conference: Changes in Fluxes in Estuaries - Implications from Science to Management. Olsen and Olsen, Fredensborg, Denmark.

Boreman, J. 1996. Why tag fish? Underwater Naturalist 23(2):15-17.

Sprankle, K., **J. Boreman**, and J. B. Hestbeck. 1996. Loss rates for dorsal loop and internal anchor tags applied to striped bass. North American Journal of Fisheries Management (16):461-464.

Boreman, J., E. Casillas, C. W. Fowler, P. N. Logan, M. H. Prager, and W. J. Richards. 1996. The large marine ecosystem program: a review of the program's concept, application, and future in the National Marine Fisheries Service. Report prepared for the Science Board of the National Marine Fisheries Service. 16pp.

Boreman, J. 1997. Sensitivity of North American sturgeon and paddlefish populations to fishing mortality. Environmental Biology of Fishes 48:399-405.

Boreman, J., B. S. Nakashima, H. W. Powles, J. A. Wilson, and R. L. Kendall, editors. 1997. Northwest Atlantic groundfish: perspectives on a fishery collapse. American Fisheries Society, Bethesda, Maryland.

Boreman, J. 1997. Methods for comparing the impacts of pollution and fishing on fish populations. Transactions of the American Fisheries Society 126:506-513.

Boreman, J. 1997. The relationship between minimum size limit and reproductive potential of Atlantic sturgeon. Working Paper, Atlantic Sturgeon Technical Committee, Atlantic States Marine Fisheries Commission, Washington, DC. 5pp.

Boreman, J. 1997. Back to the future: estimating the virgin stock biomass of Atlantic sturgeon. Working Paper, Atlantic Sturgeon Technical Committee, ASMFC, Washington, DC. 9pp.

Boreman, J. 1997. Determining the effects of habitat impacts on fish populations. Pages 116-120 *in* C. D. Stephan and K. Beidler (editors). Management of Atlantic coastal marine habitat: proceedings of a workshop for habitat managers. Atlantic States Marine Fisheries Commission, Washington, DC.

Grogan, C. S., and **J. Boreman**. 1998. Estimating the probability that historical populations of fish species are extirpated. North American Journal of Fisheries Management 18:522-529 *(runner-up for best journal paper of the year*).

Everly, A. W., and **J. Boreman**. 1999. Habitat requirements of important fish species inhabiting the Hudson River estuary: availability of information. NOAA Technical Memorandum NMFS-NE-121.

Boreman, J. 2000. Surplus production, compensation, and impact assessments of power plants. Environmental Science and Policy 3 (2000):S445-S449.

Boreman, J., and K. Friedland. 2003. Sensitivity of American shad to changes in fishing mortality. American Fisheries Society Symposium 35:267-273.

<u>Dr. Brandon R. Southall (PI) :</u>

National Oceanic and Atmospheric Administration (NOAA) Acoustics Program, Director
National Marine Fisheries Service (NMFS)
Office of Science and Technology
1315 East-West Hwy, SSMC3 13754
Silver Spring, MD 20910
phone: 301-713-2322 cell: 301-580-4062 fax: 301-713-0376
email: Brandon.Southall@noaa.gov

Experience Relevant to Proposed Research:

Dr. Brandon Southall has extensive experience in marine mammal bioacoustics with both animals in the field and in controlled laboratory conditions. He has conducted controlled sound exposure studies both in air and underwater with individuals from three pinniped species in the context of auditory masking and temporary threshold shift, and has published numerous papers on these topics. His expertise in experimental design, the importance of careful controls, and technical aspects of stimulus characterization will be useful in the current BRS experiments. He has also conducted extensive research on nominal ambient noise conditions and variability in acoustic communication with breeding northern elephant seals, as well as various aspects of underwater acoustic communication in these species. He authored an invited paper in a special issue of the journal Aquatic Mammals in which the field and laboratory data were integrated to make quantitative predictions of signal detection ranges for various northern elephant seal vocalizations in changing environmental background noise. He has participated in similar behavioral response studies involving controlled playbacks of conspecific acoustic stimuli to adult northern elephant seals. These playbacks required many of the same scientific considerations and technical aspects (e.g., stimulus calibration, rating assessment of behavioral responses, handling relevant environmental variables) that will be required of the proposed BRS experiments involving sound playbacks to cetaceans, albeit in different conditions.

Education:

Doctor of Philosophy (Ocean Sciences), 2002. University of California, Santa Cruz, Dr. R. J. Schusterman, mentor.

Master of Science (Marine Science), 1998. University of California, Santa Cruz,

Bachelor of Arts (Environmental Biology); Bachelor of Arts (English), 1994. University of Montana

(Magna cum laude)

Professional Experience:

- **Director, NOAA Ocean Acoustics Program**, 2004-present. Directed science funding and activities of NOAA's Ocean Acoustics Program. Provided technical expertise in the context of science and management activities within NOAA. Represented NOAA as program manager within National Ocean Partnership Program (NOPP), Inter-agency Coordinating Group on Ocean Noise, and within Inter-agency panel convened by the U.S. State Department. Served as lead author for in-review marine mammal noise exposure criteria and as an advisor to the regulatory side of NOAA in implementing science-based changes to the exposure threshold criteria for determining effects of sound on marine life.
- **Fisheries Biologist/Science Advisor**, 2003-2004. NOAA Ocean Acoustics Program. Provided technical expertise to the NMFS Office of Protected Resources in acoustics. This includes assisting in the development of acoustic exposure guidelines for marine mammals, planning and executing an international conference on shipping noise, organizing a nation-wide educational lecture series on marine mammals and noise, and providing technical analysis of acoustic data in assisting protected species management.
- **Research Associate**, 2003-present. Institute of Marine Sciences, University of California, Santa Cruz. On-going laboratory and field research on hearing and noise impacts in marine mammals involving developing new techniques for understanding noise masking of acoustic communication. Involvement in sound playback studies with northern elephant seals focused on the importance of signal directionality and other variables in determining response probability. Involvement in extensive measurements of background ambient noise levels.
- **Post-Doctoral Researcher**, 2002-2003. Pinniped Cognition and Sensory Systems Laboratory, Long Marine Laboratory, University of California, Santa Cruz. Laboratory research on pinniped hearing including auditory

fatigue, aerial auditory masking, sound localization, and age-related hearing loss as well as field studies of acoustic communication in three pinniped species [California sea lion (*Zalophus californianus*), northern elephant seal (*Mirounga angustirostris*), and harbor seal (*Phoca vitulina*)]. Preparation of technical manuscripts, grants, annual reports, public statements, and formal presentations of findings at international conferences.

- **Research and Fisheries Biology Consultant**, 2002. New England Aquarium: provided guidance on technical and procedural aspects of ongoing masked hearing studies with a green sea turtle. Monterey Bay Aquarium: completed fisheries reports on three marlin species for the Seafood Watch program, which involved reviewing stock assessments, landing records, and scientific literature on biology and life history patterns to generate species-specific recommendations for consumer guides designed to support sustainable fisheries.
- **Graduate Student Researcher**, 1996-2002. Pinniped Cognition and Sensory Systems Laboratory. Conducted audiometric research in a variety of areas including absolute aerial and underwater hearing, underwater auditory masking, and auditory fatigue. Participated in pinniped cognition research as well as animal training and husbandry for each of three pinniped species. Additionally, conducted bioacoustic research on northern elephant seals at Año Nuevo State Reserve, including determining vocalization source levels, measuring natural ambient noise levels, and assessing context-specific variability in various vocalization parameters.
- **Principal Investigator**, Bioacoustic Research Project, 1994-1995. Dolphin Research Center, Grassy Key, Florida. Research on vocal mimicry and trauma-induced hearing loss in California sea lions.

Publications (Peer-Reviewed):

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. Greene Jr., D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. (In review). Marine mammal noise exposure criteria: single exposures and single individuals. Target Journal: Journal of the Acoustical Society of America.

Southall, B. L., R. Braun, F. M. D. Gulland, A. D. Heard, R. W. Baird, S. M.,Wilkin and T.K. Rowles. (**2006**). Hawaiian melon-headed whale (*Peponocephala electra*) mass stranding event of July 3-4, 2004. NOAA Technical Memorandum NMFS-OPR-31, 73 pp.

Hohn, A.A., D. S. Rotstein, C. A Harms, and **B. L. Southall**. (**2006**). Report on marine mammal unusual mortality event UMESE0501Sp: Multispecies mass stranding of pilot whales (*Globicephala macrorhynchus*), minke whale (*Balaenoptera acutorostrata*), and dwarf sperm whales (*Kogia sima*) in North Carolina on 15-16 January 2005. NOAA Technical Memorandum NMFS-SEFSC-537, 222 p.

Holt, M. M., R. J. Schusterman, D. Kastak, and **B. L. Southall**. (**2005**). Localization of aerial pure tones by pinnipeds. Journal of the Acoustical Society of America **118**, 3921-3926.

Kastak, D., **B. L. Southall**, R. J. Schusterman, and C. Reichmuth Kastak. (**2005**). Underwater temporary threshold shift in pinnipeds: Effects of noise duration and intensity. Journal of the Acoustical Society of America **118**, 3154-3163.

Southall, B. L., R. J. Schusterman, D. Kastak, and C. R. Kastak. (**2005**). Reliability of underwater hearing thresholds in pinnipeds. Acoustics Research Letters Online **6**, 243-249.

Southall, B. L. and L. Johnson. (**2005**). Review of: International regulation of underwater sound: establishing rules and standards to address ocean noise pollution. Marine Technology Society Journal **38**, 34-36.

Hayes, S. A., A. Kumar, D. P. Costa, D. Mellinger, J. Harvey, **B. L. Southall**, and B. J. Le Boeuf. **(2004)**. Evaluating the function of the male harbour seal (*Phoca vitulina*) roar through playback experiments. Animal Behaviour **67**, 1133-1139.

Holt, M. M., R. J. Schusterman, **B. L. Southall**, and D. Kastak. (**2004**). Localization of aerial broadband noise by pinnipeds. Journal of the Acoustical Society of America **115**.

Southall, B. L. R. J. Schusterman, and D. Kastak. **(2003)**. Auditory masking in three pinnipeds: aerial critical ratios and direct critical bandwidth measurements. Journal of the Acoustical Society of America **114**, 1660-1666.

Southall, B. L. R. J. Schusterman, and D. Kastak. **(2003)**. Acoustic communication ranges for northern elephant seals. Aquatic Mammals **29**, 202-213.

Schusterman, R. J., D. Kastak,, D. H. Levenson,, C. J. Reichmuth, and **B. L. Southall**. (**2003**). Pinniped sensory systems and the echolocation issue," in Echolocation in bats and dolphins, J.A. Thomas, C. Moss, M. Vater (eds.) (University of Chicago Press, Chicago).

Southall, B. L. (**2002**). Northern elephant seal field bioacoustics and aerial masked hearing thresholds in three pinnipeds. Ph.D. Thesis, University of California at Santa Cruz.

Southall, K. D., G. W. Oliver, J. W. Lewis, B. J. Le Boeuf, D. H. Levenson, and **B. L. Southall**. (**2002**). Visual pigment sensitivity in three deep diving marine mammals. Marine Mammal Science **18**.

Schusterman, R.J., **B. L. Southall**, D. Kastak, and C. Reichmuth Kastak. (**2001**). Pinniped vocal communication: Form and function. *Proceedings of the 17th International Congress on Acoustics, Volume IV*. September 2-7, Rome, Italy.

Southall, B. L., R. J. Schusterman, and D. Kastak. (**2000**). Masking in three pinnipeds: underwater low frequency critical ratios. Journal of the Acoustical Society of America **108**, 1322-1326.

Schusterman, R. J., D. Kastak, D. H. Levenson, C. J. Reichmuth, and **B. L. Southall**. (**2000**). Why pinnipeds don't echolocate. Journal of the Acoustical Society of America.

Kastak, D., R. J. Schusterman, **B. L. Southall**, and C. J. Reichmuth. (**1999**). Underwater temporary threshold shift in three species of pinniped. Journal of the Acoustical Society of America **106**, 1142-1148.

Southall, B. L. (**1998**). Low frequency auditory masking in three pinniped species. M.Sc. Thesis, University of California at Santa Cruz.

<u>Publications (Reports, Proceedings, and Memoranda):</u>

Southall, B. L. and Gentry, R. L. (**2005**). NOAA's Ocean Acoustics Program: Supporting Science, Management, and Public Education. Proceedings of the IEEE/MTS Oceans 2005 Conference (**050304-98**).

Southall, B. L. (**2005**). Final report of the 2004 International Symposium "Shipping Noise and Marine Mammals: A Forum for Science, Technology, and Management." National Marine Fisheries Service, Office of Protected Resources, Technical Report.

<u>Relevant Technical Presentations:</u>

Southall, B. L., D. Kastak, C. R. Kastak, S. J. Insley, M. M. Holt, J. Mulsow, and R. J. Schusterman. (**2006**). Sound production and detection by pinnipeds. *151st Meeting of Acoustical Society of America* (Invited Lecture). 5-9 June, Providence, RI, U.S. J. Acoust. Soc. Amer. 119(5, pt. 2), 3403.

Southall, B. L. (**2005**). Sound in the marine environment: physics, acoustic communication, and the effects of human noise on marine animals. National Marine Mammal Stranding Network Conference (Invited Lecture). 3-7 April, Landsdowne, VA.

Southall, B. L. and Gentry, R. L. (**2005**). NOAA's Ocean Acoustics Program: Supporting Science, Management, and Public Education. Proceedings of the IEEE/MTS Oceans 2005 Conference.

Holt, M. M., S. J. Insley, **B. L. Southall**, and R. J. Schusterman**. (2005**). Methodological considerations of acoustic playbacks to test the behavioral significance of call directionality in male northern elephant seals (*Mirounga angustirostris*). *150th Meeting of Acoustical Society of America*. 17-21 Oct, Minneapolis, MN, USA. J. Acoust. Soc. Amer. **118**, 1907.

Holt, M. M., R. J. Schusterman, S. J. Insley, and **B. L. Southall. (2005**). Behavioral and playback investigations of call directionality in male northern elephant seals. *16th Biennial Conference on the Biology of Marine Mammals*. 12-16 December, San Diego, CA, USA.

Kastak, D., R. J. Schusterman, **B. L. Southall**, M. M. Holt, and C. R. Kastak. (**2005**). Animal behavioral psychoacoustics: Issues related to methodology and interpretation. *149th Meeting of Acoustical Society of America*. 16-20 May, Vancouver, BC, Canada. J. Acoust. Soc. Amer. **117**, 2583.

Miller, J. H., A. E. Bowles, R. L. Gentry, W. T. Ellison, J. J. Finneran, C. R. Greene, D. Kastak, D. R. Ketten, P. E. Nachtigall, W. J. Richardson, **B. L. Southall**, J. A. Thomas, and P. L. Tyack. (**2005**). Strategies for weighting exposure in the development of acoustic criteria for marine mammals. *150th Meeting of Acoustical Society of America*. 17-21 Oct, Minneapolis, MN, USA. J. Acoust. Soc. Amer. **118**, 2019.

Southall, B. L., R. J. Schusterman, D. Kastak, and C. R. Kastak. (**2004**). Underwater hearing thresholds in pinnipeds measured over a 6-year period. *148th Meeting of Acoustical Society of America* (Invited Lecture). 15-19 November, San Diego, CA, U.S. J. Acoust. Soc. Amer. 116(4), 2504.

Southall, B. L., R. J. Schusterman, D. Kastak, C. R. Kastak, and M. Holt (**2004**). Pinniped bioacoustics: Atmospheric and hydrospheric signal production, reception, and function. *147th Meeting of Acoustical Society of America* (Invited Lecture). May 24-28, New York, New York, U.S. J. Acoust. Soc. Amer. 115(5), 2405.

Kastak, D., **B. L. Southall**, M. M. Holt, C. R. Kastak, and R. J. Schusterman. (**2004**). Noise-induced temporary threshold shift in pinnipeds: Effects of noise energy. *148th Meeting of Acoustical Society of America*. 15-19 November, San Diego, CA, U.S. J. Acoust. Soc. Amer. 116(4), 2531-2532.

Southall, B. L. and R. J. Schusterman. (**2003**). Vocal individuality and conditioned emotional responses in pinniped communication. 1st International Conference on Acoustic Communication by Animals (Invited Lecture). 27-30 July, University of Maryland, College Park, Maryland.

Schusterman, R. J., D. Kastak, **B. L. Southall**, C. Reichmuth Kastak, M. M. Holt. (**2003**). Noise induced temporary threshold shift in pinnipeds: effects of exposure medium, intermittence, duration, and intensity. *Symposium on Environmental Consequences of Underwater Sound*, May 12-16, San Antonio, Texas.

Southall, B. L., R. J. Schusterman, D. Kastak, and C. Reichmuth Kastak. (**2001**). Pinniped hearing and anthropogenic noise. *142nd Meeting of the Acoustical Society of America* (Invited Lecture). December 3-7, Ft. Lauderdale, Florida, Journal of the Acoustical Society of America **110** (5, pt. 2): 2722

Southall, B. L. , R. J. Schusterman, and D. Kastak. (**2001**). Noise constraints on pinniped vocal communication: Integrating source level, ambient noise, and audiometric data. *14th Biennial Conference on the Biology of Marine Mammals* (Invited Lecture). November 28-December 3, Vancouver, British Columbia, Canada. p. 202.

Schusterman, R .J., **B. L. Southall**, D. Kastak, and C. Reichmuth Kastak. (**2001**). Acoustic communication in pinnipeds. In: *Advances in Ethology: Contributions to the XXVII International Congress on Acoustics, August 22-29,* Tubingen, Germany. Blackwell Sciences, Berlin. Page 261.

Schusterman, R. J., D. Kastak, **B. L. Southall**, and C. Kastak. (**2000**). Underwater temporary threshold shifts in pinnipeds: Tradeoffs between noise intensity and duration. *140th Meeting of the Acoustical Society of America*, December 3-8, Newport Beach, California, Journal of the Acoustical Society of America **108** (5, pt. 2): 2515.

Southall, B. L., D. Kastak, R. J. Schusterman, C. J. Reichmuth, and J. W. Grayson. (**1999**). Underwater temporary threshold shift in pinnipeds: the effects of moderate noise levels. *13th Biennial Conference on the Biology of Marine Mammals*, November 28-December 3, Wailea, Hawaii. p. 176.

Schusterman, R. J., D. Kastak, D. H. Levenson, C. J. Reichmuth, and **B. L. Southall**. (**1999**). Why pinnipeds don't echolocate. *13th Biennial Conference on the Biology of Marine Mammals*, November 28-December 3, Wailea, Hawaii. p. 168.

Holt, M. M., R. J. Schusterman, D. Kastak, and **B. L. Southall**. (**1999**). Pinniped acoustical psychophysics: individual strategies. *13th Biennial Conference on the Biology of Marine Mammals*, November 28-December 3, Wailea, Hawaii. p. 84.

Hayes, S. A., A. Kumar, D. P. Costa, **B. L. Southall**, J. T. Harvey, B. J. Le Boeuf, and D. K. Mellinger. (**1999**). I am harbor seal, hear me roar; a playback experiment. *13th Biennial Conference on the Biology of Marine Mammals*, November 28-December 3, Wailea, Hawaii. p. 79.

Kastak, D., **B. L. Southall**, R. J. Schusterman, and C. J. Reichmuth. (**1999**). Temporary threshold shift in pinnipeds induced by octave-band noise in water. *138th Meeting of the Acoustical Society of America*, November, 1-5, Columbus, Ohio, Journal of the Acoustical Society of America **106** (4, pt. 2): 2251.

Southall, B. L., R. J. Schusterman, and D. Kastak. (**1998**). Low frequency masked hearing thresholds in two pinniped species. *World Marine Mammal Conference*, January 20-25, Monaco. p. 127.

Schusterman, R. J., D. Kastak, D. H. Levenson, and **B. L. Southall**. (**1997**). Pinniped behavioral psychophysics: visual sensitivity, auditory TTS and masking. *Symposium on Information Processing by Aquatic Mammals*, April 6-11, Vallejo, California.

Southall, B. L. and K. Krieger. (**1994**). Bioacoustic analysis of vocalizations of the California sea lion. *International Marine Animal Trainers Association*, November, 6-11, Tacoma, WA.

Professional Associations:

Society for Marine Mammalogy, 1996-present.
Animal Behavior Society, 1995-2003.
Acoustical Society of America, 1995-present.
American Institute of Physics, 1995-present.

Honors:

- National Oceanic and Atmospheric Administration, Bronze Medal 2005
  For the development of explicit, science-based acoustic exposure criteria to assess the effects of noise on marine mammals.
- **GAANN full-tuition fellowships** 2000-2001, 2001-2002

Ocean Sciences Department, University of California, Santa Cruz

- **Outstanding Student Achievement Award**, 1997-1998
  Outstanding student in the Ocean Sciences Department, University of California, Santa Cruz
- **University Regents Academic Fellowships**, 1996-1998 (Three semesters total)
  University of California, Santa Cruz
- **James W. Gebhart Award**, 1993
  Outstanding student in science education and conservation in the Departments of Biology and Environmental Sciences, University of Montana
- **University Scholar Presidential Recognition Award**, 1993
  Outstanding senior in the Division of Natural Sciences, given by the Office of the President of the University of Montana
- **Outstanding Citizenship Award**, 1989
  Middlesex county (MA) Department of Public Service

External Grants:

Friends of Long Marine Laboratory, Graduate Student Research Grants, 1997, 1998, 1999, 2000, 2001 ($2050 total)
University of California, Santa Cruz Department of Ocean Sciences Graduate Student Research and Travel Funds, 1997, 1998, 1999, 2000 ($850 total)
Dept. of Defense Augmentation Awards for Science and Engineering Research Training (Dr. R.J. Schusterman, PI), FY 1998
American Cetacean Society, 1997 ($500)
Earl and Ethel Myers Oceanographic Trust, 1996, 1997 ($1,750)

Professional Activities and Services:

Member, Sound External Advisory Panel, Joint Industry Research Programme – 2006 to present
Invited expert panelist – International workshop on sound in the marine environment. Organized by the International Association of Oil and Gas Producers.
Organized NOAA Fisheries National Acoustics Lecture Series on Marine Mammals and Noise – 2004 to present.
Invited expert panelist – National Marine Fisheries Service Noise Standards Panel, 25-27 March, 2003.
Invited lectures: 2004 Annual Meeting of the Working Group on Marine Mammal Unusual Mortality Events; 2002 Biology Colloquium series at Sonoma State University; 2002 Seymour Center Lecture Series, Long Marine Laboratory; 2002 Biology Department Lecture Series, University of Massachusetts; 2002 Ano Nuevo State Reserve; 1998 New England Aquarium; 1998 American Cetacean Society, Monterey, California.

Dr. Ian Boyd (Chief Scientist):

Experience Relevant to Proposed Research:

Dr. Ian Boyd is a biologist who specializes in the study of marine mammals. He is Director of the Sea Mammal Research Unit (SMRU) at the University of St Andrews, UK. This institute is a collaborative centre within the UK Natural Environment Research Council and is responsible for delivering advice on the management of marine mammals to the UK government. Dr. Boyd's research experience is mainly in the reproductive energetics of marine mammals but he has a broader background also in the study of mammalian reproductive ecology. He spent 14 years leading one of the UK research programs in Antarctica before becoming Director at SMRU. His research interests mainly lie in using marine top predators like marine mammals as indicators of marine ecosystem variability. He has conducted a broad range of experimental research on marine mammals including the instrumentation of animals to measure acoustic background noise and vocalizations and behavioral responses to environmental variability. He has also been the lead PI of studies using passive acoustics to measure cetacean abundance. Dr Boyd has received a number of awards for his research leadership, including the Scientific Medal from the Zoological Society of London and the Bruce Medal for polar research. He is a fellow of the Royal Society of Edinburgh which is the Scottish national academy of science.

Current Post:	Professor of Biology Director, NERC Sea Mammal Research Unit
Address:	SMRU, Gatty Marine Laboratory, University of St Andrews, St Andrews KY16 8LB
Education:	1979 B.Sc., (First Class Honours) in Zoology, University of Aberdeen. 1982 Ph.D., Cambridge University (St John's College). 1995 D.Sc., University of Aberdeen.

Previous Appointments:

2001 – present	Director, NERC Sea Mammal Research Unit
2001 – present	Professor of Biology, University of St Andrews
1998 - 2001	Science Programme Director , British Antarctic Survey
1987 – 2001	Senior Principal Scientific Officer, British Antarctic Survey. Promotion UG7 1991. Merit Promotion UG6 1996.
1982 – 1987	Physiological ecologist, Institute of Terrestrial Ecology, Monks Wood, Huntingdon. Promotion HSO to SSO 1986.
1979 – 1982	NERC Research Studentship at Department of Anatomy, Cambridge University and Sea Mammal Research Unit (NERC)

Honorary Professorships:

1997-present Honorary Professor, University of Birmingham (Lecturer 1993; Senior Lecturer 1995)

Medals/Awards:

2006	Marshall Award for Freshwater and Marine Conservation, Zoological Society of London
2002	Elected Fellow of the Royal Society of Edinburgh (Scotland's National Academy)
1998	Scientific Medal, Zoological Society of London
1995	Bruce Medal for Polar Science, Royal Society of Edinburgh.
1995	Antarctic Service Medal of the United States.
1980	Churchill Fellowship

Subsidiary appointments (since 2001 only):

1999 - present	Editor-in-chief, Journal of Zoology
2005 – present	Board of Directors, NERC Marine Science
2003 – present	MoD/NERC Co-operative Arrangement for Research in Ocean Science (CAROS)
2005 – present	Steering Committee, National Centre for Statistical Ecology
2005 – present	Chairman, Marine Science Scotland, Steering Group
2005 – present	Chairman, European Science Foundation, International working group on marine mammals and noise

2003	Member, RSE Enquiry Into the Future of the Scottish Fishing Industry
2002 – present	Member, Scottish Seals Working Group
1993 – present	UK Special Committee on Seals (NERC)

Research Track Record:
Manages a NERC Collaborative Centre that is embedded within a University. Consequently; not involved directly in research but manages a large portfolio of research that is carried out by others producing about 30-50 scientific papers per year plus substantial direct advice to government under the terms of the Conservation of Seals Act 1970. Personal research is directed toward understanding how top predators in marine ecosystems reflect the underlying structure and dynamics of the ecosystem. This is summarised by an edited book about to be published:

Boyd, I.L., Wanless, S. and Camphuysen, C.J. 2006. Top predators in marine ecosystems. Cambridge University Press, Cambridge.

Dr. Boyd has published 127 ISI listed publications and 8 books.

Staff and facilities managed:
SMRU is composed of 48 staff and 20 PhD students. It has 4 Professors and 3 Royal Society Post-doctoral researchers and a further 9 principal scientists. It has its main labs at the Gatty Marine Laboratory in St Andrews and a subsidiary office in Plymouth. The lab in St Andrews has a purpose-built facility for experimental studies on captive marine mammals.

Knowledge transfer activities:
Dr. Boyd edits the annual advice to the UK government on the management of seal populations; creating a spin-out company (SMRU Ltd) to expand the near-market activities of SMRU and he is a leader in a project to provide the Royal Navy with an environmental risk management tool for use on all UK warships and aircraft.

Recent selected papers:
Boyd, I.L. & Murray, A.W.A. (2001). Monitoring a marine ecosystem using responses of upper trophic level predators. Journal of Animal Ecology 70, 747-760.
Boyd, I.L. (2002) Estimating food consumption of marine predators: Antarctic fur seals and macaroni penguins. Journal of Applied Ecology 39, 103-119.
Boyd, I.L., Staniland, I.J. & Martin A.R. (2002) Spatial distribution of foraging by female Antarctic fur seals. Marine Ecology Progress Series. 242, 285-294.
Mori, Y & **Boyd, I.L.** (2004) The behavioural basis for non-linear functional responses: the case of the Antarctic fur seal. Ecology 85, 398-410.
Dall, S.R.X. & **Boyd, I.L.** (2004) Lactation helps mothers to cope with unreliable food supply. Procedings of the Royal Society of London B. 271, 2049-2057
Hooker, S.K., Miller, P.J.O., Johnson, M.P., Cox, O.P. & **Boyd, I.L**. (2005) Ascent exhalation in diving Antarctic fur seals. Proceedings of the Royal Society of London B. 272, 355-363.

Recent books:
Boyd, I.L., Wanless, S. & Camphuysen, K. (2006) Top predators in marine ecosystems: their role in monitoring and management. Cambridge University Press, Cambridge.

Updated: 04/06/07

Dr. Christopher W. Clark:

Cornell University
Laboratory of Ornithology
159 Sapsucker Woods Road Ph: 607-254-2408 .
Ithaca, New York 14850 E-mail:cwc2@cornell.edu

Experience Relevant to Proposed Research:

Dr. Christopher Clark is the I. P. Johnson Director of the Bioacoustics Research Program at the Cornell Laboratory of Ornithology and Senior Scientist in the Department of Neurobiology & Behavior at Cornell University. Dr. Clark's research concentrates on animal acoustic communication with a particular focus on the development and application of advanced acoustic methods for scientific conservation of endangered species. He leads the Bioacoustics Research Program in the design, development and application of computer-based systems for quantitative analysis of animal vocalizations, and acoustic techniques to detect, locate, track and census free-ranging animals. Through ongoing collaborations with U.S. and international colleagues Dr. Clark conducts integrated research at a variety of spatial and temporal scales to investigate the influence of ecological, environmental and anthropogenic factors on animal acoustic behavior.

In 1977, Dr. Clark conducted the first successful playback experiments with baleen whales off southern Argentina, and has continued to conduct marine bioacoustic field research on a variety of large cetaceans in different oceans. In 1983-1985 he was co-principle investigator with Dr. Peter Tyack on the first studies quantifying migrating grey whale and feeding humpback whale responses to playback of industrial sounds. In 1997-98 he was permit holder and a principle investigator with Dr. Peter Tyack during the Surveillance Towed Array Sensor System low frequency active scientific research program investigating the responses of baleen whales to LF playbacks off southern California, central California and Hawaii. Since 2000, he has led the ongoing and near-continuous research efforts to apply passive acoustic methods for detection of northern right whales off New England and in mid-Atlantic waters.

Scientists in the Bioacoustics Research Program (see http://www.birds.cornell.edu/brp/) conduct a multitude of basic scientific and applied research projects around the globe (Africa, Australia, Europe, North America, Central America, South America; Arctic, Atlantic, Pacific, and Southern Oceans) on a diversity of marine species and taxonomic groups. These efforts are directed at understanding the hows and whys of animal acoustic communication, often with a special focus on determining the impacts of human noise-generating activities on individuals and populations over large spatial and temporal scales. Such ambitious undertakings are enabled by a suite of customized data collection and analysis systems. Sound recording devices and analyses software, designed and fabricated by the Program's teams of hardware and software engineers, allow collection of acoustic recordings from marine environments for many months and the analysis of very large data sets.

Present Position:

Imogene P. Johnson Director, Bioacoustics Research Program, Cornell Laboratory of Ornithology
Senior Scientist Department of Neurobiology and Behavior, Cornell University.

Education and Employment:

State Univ. of New York, Stony Brook	B.Sc.	1972	Biology
State Univ. of New York, Stony Brook	B.E.	1972	Engineering
State Univ. of New York, Stony Brook	M.S.	1974	Electrical Engineering
State Univ. of New York, Stony Brook	Ph.D.	1980	Biology
The Rockefeller University, NY, NY	Post. Doc.	1981-83	Bio/Anim. Comm.
The Rockefeller University, NY, NY	Asst. Prof.	1983-87	Bio/Anim. Comm

Professional Societies:

Acoustic Society of America Fellow, Animal Behavior Society, AAAS, IEEE
Society for Marine Mammalogy, Sigma Xi, Tau Beta Pi, Explorers' Club

Professional Appointments:

Member, U. S. delegation to the International Whaling Commission's Scientific Committee, since 1985
Member, NRC Committee on Environmental Impacts of Wind Energy Projects, since 2005

Relevant Research:

1997 - 1999: Responses of baleen whales to experimental playback of low-frequency sound from the Navy SURTASS LFA. Three-phased project investigating the behavioral responses of free-ranging whales to controlled exposure of the U.S. Navy's Surface Towed Array Surveillance System (SURTASS) Low-Frequency Active (LFA) sound source. Data from the research was utilized in the Navy's EIS and SEIS for the LFA system. DoD

1996 - present: Acoustic monitoring of large whale distributions, behaviors, and movements relative to environmental factors and man-made activities off the British Isles using IUSS assets in the North Atlantic. Joint Nature Conservation Commission, UK and DoD.

1999 - present: Design, implement, and distribute the Raven software instrument package for bioacoustics. NSF.

1999 - present: New directions in the study of low-frequency sound in baleen whales. Conducted multi-modal research using an integrated approach (genetic biopsy, passive acoustic, photo-ID, active acoustic, oceanographic sampling) to investigate relationships between ecological and environmental factors on whale behavior. ONR

2001- present: Marine Mammal Detection and Mitigation System. Design, build and field test a passive acoustic system to detect and identify marine mammals. STTR Phase II in collaboration with Scientific Solutions, Inc.

2002 - present: Application of passive acoustic methods for detection of northern right whales off New England and in mid-Atlantic waters: Numbers and Distributions. Collaborative research with Dr. Stormy Mayo and Dr. Moe Brown integrating physical oceanographic and biological productivity measures; aerial survey, genetic and photo-ID data; and acoustic detections, locations and tracks of right whale within critical habitat. NOAA, Northeast Consortium, MA Division of Marine Fisheries.

Relevant Publications:

Clark, C.W. 1995. Application of US Navy underwater hydrophone arrays for scientific research on whales. Annex M, **Rep. int. Whal. Commn**. 45:210-212.

Clark, C.W. and Altman, N.S. 2006. Acoustic detections of blue whale (*Balaenoptera musculus*) and fin whale (*B. physalus*) sounds during a SURTASS LFA exercise**. J. Ocean Engr**. 31: 120-128.

Clark, C. W., and Clapham, P. J. 2004. Acoustic monitoring on a humpback whale (*Megaptera novaeangliae*) feeding ground shows continual singing into late Spring. **Proc. Roy. Soc. Lond**., B. 271: 1051-1057.

Clark, C.W. and Ellison, W.T. 2000. Calibration and comparison of the acoustic location methods used during the spring migration of the bowhead whale, *Balaena mysticetus*, off Pt. Barrow, Alaska, 1984-1993. **J. Acoust. Soc. Am**. 107(6):3509-3517.

Clark, C. W. and Ellison, W.T. 2004. Potential use of low-frequency sounds by baleen whales for probing the environment: evidence from models and empirical measurements. In: Echolocation in Bats and Dolphins (eds. J. Thomas, C. Moss and M. Vater). The University of Chicago Press. Pp. 564-582.

Clark, C.W. and Fristrup, K. 1997. Whales '95: A combined visual and acoustic survey of blue and fin whales off southern California. **Rep. int. Whal. Commn**. 47:583-600.

Clark, C.W., Borsani, J.F. and Notarbartolo-di-Sciara, G. 2002. Vocal activity of fin whales, Balaenoptera physalus, in the Ligurian Sea. Mar. Mamm. Science 18(1): 281-285.

Charif, R.A., Clapham, P.J. and Clark, C.W. 2001. Acoustic detections of singing humpback whales in deep waters off the British Isles. **Mar. Mamm. Sci** 17(4):751-768.

Charif, R.A., Mellinger, D.K., Dunsmore, K.J., Fristrup, K.M. and Clark, C.W. 2002. Estimated source levels of fin whale (*Balaenoptera physalus*) vocalizations: adjustments for surface interference. **Mar. Mamm. Sci.** 18(1):81-98.

Charif, R.A., C.W. Clark, and K.M. Fristrup. 2004. Raven 1.2 User's Manual. Cornell Laboratory of Ornithology, Ithaca, NY.

Croll, D.A., Clark, C.W., Calambokidis, J., Ellison, W.T., and Tershy, B.R. 2001. Effect of anthropogenic low-frequency noise on the foraging ecology of Balaenoptera whales. **Animal Conservation** 4:13-27.

Croll, D.A., Clark, C.W., Acevedo, A., Tershy, B., Flores, S., Gedamke, J. and Urban, J. 2002. Only male fin whales sing loud songs. **Nature** 417:809.

Frankel, A.S. and Clark, C.W. 1998. Results of low-frequency m-sequence noise playbacks to humpback whales in Hawai'i. **Can. J. Zool**. 76(3):521-535.

Frankel, A.S. and Clark, C.W. 2000. Behavioral responses of humpback whales (*Megaptera novaeangliae*) to full-scale ATOC signals. **J. Acoust. Soc. Am**. 108 (4):1930-1937.
Frankel, A.S. and Clark, C.W. 2002. ATOC and other factors affecting the distribution and abundance of humpback whales (*Megaptera novaeangliae*) off the coast of the north shore of Kauai. **Mar. Mamm. Sci.** 18 (3): 644-662.
Frankel, A.S., Clark, C.W., Herman, L.M. and Gabriele, C.M. 1995. Spatial distribution, habitat utilization, movements and social interactions of humpback whales, *Megaptera novaeangliae*, off Hawai'i using acoustic and visual techniques. **Can. J. Zool**. 73:1134-1146.
Fristrup, K. and Clark, C.W. 1997. Combining visual and acoustic survey data to enhance density estimation. **Rep. int. Whal. Commn**. 47:933-936.
Fristrup, K.M., Hatch, L.T. and Clark, C. W. 2003. Variation in humpback whale (*Megaptera novaeangliae*) song length in relation to low-frequency sound broadcasts. **J. Acoust. Soc. Am**., 113 (6): 3411-3424.
George, J. C. “Craig”, Zeh, J., Suydam, R., and Clark, C. 2004. Abundance and population trend (1978-2001) of the western Arctic bowhead whales surveyed near Barrow, Alaska. **Mar. Mamm. Sci.** 20:755-773.
Kraus, S., M. W. Brown, H. Caswell, C. W. Clark, M. Fujiwara, P. K. Hamilton, R. D. Kenney, A. R. Knowlton, S. Landry, C. A. Mayo, W. A. McLellan, M. J. Moore, D. P. Nowacek, D. A. Pabst, A. J. Read and R. M. Rolland. 2005. North Atlantic right whales in crisis. **Science** 309:561-562.
Mellinger, D.K. and Clark, C.W. 2000. Recognizing transient low-frequency whale sounds by spectrogram correlation. **J. Acoust. Soc. Am**. 107:3518-3529.
Mellinger, D.K. and Clark, C.W. 1993. A method for filtering bioacoustic transients by spectrogram image convolution. **Proc. IEEE Oceans '93**:122-127.
Potter, J.R., Mellinger, D.K. and Clark, C.W. 1994. Marine mammal call discrimination using artificial neural networks**.** **J. Acoust. Soc. Am**. 96:1255-1262.

Accepted or In Press Papers:

Clark, C.W., and Gagnon, G.C. 2006. Low-frequency vocal behaviors of baleen whales in the North Atlantic: Insights from IUSS detections, locations and tracking from 1992 to 1996. J. Underwater Acoust. (USN), 52 (3) July 2004 (in press).
Clark, C.W., Gillespie, D., Nowacek, D.P., and Parks, S.E. 2006. Listening to Their World: Acoustics for Monitoring and Protecting Right Whales in an Urbanized Ocean. In: The Urban Whale (eds. S. Kraus and R. Rolland). Harvard University Press. (in press).
Mellinger, D. and C.W. Clark. 2006. MobySound: A reference archive for studying automatic recognition of marine mammal sounds. Applied Acoustics (in press).
S. E. Parks and C. W. Clark. 2006. Acoustic Communication: Social sounds and the potential impacts of noise. In: The Urban Whale (eds. S. Kraus and R. Rolland). Harvard University Press. (in press).

Updated: 04/06/07

Dr. Darlene R. Ketten:

Biology Department
Woods Hole Oceanographic Institution
Room 201-205 Shiverick/ MS #36
Woods Hole, Mass. 02543
office: 508-289-2731
fax: 508-457-2028
email: dketten@whoi.edu

Department of Otology & Laryngology
Harvard Medical School
Massachusetts Eye and Ear Infirmary
243 Charles St.
Boston, Mass. 02114
office: 617-573-4083
email: drk@cirl.meei.harvard.edu

Experience Relevant to Proposed Research:

Dr. Darlene R. Ketten is a marine biologist and neuroanatomist specializing in functional analyses and biomedical imaging of sensory systems. Her work is a blend of modern biomedical imaging, forensics, and biophysical models of hearing in both humans and marine mammals.

Dr. Ketten's training includes specialty courses and accreditation in Otopathology (Harvard Medical School, 1987), Neuroradiology (AFIP, 2003), Veterinary Pathology (AFIP, 2005), and Forensic Pathology (AFIP, 1995, 2005). She serves as a specialty lecturer on inner ear imaging, anatomy, and CT/MRI diagnostic imaging for head and neck trauma for the American Medical Association - Head and Neck Surgery courses.

Dr. Ketten's research focuses on two areas: how structural differences in marine vs terrestrial mammal ears relate to physical differences, habitats and feeding behaviors; and how electrode placement and inner ear pathologies impact hearing and the effectiveness of hearing aids and inner ear prostheses.

In the course of her work, Dr. Ketten also employs her forensic training to conduct necropsies and assists with autopsies, particularly those requiring expertise in head and neck trauma, neuropathology, and auditory pathology. To date she has assisted or conducted exams on over 150 species and has been the prosector and author for 159 human clinical case reports and 92 marine mammal case reports. Marine Mammal Case Reports are detailed analyses of gross and microscopic anatomy that include life history information, cause of death, and pathology assessments and are filed with NOAA Fisheries and other governmental agencies.

Education:

l971	B.A.	Washington University Biology and French
l979	M.S.	Massachusetts Institute of Technology, Biological Oceanography
1984	Ph.D.	The Johns Hopkins University The Johns Hopkins Medical Institutions Neuroethology and Experimental Radiology

Professional Appointments:

2002-present	Senior Scientist	Biology Department Woods Hole Oceanographic Institution
1997-2002	Associate Scientist	Biology Department Woods Hole Oceanographic Institution
1993-present	Assistant Professor (joint appt. with WHOI) Research Director	Department of Otology and Laryngology Harvard Medical School Head and Neck Imaging Massachusetts Eye and Ear Infirmary
1988-1993	Instructor	Department of Otology and Laryngology Harvard Medical School
	Research Associate	Cochlear Implant Research Laboratory, Massachusetts Eye and Ear Infirmary

Awards and Fellowships:

2001-present	Fellow, Acoustical Society of America
2001-2004	Fellow, WHOI Ocean Life Institute
2000-2002	Featured Principal Investigator, ONR
1980-1984	NIH Honors Fellowship Award

Professional Memberships:

2004- present	Association of Military Surgeons of the United States (AMSUS)
1996- present	Radiological Society of North America (RSNA)
1982- present	Acoustical Society of America, fellow (ASA)
1987- present	Association for Research in Otolaryngology (ARO)
1978- present	Sigma Xi

Specialty/Accreditations

1995, 2005	Forensic Pathology	AFIP/CME
2003	Neuro Radiology	AFIP/CME
2004	Veterinary Pathology	AFIP/CME
2005	Basic Pathology	MIT-HST Program

Research Interests:

Sensory mechanisms of aquatic organisms.
Evolution of marine mammals.
Three-dimensional functional modeling and biomedical imaging.

Journal Publications (Last Five Years)

2001 Nadol, J.B., Jr., J.Y. Shiao, B.J. Burgess, D.R. Ketten, D.K. Eddington, B.J. Gantz, I. Kos, P. Montandon, N.J. Coker, J.T. Roland, Jr., and J.K. Shallop Histopathology of Cochlear Implants in humans. *Annals of Otology, Rhinology, and Laryngology*. 110(9):883-91.

2001 Webb, J.F., Smith, W.L. and Ketten, The Laterophysic Connection, A Unique Swim Bladder-Lateral Line Connection in Butterflyfishes: An Evolutionary Novelty with Implications for Sensory Function. J. Morphol. 248(3): 298-299.

2002 de Muizon, C., D.P. Domning, and D.R. Ketten Odobenocetops peruvianus, the walrus-convergent delphinoid from the lower Pliocene of Peru. *Smithsonian Cont. Paleobiol.*, no. 93:223-261.

2002 Skinner, M.W., D.R. Ketten, L.K. Holden, B.R. Whiting, K.T. Bae, L.T. Cohen, J.G. Neely, G.A. Gates, P.G. Smith, G.R. Kletzker Is there a relation between speech recognition and the position of cochlear implant electrodes in the inner ear? *Seminars in Hearing*, vol. 23(1):97-98.

2002 Skinner, M.W., D.R. Ketten, L.K. Holden, P.G. Smith, G.A. Gates, J.G. Neely, B. Brunsden, and B. Blocker CT Derived Estimation of Cochlear Morphology and Electrode Array Position in Relation to Word Recognition in Nucleus-22 Recipients. *JARO*, 03: 332-350.

2003 Mountain, D.C., Hubbard, A.E., Ketten, D.R. and O'Malley, J. The helicotrema: Measurements and models In: Biophysics of the Cochlea: from Molecules to Models. A.W. Gummer, E. Dalhoff, M. Nowotny, M. Scherer (eds.). World Scientific, Singapore, pp. 393-399.

2003 Ketten, D.R., T. Rowles, S. Cramer, J. O'Malley, J. Arruda, and P. Evans. Cranial Trauma in Beaked Whales. Proceedings of the Workshop on Active Sonar and Cetaceans, *ECSN*, no. 42, pp. 21-27.

2004 Ramcharitar, J.U, Deng, X., Ketten, D., and Popper, A. N. Form and Function in the Unique Inner Ear of a Teleost: The Silver Perch (Bairdiella chrysoura). *J. Comparative Neurol*ogy, 475(4):531-9.

2004 Ketten, D.R. Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and Implications for Underwater Acoustic Impacts. *Polarforschung*, 72. Jahrgung, Nr. 2/3, pp. 79-92.

2005 Horowitz, S., Smmons, A.M., and Ketten, D.R Optical and tomographic imaging of a middle ear malformation in the bullfrog (*Rana catesbeiana*), *Jour. Acous. Soc. of Amer***.,** Vol. 118, No. 2, pp. 1166–1171, August 2005

2006 Miller, B.S., Zosuls, A.L., Ketten, D.R.and Mountain, D.A. Middle ear stiffness of the bottlenose dolphin (*Tursiops truncates*), *IEEE Journal of Oceanic Engineering*. Vol. 31, No. 1, pp. 87-94.

2006 Koopman, H.N., S.M. Budge, D.R. Ketten, and S.J. Iverson. The topographical distribution of lipids inside the mandibular fat bodies of odontocetes: Remarkable complexity and consistency *IEEE Journal of Oceanic Engineering*. Vol. 31, No. 1, pp. 95-106.

In Press

2004 Skinner, M.W., L.T. Cohen, D.R. Ketten, L.K. Holden, E. Muka, B. Whiting, F.J. Wippold, K.T.. Bae, P.G. Smith, G.A. Gates, J.G. Neely, G.R. Kletzker, B. Brunsden, and R. Havener 2D Radiograph and CT Derived Estimates of the Position of Cochlear Implant Electrodes in Nucleus-22 Recipients. (in review, *JARO*)

2005 Webb, J.F., Shearman, E., Walsh, R.. Ketten, D.R., and Herman, J.L. Inner Ear and Swim Bladder Morphology Associated with a Novel Sensory Specialization in Chaetodontid Fishes. *Comp. Integr. Biol*. (in press).

2005 Chadwick, R.S, Manoussaki, D., Dimitriadis, E.K., Shoelson, B., Ketten, D.R., Arruda, J., O'Malley, J.T. Cochlear coiling and low-frequency hearing. (Passive and Active Structural Acoustic Filtering in Cochlear Mechanics, accepted)

2006 Ketten, D.R., D.G. Dunn, S.A. McCall, F.H. Gannon, T.P. Lipscomb, M. L. Fleetwood. Dysbaric Disease in Whales: A Cautionary Tale of "Bent" Analyses (submitted)

2006 Popper, A.N. and D.R. Ketten, Underwater Hearing. In: Handbook of the Senses, Elsevier Press, Oxford, England (accepted)

2006 Cox T.M., T.J. Ragen, A.J. Read, E. Vos, R.W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernández, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houser, T. Hullar, P.D. Jepson, D. Ketten, C.D. MacLeod, P. Miller, S. Moore, D. Mountain, D. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Mead, L. Benner. Understanding the Impacts of Anthropogenic Sound on Beaked Whales, Journal of Cetacean Research and Methods (in press).

Book Chapters/Technical Reports (Last Five Years)

2000 Ketten, D.R. Cetacean Ears. In: *Hearing by Whales and Dolphins*. W. Au, R. Fay, and A. Popper (eds.), SHAR Series for Auditory Research, Springer-Verlag, pp. 43-108.

2003 Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals, Ocean Noise and Marine Mammals. National Research Council, 204 pages.

2004 International Whaling Commission,Scientific Committee Report Annex K: Report of the Standing Working Group on Environmental Concerns, Marine Mammal Hearing and Evidence for Hearing Loss,Appendix 4 (pp 27-31).

2005 Norman, S.A., S. Raverty, B. McLellan, A. Pabst, D.R. Ketten, M. Fleetwood, J.K. Gaydos, B. Norberg, L. Barre, T. Cox, B. Hanson, and S. Jeffries Multidisciplinary Investigation of Harbor Porpoises (*Phocoena phocoena*) Stranded in Washington State from 2 May – 2 June 2003 Coinciding with the Mid-Range Sonar Exercises of the *USS SHOUP*. NOAA Northwest Fisheries. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, NOAA Technical Memorandum NMFS-NWR-34.

2005 Ketten, D.R. Beaked Whale Necropsy Findings for Strandings in the Bahamas, Puerto Rico, and Madeira, 1999-2002 , Woods Hole Oceanonographic Institution Technical Publication WHOI-2005-09. 36 pp.

Short Communications/Refereed Abstracts (Last Year)

2005 Norman, SA, B. Norberg, L. Barre, S. Raverty, J.K. Gaydos, D.R. Ketten, S. Cramer, M. Fleetwood, W.A. McLellan, A. Pabst, T. Cox, B. Hanson, S. Jeffries Multidisciplinary Investigation of Stranded Harbor Porpoises (*Phocoena phocoena*) in Washington State with an Assessment of Acoustic Trauma as a Contributory Factor, International Association for Aquatic Animal Medicine

2005 Miller, B., D. Mountain, A. Zosuls, S. Newburg, and D. Ketten Middle and Inner Ear Stiffness Measurements in the Bottlenose Dolphin, *Tursiops truncatus*. Assoc. Res. Otolaryngol. Abs. 1175

2005 Montie, E., Schneider, G., Moore, M., Ketten, D., Arruda, J., Touhey, K., Bogomolni, A., and Hahn, M Using Magnetic Resonance Imaging (MRI) to Obtain Volume Estimates of Cetacean Brain Regions that Depend on Thyroid Hormones for Maturation. Florida Marine Mammal Health Conference, Gainesville, FL

2005 Woods, C.F. Webb, J.F. and Ketten, D.R. The Physoclistous Swim Bladder of Chaetodontid Butterflyfishes: Implications for Acoustic Function, ASIH.

2005 Webb, J.F., Herman, J.L. and D.R. Ketten. 2005. Ear and otolith morphology in a prominent group of coral reef fishes with a putative specialization for enhanced hearing. Society for Integrative and Comparative Biology, San Diego, CA.

2005 Webb, J.F., Herman, J.L., Walsh, R.M.; Ketten, D.R.; Casper, B. M.; Mann, D.A The Ear and Auditory Capabilities of Butterflyfishes with a Laterophysic Connection (Family Chaetodontidae), ASIH.

2005 Chadwick, R.S, Manoussaki, D., Dimitriadis, E.K., Shoelson, B., Ketten, D.R., Arruda, J., O'Malley, J.T. Is cochlear coiling a determinant of low-frequency hearing ability?

2005 Moein-Bartol, S., D.R. Ketten Functional Measures of Sea Turtle Hearing, Environmental Consequences of Underwater Sound, NOPP-ONR Review, Arlington, Virginia.

2005 Ketten, D.; J. Arruda; S. Cramer,. O'Malley; J. Reidenberg, S. McCall; J. Craig. Experimental Measures of Blast Trauma in Marine Animals. Environmental Consequences of Underwater Sound,. NOPP-ONR Review, Arlington, Virginia

2005 Ketten, D.R., D. Mountain, A.E. Hubbard, R. Hillson and G. Schmidt Models of Beaked Whale Hearing and Responses to Underwater Noise Environmental Consequences of Underwater Sound. ECOUS Workshop, Arlington, VA

2005 Fish, F. E., M. K. Nusbaum, J. T. Beneski, D. R. Ketten, and T. M. Williams¨ Dolphin flukes as passively self-adjusting flexible propulsors, Society for Integrative and Comparative Biology, San Diego, CA,

2005 Bowles, A, R,Gentry, W. Ellison, J. Finneran, C. Greene, D. Kastak, D. Ketten, J. Miller, P. Nachtigall, J. Richardson, B. Southall, J. Thomas, P. Tyack. Strategies for weighting exposure in the development of acoustic criteria for marine mammals. .Acoustical Society of America, NY.

2005 Webb, J.F., J.L. Herman, and D.R. Ketten. 2005. Ear and otolith morphology in a prominent group of coral reef fishes with a putative specialization for enhanced hearing. Society for Integrative and Comparative Biology, San Diego.

2005 Campbell-Malone, R., Daoust, P-Y., De Guise, S., Doyle, K., Ketten, D.R, Moore, M. J. Bones Beyond the Beach: Investigating bone lesions discovered after necropsy. Northeast Right Whale Consortium. New Bedford, MA

2005 Webb, J.F., W.L. Smith, J.L. Herman, C.F. Woods, and D.R. Ketten. 2005 The laterophysic connection: Peripheral specialization for reception of acoustic stimuli in Chaetodontid butterflyfishes? The 2005 Meeting of the J.B. Johnston Club and the Seventeenth Annual Karger Workshop, Washington, D.C.

2003 Campbell-Malone, R., Daoust, P-Y., DeGuise, S., Ketten, D.R., Moore, M. J. Interpretation of the timing and pathology of mandibular fractures in ship-struck right whales. 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA

2005 Fish, F. E., M. K. Nusbaum, J. T. Beneski, D. R. Ketten, and T. M. Williams· Dolphin Flukes as Passively Self-Adjusting Flexible Propulsors for High Efficiency Transport, 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA

2005 Miller, Brian S.[1]; Zosuls, Aleks L.[1]; Newburg, Seth O.[1]; Ketten, Darlene R.[2]; and Mountain, David C A hearing test for dead odontocetes: what cadaver ears can tell us about dolphin hearing 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA

2005 Montie, E., Ketten, D., Schneider, G., Moore, M., Touhey, K., Bogomolni, A., and Hahn, M Neuroanatomy, Brain Volume Estimates, and Pathologies of Cetaceans and Pinnipeds from Magnetic Resonance Images. 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA

2005 Hammock, J. O'Malley, J. Arruda, J. Lytwyn, K. Rifenbury, K. Marshall, J. Dacey, J.W.H., Ketten, D.R. What's a marine nose for? A comparison of the structure and function of the sea otter nasal cavity with those of terrestrial mammals. 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA.

2005 Norman, S.A., S. Raverty,, D.R. Ketten, W. A. McLellan, A. Pabst, J.K. Gaydos, M. Fleetwood, T. Cox, B. Norberg, L. Barre, B. Hanson, S. Cramer, and S. Jeffries Multidisciplinary Investigation of Harbor Porpoises (*Phocoena phocoena*) in Washington State with an Assesment of Acoustic Trauma as a Contributory Factor. 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA.

2005 Hartley, D., C. Merigo, T. W. Blanchard, J. L. Dunn, T, Frady, D.RT. Ketten, D. S. Rotstein, and J. Whaley. Managing Solitary Beluga Whales in the Northeastern US - the story of "Poco". 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA.

2005 Ketten, D.R., J. Shoshani, D. P. Domning, J. O'Malley, J. Arruda, S. Cramer, C. O'Connell, and J. Meng Great ears: functional comparisons of land and marine leviathan auditory systems. *Invited paper*, 9th International Mammalogical Congress. Sapporo, Japan

2006 Miller, B.S., Zosuls, A.L., Newburg, S. O., Ketten, D.R.and Mountain, D.A Modeling the mechanics of dolphin hearing. Assoc. for Research in Otolaryngology

2006 Ketten, D.R.,, J. Shoshani, J. O'Malley, J. Arruda, D. Manoussaki, E. K. Dimitriadis, B. Shoelson, R. S. Chadwick. Great Ears: Functional comparisons of land and marine leviathan ears. Assoc. for Research in Otolaryngology

Dr. Peter Tyack:

Senior Scientist (with tenure)
Biology Department
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543
Birth: 3l December l953, Boston MA

Experience Relevant to Proposed Research:

Dr. Tyack's research centers on social behavior and acoustic communication in cetaceans, with a methodological focus on tagging and playback experiments to wild animals. Since 1980, he has been conducting playback experiments to humpback and right whales, to sperm whales and bottlenose dolphins. He worked with Christopher Clark and acousticians from BBN to formulate the first experiments designed to related behavioral avoidance responses of migrating gray whales to specific received levels of sound. They also developed and conducted the SURTASS LFA scientific research program to evaluate responses of blue, fin, gray, and humpback whales to LFA sonar signals. He has written an article defining the methods and goals of controlled exposure experiments. He has worked with an engineer at WHOI, Mark Johnson, to develop a tag that can record acoustic exposure and behavioral responses to sound. This tag has been used to measure sound exposure on sperm whales, and to measure responses of sperm whales to sounds of mid-frequency sonars and airgun arrays used for seismic exploration. His WHOI group has also learned how to tag beaked whales, and has published on the diving behavior of beaked whales and responses of beaked whales to vessel noise. They have specified the vocal behavior of beaked whales and have modeled the probability of detecting beaked whales by listening to their echolocation clicks.

Education:

A.B., *summa cum laude* in Biology, Harvard College, l976.
Ph.D., in Animal Behavior, Rockefeller University, 1982, Donald R. Griffin, advisor.

Employment:

1971-1972:	Research Assistant	Alza Co
1974-1975:	Research Associate	New York Zoological Society
1976:	Staff Biologist	Oregon Public Utilities Commission
1977-1981:	Research Associate	New York Zoological Society
1977-1982:	Graduate Fellow	Rockefeller University
1982-1983:	Postdoctoral Scholar	Woods Hole Oceanographic Institution
1983-1985:	Guest Investigator	Woods Hole Oceanographic Institution
1985-1989:	Assistant Scientist	Woods Hole Oceanographic Institution
1989-1999:	Associate Scientist	Woods Hole Oceanographic Institution
1994-1995:	Fellow	Center for Advanced Study in the Behavioral Sciences, Stanford CA
1999-:	Senior Scientist	Woods Hole Oceanographic Institution
2001-2002	Visiting Scientist	SACLANT Undersea Research Centre, Italy
2000-2005	Walter A. and Hope Noyes Chair in Oceanography	Woods Hole Oceanographic Institution

Memberships:

Federal Advisory Committee on Acoustic Impacts on Marine Mammals, US Marine Mammal Commission (2004-2005)

Committee on Characterizing Biologically Significant Marine Mammal Behavior. Ocean Studies Board, National Research Council (2003-2004)

Committee to Review Results of ATOC's Marine Mammal Research Program. Ocean Studies Board, National Research Council (1996-2000)

Committee on Low Frequency Sound and Marine Mammals, Ocean Studies Board, National Research Council (1992-1994)

Advisory Board for Marine Mammal Research Program, ATOC.

Trustee, Center for Coastal Studies (1996-1999)
Member, Scientific Advisory Board, New England Aquarium (1992-1996)
Member; Acoustical Society of America, Animal Behavior Society; A.A.A.S., Sigma Xi
Charter Member, Society for Marine Mammalogy
Associate, Behavioral and Brain Sciences.
Fellow, Center for Climate and Ocean Research (CICOR)
Fellow, Acoustical Society of America
Member, Committee of Scientific Advisors on Marine Mammals, Marine Mammal Commission 2000-2003
Associate Editor, Marine Mammal Science (1998-2003), Encyclopedia of Ocean Sciences, IEEE Journal of Oceanic Engineering
Adjunct Scientist, Mote Marine Aquarium
Adjunct Professor, Department of Oceanography, University of Rhode Island

Research Interests:

- Social behavior and acoustic communication in cetaceans.
- Vocal learning and mimicry in the natural communication systems of cetaceans.
- Individually distinctive signature signals, vocal learning, and mimicry in the bottlenose dolphin and the sperm whale.
- Acoustic structure and social functions of the songs of baleen whales.
- Responses of cetaceans to manmade noise.
- Playback to cetaceans of their own and conspecific vocalizations.
- Development of methods to identify which cetacean produces a sound within a social group.

Books:

2005 Wartzok D, J. Altmann, W. Au, K. Ralls, A. Starfield, P. L. Tyack. Marine Mammal Populations and Ocean Noise: Determining when noise causes biologically significant effects. (NRC report) Washington, D.C.: National Academy Press.

2003 de Waal, F. B. M. and P.L. Tyack, editors. Animal Social Complexity: Intelligence, Culture, and Individualized Societies. Harvard University Press

2000 Mann, J., Connor, R., Tyack, P.L., and H. Whitehead. *Cetacean Societies: field studies of whales and dolphins*. Chicago: University of Chicago Press.

2000 Popper, A.N., DeFerrari, H.A., Dolphin, W.F., Edds-Walton, P.L., Greve, G.M., McFadden, D., Rhines, P.B., Ridgway, S.H., Seyfarth, R.M., Smith, S.L., and P.L. Tyack. *Marine mammals and low-frequency sound*. (NRC report) Washington, D.C.: National Academy Press.

1994 Green, D.M., DeFerrari, H.A., McFadden, D., Pearse, J.S., Popper, A.N., Richardson, W.J., Ridgway, S.H., and P.L. Tyack. *Low-frequency sound and marine mammals: current knowledge and research needs*. (NRC report) Washington, D.C.: National Academy Press.

Recent Relevant Publications:

Submitted

Johnson M., Madsen P.T., Zimmer W.M.X.Z., Aguilar de Soto N., Tyack P.L. Foraging Blainville's beaked whales (*Mesoplodon densirostris*) produce distinct click types matched to different phases of echolocation. *Journal of Experimental Biology*.

Miksis-Olds J. L., Donaghay Percy L., Miller, J. H., Tyack, P. L., Reynolds, J. E. III. Simulated vessel approaches elicit differential responses from manatees. *Behavioral Ecology and Sociobiology*

Nowacek D. P., Thorne L. H., Johnston D. W., Tyack P. L. Responses of cetaceans to anthropogenic noise: an update and evaluation of potential behavioral and physiological consequences. *Journal of Acoustical Society of America*

Miller P., Johnson M., Madsen P. T., Quero M. E., Biassoni N., King R. and Tyack P.L. Gulf of Mexico sperm whales alter foraging behaviour when exposed to airgun sounds. *Proceedings of the Royal Society of London*.

<u>Peer reviewed articles in scientific journals</u>

Johnson M., Madsen P.T., Zimmer W.M.X.Z., Aguilar de Soto N., Tyack P.L. Foraging Blainville's beaked whales (*Mesoplodon densirostris*) produce distinct click types matched to different phases of echolocation. *Journal of Experimental Biology* 209:5038-5050.

DeRuiter, S. L., Tyack Peter L., Lin Ying-Tsong, Newhall A. E., Lynch J. F., Miller P. J.O. In press. Modeling acoustic propagation of airgun array pulses recorded on tagged sperm whales (*Physeter macrocephalus*). *Journal of Acoustical Society of America*120:4100-4114.

Tyack, P. L., Johnson, M., Soto, N. A. d., Sturlese, A. & Madsen, P. T. 2006. Extreme diving behaviour of beaked whale species known to strand in conjunction with use of military sonars. *Journal of Experimental Biology***209**:4238-4253.

Madsen P.T., Johnson M., Miller P., Aguilar de Soto N. and Tyack P. 2006. Quantitative measures of airgun pulses impinging on sperm whales using onboard tags and controlled exposures. *Journal of Acoustical Society of America* **120**:2366-2379

Watwood, S. L., Miller, P. J. O., Johnson, M., Madsen, P. T. and Tyack, P. L. 2006. Deep-diving foraging behavior of sperm whales (*Physeter macrocephalus*). *J. Animal Ecology* **75**:814-825.

Aguilar de Soto, N., Johnson, M., Madsen, P. T., Tyack, P. L., Bocconcelli, A. & Borsani, J. F. 2006. Does intense ship noise disrupt foraging in deep-diving Cuvier´s beaked whales (*Ziphius cavirostris*). *Marine Mammal Science*. 22:690-699.

Madsen, P. T., Wahlberg, M., Tougaard, J., Lucke, K. & Tyack P. 2006. Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. *Marine Ecology Progress Series* 309: 279–295

Cox, T. M., Ragen, T. J., Read, A. J., Vos, E., Baird, R. W., Balcomb, K., Barlow, J., Caldwell, J., Cranford, T., Crum, L., D'Amico, A., D'Spain, G., Fernández, A., Finneran, J., Gentry, R., Gerth, W., Gulland, F., Hildebrand, J., Houser, D., Hullar, T., Jepson, P. D., Ketten, D., MacLeod, C. D., Miller, P., Moore, S., Mountain, D., Palka, D., Ponganis, P., Rommel, S., Rowles, T., Taylor, B., Tyack, P., Wartzok, D., Gisiner, R., Mead, J. & Benner, L. 2006. Why Beaked Whales? Report of Workshop to Understand the Impacts of Anthropogenic Sound. *Journal of Cetacean Research and Management* **7**:177-187. 2005

Zimmer W. M. X., Johnson M., Madsen P. T., Tyack P. L. 2005. Echolocation clicks of Cuvier's beaked whales (*Ziphius cavirostris*). *Journal of the Acoustical Society of America* 117:3919-3927

Zimmer W.M.X., Madsen P.T., Teloni V., Johnson M.P., Tyack P.L. 2005. Off-axis effects on the multi-pulse structure of sperm whale usual clicks with implications for the sound production. *Journal of Acoustical Society of America* 118: 3337-3345.

Zimmer W., Tyack P.L., Johnson M., Madsen P. 2005. 3-Dimensional beam pattern of regular sperm whale clicks confirms bent-horn hypothesis. *Journal of the Acoustical Society of America* 117:1473-1485

Madsen P.T., Johnson M., Aguilar DeSoto N., Zimmer W.M.X. and Tyack P. 2005. Biosonar performance of foraging beaked whales (*Mesoplodon densirostris*). *Journal of Experimental Biology* 280:181-194

Teloni V., Zimmer W.X.M., Tyack P.L. 2005. Sperm whale trumpet sounds. *Bioacoustics* 15: 163-174. 2004

Miller P. J. O., Johnson M. P. Tyack, P. L. 2004. Sperm whale behaviour indicates the use of rapid echolocation click buzzes 'creaks' in prey capture. *Proceedings of the Royal Society B* 271:2239-2247.

Johnson M., Madsen P. T., Zimmer W. M. X., de Soto N. A., Tyack P. L. 2004. Beaked whales echolocate on prey. *Proceedings of the Royal Society B [Biology Letters]* 271:S383-S386. **DOI:** 10.1098/rsbl.2004.0208

Miller, P. J. O., Johnson, M., Tyack, P., and Terray, E. 2004. Swimming gaits, passive drag, and buoyancy of diving sperm whales (*Physeter macrocephalus*), *Journal of Experimental Biology*, 207:1953-1967.

Tyack, P; Gordon, J. and D. Thompson. 2004. Controlled exposure experiments to determine the effects of noise on large marine mammals. *Marine Technology Society Journal*, 37(4): 41-53.

Nowacek, D., Johnson, M., and P. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alarm stimuli, *Proceedings of the Royal Society B* 271:227-231. 2003

Zimmer W. M.X., M. P. Johnson, A. D'Amico, P. L. Tyack. 2003. Combining data from a multi-sensor tag and passive Sonar to determine the diving behavior of a sperm whale (*Physeter macrocephalus*). *IEEE Journal of Oceanic Engineering* 28:13-28.

Johnson M. and P. L. Tyack 2003. A Digital Acoustic Recording Tag for Measuring the Response of Wild Marine Mammals to Sound. *IEEE Journal of Oceanic Engineering* 28:3-12. 2002

Baird R. W., J. F. Borsani, M. B. Hanson and P. L. Tyack. 2002. Diving and night-time behaviour of long-finned pilot whales in the Ligurian Sea. *Marine Ecology Progress Series* 237:301-305. 2001

Matthews J.N., S. Brown, D. Gillespie, M. Johnson, R. McLanaghan, A. Moscrop, D. Nowacek, R. Leaper, T. Lewis and P. Tyack. 2002. Vocalisation rates of the North Atlantic right whale *(Eubalaena glaciali*s). *Journal of Cetacean Research and Management.* 3(3):271–282.

Miksis J. L., M. D. Grund, D. P. Nowacek, A. R. Solow, R. C. Connor and P.L. Tyack. 2001. Cardiac Responses to Acoustic Playback Experiments in the Captive Bottlenose Dolphin, *Tursiops truncatus*. *Journal of Comparative Psychology* 115:227-232.

Gordon J. and P.L. Tyack. 2001. Acoustic techniques for studying cetaceans. In: Marine mammals: biology and conservation. (P.G.H. Evans and T. Raga, eds), Plenum Press, London, pp. 293-324.

Gordon J. and P.L. Tyack. 2001. Sounds and Cetaceans. In: Marine mammals: biology and conservation. (P.G.H. Evans and T. Raga, eds), Plenum Press, London, pp. 139-196.

Tyack P.L. 2001. Bioacoustics. Encyclopedia of Ocean Science. (Steele J. ed.) Academic Press, London, pp. 295-302. 2000

Nowacek D., R. S. Wells, and P. L. Tyack. 2000. A platform for continuous behavioral and acoustic observations of free-ranging marine mammals: overhead video combined with underwater audio. *Marine Mammal Science* 17:191-199.

Miller, P.J.O., N. Biassoni, A. Samuels, and P.L. Tyack. 2000. Whale songs lengthen in response to sonar. *Nature* 405:903

Updated: 04/06/07

Dr. Adam S. Frankel:

Marine Acoustics, Inc.
4100 N. Fairfax Drive
Suite 730
Arlington, VA 22203
adam.frankel@marineacoustics.com

Experience Relevant to Proposed Research:

Dr. Adam S. Frankel has extensive experience in animal bioacoustics and the used of controlled exposure of marine mammals to sound. His first major research project was the playback of natural and artificial sounds to humpback whales in Hawai‘i. This was followed by a multi-year project using passive acoustic localization techniques to track singing humpback whales off Hawai‘i, documenting their behavior and habitat use. More recently, Dr. Frankel directed the Hawaiian portion of the Acoustic Thermometry of Ocean Climate Marine Mammal Research Program (ATOC-MMRP). This project studied the responses of humpback whales to the presentation of low-frequency ATOC signals. The first study used a smaller source, to limit the potential number of animals affected. After this study showed that responses were detectable, but of a very small magnitude, the experiment was repeated with a full-scale source (i.e., the ATOC projector). Most recently, he led a research project tracking the movements of migrating gray whales and their response to a 22 kHz active whale-finding sonar. Finally, Dr. Frankel has been the program manager for the Acoustic Integration Model© (AIM), a software model that can be used to predict the acoustic exposure of animals based upon their behavior as well as the source and environmental conditions.

Academic Affiliations:

12/01 – present: Adjunct Professor of Marine, Earth and Atmospheric Sciences, North Carolina State University.

8/00 – present: Adjunct Professor of Biology, University of North Carolina, Wilmington.

2/00 – present: Founding member of the Hawai‘i Marine Mammal Consortium

Degrees Received:

December 1994, Doctor of Philosophy, Department of Oceanography, University of Hawaii at Manoa. Dissertation Title: Acoustic and Visual Tracking reveals distribution, song variability and social roles of humpback whales in Hawaiian waters.

December 1987, Master of Science, Department of Zoology, University of Hawaii at Manoa. Thesis Topic: Sound Playback Experiments with Humpback Whales *Megaptera novaeangliae* in Hawaiian Waters.

May 1984, Bachelor of Science, Department of Biology, College of William and Mary.

Research Experience:

1/04 – Designed and implemented gray whale observation study to verify the performance of a whale-tracking sonar system. Secondary objective was to examine for any behavioral responses of whales to the sonar system.

1/00 – present Senior Scientist at Marine Acoustics. Involved in sound propagation research, bowhead whale census, and the transmission of airborne noise into the water column. Directed visual and passive acoustic marine mammal surveys. Program manager for the Acoustic Integration Model.

12/94 – 1/00: Post-Doctoral Research Associate at Cornell Bioacoustics Research Program. Main research focus is the effects of low frequency sound on marine mammals, continuing to oversee ATOC project. Lead project in New Zealand on sperm whale passive acoustic tracking. Participated in several other marine mammal bioacoustics research projects. Participated in Low Frequency Active (LFA) research project on blue, fin and gray whales.

9/93 - 12/94: Field director for ATOC marine mammal research program. Directed shore-based acoustic and visual research, boat-based acoustic data collection, preparation of moored hydrophone array system.

1/87 - 1/92: Co-Principal Investigator and Field Director of the University of Hawaii research projects: "Sound playback experiments with Humpback Whales" and "Acoustic Localization of Vocalizing Humpback Whales.

1/85 - 12/86: Senior research assistant for University of Hawaii research project entitled "Sound playback experiments with Humpback Whales."

Professional Experience:

1/00 – present: Senior Scientist at Marine Acoustics, Inc. Prepare and assist in preparation of environmental documentation.

12/99-12/99: Invited lecturer at Marine Mammal Bioacoustics short course, held by the Acoustical Society of America at the Thirteenth Biennial Conference on the Biology of Marine Mammals.

6/98 - 6/98: Instructor at Bioacoustics Workshop to be held at the University of New Hampshire, Burlington.

Presentations and Publications:

Frankel, A.S. 2002. Sound Production. in Perrin, Würsig and Theiwissen, eds. The Encyclopedia of Marine Mammals. Academic Press, San Diego. pp 1126-1138.

Frankel, A.S. and C.W. Clark. 2002. Factors affecting the distribution and abundance of humpback whales (*Megaptera novaeangliae*) off the North Shore of Kaua'i. Mar. Mamm. Sci. 18(3):644-662.

Frankel, A.S. and C.W. Clark. 2000. Behavioral Responses of Humpback Whales (*Megaptera novaeangliae*) to Operational ATOC signals. J. Acoust. Soc. Am. 108(4): 1930-1937.

Frankel, A.S. and C.W. Clark. 1998. Results of low-frequency m-sequence noise playbacks to humpback whales, *Megaptera, novaeangliae*, in Hawai'i. Can. J. Zool. 76(3) 521-535.

Frankel, A.S., J.R. Mobley, and L.M. Herman. 1995. Estimation of auditory response thresholds in humpback whales using biologically meaningful sounds. In Sensory systems of aquatic mammals. Edited by Kastelein, R.A., J.A. Thomas and P.E. Nachtigall. De Spil, Netherlands. pp. 55-70.

Frankel, A.S., C.W. Clark, L.M. Herman, L.M. and C.M. Gabriele. 1995. Spatial Distribution, Habitat Utilization, and Social Interactions of Humpback Whales, *Megaptera novaeangliae*, off Hawai'i using Acoustic and Visual Techniques. Can. J. Zool. 73(6) 1134-1146.

Frankel, A.S., L.M. Herman and J.R. Mobley. 1993. The responses of humpback whales to playback of natural and artificial sounds in Hawaii. Invited Paper, Acoustical Society of America

Frankel, A.S. 1987. Sound playback experiments with humpback whales *Megaptera novaeangliae* in Hawaiian waters. A Thesis submitted to the Graduate Division of the University of Hawaii in Partial Fulfillment of the Requirements for the Degree of Master Of Science In Zoology.

Au, W.W.L., A.S. Frankel, D.A. Helweg and D.H. Cato. 2001. Against the Humpback Whale Sonar Hypothesis. IEEE J. Ocean. Eng. 26(2): 295-299.

Mobley, J.R., L.M. Herman, and A.S. Frankel. 1988. Responses of wintering humpback whales (*Megaptera novaeangliae*) to playback of recordings of winter and summer vocalizations and of synthetic sound. Behavioral Ecology and Sociobiology. **23**: 2111-223.

Professional Societies:

The Society for Marine Mammalogy
Acoustical Society of America
Hawai'i Marine Mammal Consortium

Diane E. Claridge

Bahamas Marine Mammal Research Organisation
P.O. Box AB-20714
Marsh Harbour
Abaco, Bahamas
bmms@oii.net
Place of Birth: Nassau, Bahamas
Nationality: Bahamian/Canadian
phone: 242 366-4155
e-mail: bmms@oii.net

Experience Relevant to Proposed Research

Ms. Claridge has extensive experience in marine mammal observing, marine mammal research, and stranding response. She is the Director of the Bahamas Marine Mammal Research Organisation, which conducts systematic boat-based surveys for describing the distribution and habitat use of different marine mammal species. The Bahamas Marine Mammal Research Organization employs photo-identification techniques for the recognition of individual whales and dolphins; they developed new statistical approaches for using these data to determine abundance estimates and occupancy patterns, collect skin and faecal samples for molecular genetic analysis, use Geographic Information System mapping techniques to describe species' distribution within the study area, and organise stranding response. Ms. Claridge has held a Bahamian Research Permit since 1992 for engaging in scientific research on marine mammals within the Bahamas, which is renewed annually.

Education

- Sc. Environmental Science, Florida Institute of Technology, USA. 1988.
- M. Sc. Zoology, University of Aberdeen, Aberdeen, U.K. 2006.

Professional Experience

- *Bahamas Marine Mammal Research Organisation*, Sandy Point, Abaco, Bahamas. Director, 1991-present. Non-profit organisation (formerly known as Bahamas Marine Mammal Survey) whose goals are to increase scientific knowledge, and through public education, contribute to the conservation of marine mammals in the Bahamas. Responsibilities include overseeing of all aspects of research projects, organising stranding response, training Bahamian student interns, hosting visiting scientists, and running an environmental summer camp. (see: www.bahamaswhales.org).
- *Geo-Marine, Inc.*, Plano, Texas, USA. Contracted Lead Scientist, Marine Resources Assessment, 2005-2006. Subcontract to compile data collected by the Bahamas Marine Mammal Survey since 1991.
- *Woods Hole Oceanographic Institute*, Woods Hole, Massachusetts, USA. Contracted Lead Field Scientist, Marine Mammal Monitoring Verification Tests and Beaked Whale Tagging Project, 2005-2006. Conducting field work in co-ordination with the Naval Undersea Warfare Center at the US Navy's Atlantic Undersea Evaluation and Testing Center, Andros Island, Bahamas.
- *Bahamas Naturalist Expeditions, Ltd.*, Marsh Harbour, Abaco, Bahamas. Co-founder & Naturalist Guide, 1994-1997. Bahamian eco-tourism company that leads natural history tours of the National Parks and wilderness areas of Great Abaco Island to promote conservation of these habitats.
- *Bahamas National Trust*, Nassau, Bahamas. Contract Biologist and Information Officer, 1992-1995. Contracted to conduct biological survey and document human use of the Pelican Cays Land and Sea Park, Abaco.

- *Center for Whale Research, Inc*., Friday Harbor, Washington, USA. Research Biologist, 1988-2001. Photo-identification and behavioural studies of cetaceans, concentrating primarily on killer whales, humpback whales, and blue whales in the northeastern Pacific.
- *Windjammer Barefoot Cruises*, Miami, Florida, USA. Junior Officer, 1983-1984. Maintained navigation watches on board S/V Fantome (286-foot tall-ship), and organized beach activities for 126 passengers.
- *Bahamas Flotilla Cruises*, Nassau, Bahamas. Crew, 1981. Sailing, maintenance and inventory of 31-foot sailboats chartering between Nassau and the Exuma Cays.
- *R/V Dragon Lady*, Nassau, Bahamas. Crew, 1980. Dive boat (71-foot powerboat) chartered for 2-week dive excursions from Nassau to the Exuma Cays.

Publications

Parsons, K.M., Durban, J.W., **Claridge, D.E.** Herzing, D.L., Balcomb, K.C. and Noble, L.N. (2006). Population genetic structure of coastal bottlenose dolphins (*Tursiops truncatus*) in the northern Bahamas. *Marine Mammal Science* 22(2):276-298.

Claridge, D.E. (2006). Fine-scale distribution and habitat selection of beaked whales. Thesis presented for Master's of Science in Zoology, University of Aberdeen, Scotland, UK. 119 pp.

Parsons, K.M., J.W. Durban and **D.E. Claridge** (2003). Comparing two alternative methods for genetic sampling of small cetaceans. *Marine Mammal Science*, 19(1):224-231.

Parsons, K.M., Durban, J.W., **Claridge, D.E.**, Balcomb, K.C., Noble, L.R. and Thompson, P.M. (2002). Kinship as a basis for alliance formation between male bottlenose dolphins, *Tursiops truncatus*, in the Bahamas. *Animal Behaviour* 66:185-194.

Balcomb, K.C. and **Claridge D.E.** (2001). Mass stranding of cetaceans in the Bahamas caused by Navy sonar. *Bahamas Journal of Science.* 8(2), 2-12.

Durban, J.W., Parsons, K.M., **Claridge, D.E.** and Balcomb, K.C. (2000). Quantifying dolphin occupancy patterns. *Marine Mammal Science* 16(4): 825-828.

Parsons, K.M., Dallas J.D., **Claridge D.E.**, Durban J.W., Balcomb K.C., Thompson P.M. and Noble L.R. (1999). Amplifying dolphin mitochondrial DNA from faecal plumes. *Molecular Ecology*, 8:1766-1768.

Claridge, D.E. (1994). Photo-identification study to assess the population size of Atlantic bottlenose dolphins in central Abaco. *Bahamas Journal of Science.* 1(3), 12-16.

Claridge, D.E. and Patterson, O.M. (2006). Guide to the Most Common Whales and Dolphins of Abaco. *In* "The Cruising Guide to Abaco, Bahamas 2007". (S. Dodge, ed.), pp 153-158, White Sound Press, New Smyrna Beach, FL. 192 pp.

Memberships and Awards

- Society of Marine Mammalogy, Lawrence, Kansas, U.S.A. Life member.
- Friends of the Environment, Abaco, Board of Directors, 2003 – present
- Bahamas National Trust, Elected Council Member, 2003
- Scientific Advisory Board, Bahamas National Trust, 2006 – present
- PADI certified diver, current
- Bahamian Master's license, current
- Bahamas Ministry of Tourism Cacique Award for Ecotourism, 1999
- Zonta Club of New Providence Living Legends Award for the Environment, 2003

IV. PROPOSAL

A. SUMMARY

Research Objective (Behavioral Response Study-BRS): Observe behavioral responses in several deep-diving cetacean species exposed to natural and artificial underwater sounds and quantify exposure conditions associated with various effects.

Stages to meet objective (BRS Phase I, 2007):

1. Determine the acoustic exposures of mid-frequency (MF[1]) sonar sounds that elicit an identifiable behavioral indicator response in beaked whales.
2. Attempt to understand the initial steps in the chain of events that lead from exposure to MF sonar sounds, to atypical mass strandings of beaked whales.
3. Use this understanding to strive for the development of a safe response that can be used to indicate risk.
4. Test whether other man-made sounds elicit the indicator response in beaked whales and other deep-diving odontocetes.
5. Attempt to define dose:response relationships for MF sonar and other man-made sounds.

Research Method/Technique (BRS Phase I, 2007): Perform 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.

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 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.

We propose a two-phase field research project (2007-2008) to conduct BRSs of various underwater sounds to marine mammals (including beaked whales and other

[1] For underwater acoustics, MF is defined as 1,000 Hz (or 1 kHz) to 10,000 Hz (or 10 kHz).

odontocetes). The exposures will 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)[2]. 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."

Our 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) will depend upon Phase I results, but are planned to include acoustic exposures of underwater coherent/incoherent[3] 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.

<u>Hypotheses to be Tested (BRS: Phase I [2007] and Phase II [2008])</u>:

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?

---

[2] 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.

[3] 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.

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 will 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 will 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 will be compared to those predicted as the possible cause of sonar-related strandings in Cox et al. (2006). Every effort will be made to ensure that these exposures do not pose a risk to the subjects, and a primary effort of Phase I (2007) will 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 will 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.

<u>Manner in Which the Activity Involves the Taking of Marine Mammals (BRS)</u>: Although the primary species of concern are beaked whales, the responses of other odontocete species will 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 may be used as surrogate target species, such as pilot whales, melon-headed whales, sperm whales and Risso's dolphins (see Table IV.B-1). The subjects will be purposely exposed to anthropogenic underwater MF sounds, photo-identified, tagged and, due to the nature of tagging, skin samples will be collected and exported to the U.S. (see Subsection IV.C.5). Hence, this SRP application requests the importation of skin samples into the U.S., photo-identification, as well as MMPA Level B takes of marine mammals and, incidental Level B takes of other marine mammals that could possibly be in the vicinity of the BRS research area outside of the Bahamian territorial seas[4] in the Tongue of the Ocean. Visual and passive acoustic monitoring, and other safeguards will be implemented to minimize to the greatest degree possible the potential for Level A takes of marine mammals; and there

[4] U.S. MMPA does not apply within a foreign country's territorial seas.

will be clear source shutdown criteria to limit exposure to level B harassment before any injurious behavioral responses occur. See Subsection IV.D for amplifying information.

The minimum exposure level for Phase I will 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) will help define exposures at the onset of beaked whale click cessation, which will 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 refer to the cumulative sum of the square pressures over a duration of the sound referenced to the standard underwater sound reference level (1 µPa) expressed in dB, and are assumed to be standardized at dB re 1 μPa^2-s, unless otherwise stated.

IV.B. INTRODUCTION

B.1. Species:

B.1.a. Target Species = Intentional Take in table below.

B.1.b. Non-Target Species = Incidental Take in table below.

Table IV.B-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 dolphin	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

IV.B.1.c. Status of Affected Stocks

The status of each species or stock potentially affected is provided in the table above and the listings below, including the following:

- Threatened or endangered under the ESA,
- Depleted or strategic under the MMPA, and
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES Appendix I, II, or III).

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, the National Marine Fisheries Service 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.

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.

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.

IV.B.2. Background/Literature Review

B.2.a. Succinct review of the current knowledge of the problem

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 will benefit our 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 can provide benefit to all deep-diving odontocete species, and will contribute to our 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 examines 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 the NOAA/NMFS Office of Protected Resources (OPR) in managing oceanic noise issues.

B.2.b. Complete literature citations: see Section VII (References) below.

B.3. Hypothesis/Objectives and Justification

B.3.a. Clear statement of objectives and expected significance of the proposed research.

Historically, marine mammal strandings that have been coincident with MF sonar exercises have generally involved beaked whales. Until the causes of these and other strandings can be more clearly identified from the host of possible factors, it will remain difficult to discriminate an actual hazard from random coincidences of human activities and natural strandings. For those underwater acoustic stimuli where there does seem to be a relationship under certain conditions, there is an urgent need to understand what acoustic exposures are safe. One of the most effective ways to test whether MF sonar sounds could pose a risk of stranding is to conduct carefully controlled experiments (e.g., behavioral response studies [BRS]) on safe and early indicators of responses that may be linked to a causal chain of events leading to stranding. This paradigm provides a means of quantifying behavioral responses in animals exposed to known sounds and variance in response magnitude based on exposure conditions.

<u>Research Objective</u>: 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.

Stages to meet objective (BRS, Phase I, 2007):

1. Determine the acoustic exposures of MF sonar sounds that elicit an identifiable behavioral indicator response in beaked whales.
2. Attempt to understand the initial steps in the chain of events that lead from exposure to MF sonar sounds, to atypical mass strandings of beaked whales.
3. Use this understanding to strive for the development of a safe response that can be used to indicate risk.
4. Test whether other man-made sounds elicit the indicator response in beaked whales and other deep-diving odontocetes.
5. Attempt to define dose:response relationships for MF sonar and other man-made sounds.

<u>Research Method/Technique</u>: Perform multi-stimulus BRSs to assess responses of beaked whales and other deep-diving odontocetes to underwater natural sounds, novel synthetic sounds, and MF sonar sounds.

<u>Hypotheses to be Tested (BRS-07)</u>:

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 will be tested by examining behavioral responses, including dive depth and duration, surfacing frequency and time, respiration and heart rate (at the surface), vocal reactions (e.g., cessation of clicking) and changes in social cohesion. This will 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 will be compared to those predicted by current hypotheses about the cause of sonar-related strandings (Cox et al., 2006). Every effort will be made to ensure that these exposures do not pose a risk to the subjects, and a primary effort of Phase I (2007) will 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 will include assessment of:

1. Any relationship between 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.

Manner in Which the Activity Involves the Taking of Marine Mammals (BRS): Although the primary species of concern are beaked whales because of a number of stranding events associated with the operation military sonars, the responses of other odontocete species will 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, such as pilot whales, melon-headed whales, sperm whales and Risso’s dolphins may be used as surrogate target species (see Table IV.B-1). The subjects will be purposely exposed to anthropogenic underwater MF sounds, photo-identified, tagged and, due to the nature of tagging, skin samples will be collected and exported to the U.S. Hence, this SRP application requests the importation of skin samples into the U.S., photo-identification, as well as MMPA Level B takes of marine mammals and, incidental Level B takes of other 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 will be implemented to minimize to the greatest degree possible the potential for Level A takes of marine mammals; and there will be clear source shutdown criteria to limit exposure to level B harassment before any injurious behavioral responses occur. See Subsection IV.D for amplifying information.

The minimum exposure level for Phase I will 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 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

[5] U.S. MMPA does not apply within a foreign country’s territorial seas.

sound), will help define exposures at the onset of beaked whale click cessation, which will be factored into the minimum animal RL for Phase I playbacks.

Expected nature and significance of research results and how the activities being requested support an overall research plan

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 ≤15 m (49 ft) to allow for tag attachment and/or photo-identification. Animals need to be CA'd to within ≤10 m (33 ft) for tag attachment. This will be done in a way to minimize disruption: slowly, deliberately, and for as short a time as possible.

Focal Follow (FF) – Following a single focal animal (typically the tagged animal, if an animal has been tagged) to observe surface behavior directly, 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. FFs will be conducted independent of tagging as opportunities arise with delphinid odontocetes that surface frequently enough that surface observations provide sufficient data to monitor potential responses to sound. These FFs are typically conducted from 100-500 m (328 – 1640 ft) from the animal, with a small quiet boat (e.g., RIB), depending on weather conditions and visibility from the observation vessel (OV).

Playbacks (PB) – PB experiments will use an underwater MF sound source deployed from a vessel. There will be one or several designated focal animal subjects for each PB, depending upon how many animals are tagged. PBs will occur after baseline behavior of the subject(s) has/have been collected (at least one beaked whale dive + surface sequence). During a PB, the PB vessel may maneuver to stay within a designated range of the focal animal, but the vessel will usually stay far enough from the focal animal so that the visual stimulus of the vessel or source cannot be sensed by the subject. This constraint sets the required SL for a particular desired RL at the animal. The PBs follow a protocol (see Subsection IV.D below) to minimize the chances that non-focal animals will be exposed to RLs above that of the focal animal. PB events will typically last about 1-3 hours, after which the OV or a different tracking vessel will follow the focal animal to collect post-exposure control data (at least one beaked whale dive + surface sequence).

Sound playback experiments and 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 one to pool 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 are 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.

B.3.b. Statutory and regulatory requirements addressed for the target species.

(1) For ESA-listed species:

- Justify use of an ESA-listed species rather than a non-listed species, including a discussion of possible alternatives.

The only ESA-listed species that could potentially be a target species is sperm whales, which are not the primary target species (beaked whales). However, given the unpredictability of beaked whale habitats and actions, and the fact that past and recent tagging experiences with sperm whales indicate that this type of much-needed research can be done without causing injury or significant effects to the animals, it is logical to take advantage of such an opportunity with a sperm whale when neither beaked, melon-headed or pilot whale, or Risso's dolphin species are available.

The major goal of this field research is to determine how animals thought to be vulnerable respond to certain man-made underwater sounds, which are commonly present in some areas of their environment. The PB experiments involve controlled exposures that are less frequent and lower in level than many of these species may face from certain incidental commercial underwater sound 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- and MMPA-listed species from noise exposure, this will 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.

This same logic can be applied to age classes within a population. 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. We will pay particular attention during our PBs to any animal silencing responses and visual observers will 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 we are easily able to tag sperm whale juveniles with no more than minor responses from any of the animals, we propose to attempt to do so to test whether their own behavior is affected or whether they are affected by changes in the behavior of the adults around them.

- Provide a statement of whether the proposed research has broader significance; i.e., does the project respond to recommendations of a national or international scientific body charged with research or management of the endangered species and if so, how.

We propose a field research project to conduct BRSs of various underwater MF sounds to marine mammals (including beaked whales and other deep-diving odontocetes), including the collection of skin samples (as a result of tagging of animal subjects), and photo-identification of animal subjects targeted for close approaches, focal follows and tagging. This type of field research has been unanimously 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). 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.”

- Provide a statement of whether the proposed research will contribute to the objectives identified in the species recovery or conservation plan, and if so, how the proposed project will meet those objectives. Otherwise, indicate how the proposed research will otherwise contribute to conservation of the species.

The sperm whale is the only BRS target species that is listed by the US as an endangered species. The Office of Protected Resources (OPR) of 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”. Clearly, the proposed research directly addresses this objective. None of the other proposed target species for this research are listed as endangered or threatened under the

Endangered Species Act, and in the case of beaked whales, 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." The proposed research addresses the principal impact that caused these whales to be listed as strategic stocks.

(2) For ESA-listed marine mammals and MMPA-depleted species:

- Explain why the proposed research cannot be conducted using an alternative species or stock (as above).

See (1), bullet one above.

- Explain how the expected research results would:
  - Directly benefit the species or stock.

There is high probability that the results from the proposed field research activity can provide information on how, why and when underwater man-made sounds cause the deep-diving odontocete species tested to respond in a manner that can be harmful to them. With these data, the method and technique for operating underwater sound systems can possibly be modified to decrease the propensity for negative impact (or at least the level of impact) on each species and stock tested. Inclusion of other odontocete species for study can test whether some species are more or less sensitive than others, leading to more precisely targeted regulations.

  - Contribute significantly to fulfilling a critically important research need; identify, evaluate, or resolve conservation problems for the species or stock.

See (1), bullet three above.

  - Contribute significantly to understanding the basic biology or ecology of the species.

The proposed research activity involves close approaches (CAs) to animals in the wild, tagging animals with state-of-the-art DTAGs, focal follows (FFs) of animals, and playback (PB) experiments using underwater MF sounds to tagged and non-tagged animals. The DTAG provides continuous unbiased and fine-grained sampling of animal vocal and motor behavior at an unprecedented level. The primary goal of the tagging effort for the proposed research activity is to collect DTAG data on animals before, during and after PBs. These data are beneficial to understanding the basic biology and ecology of the target species (Johnson, 2003; Tyack et al. 2006a) and could potentially further the development of non-invasive monitoring and mitigation techniques such as passive acoustic monitoring (PAM) (Johnson et al. 2004; Madsen et al. 2005; Tyack et al. 2006b, Johnson et al. 2006), and non-invasive methods of detecting and studying marine mammals in the wild. Given even marginal success at any or all of these field research goals, more data will be collected to become a part of the current basic biology and ecology data bases of the target species.

(3) For enhancement activities on marine mammals: Not Applicable.

(4) For enhancement activities involving captive maintenance of threatened, endangered, or depleted species of marine mammals: Not Applicable.

IV.C. METHODS

C.1. Duration of project and location of taking:

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

AUTEC = Atlantic Undersea Test and Evaluation Center

C.2. Types of Activities, Methods and Numbers of Animals or Specimens to be Taken or Imported/Exported

C.2.a. 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, see Subsection IV.C.5. below.
- 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 will 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 this individual-based format, this example would be considered a single “take,” even though the animal was approached three times.

The four categories requested by NMFS are presented in Table IV.C.2-1 and include:

1) “Close approach, **SUCCESSFUL** tag attachment, photo-identification, focal follow, playback”. The term ‘successful’ has been inserted by the applicant to clarify this category

2) “Close approach, **SUCCESSFUL** 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 (no tag attachment) to target animal”. This category includes the animals within the group that contains the animal that the scientists are attempting to tag, or unsuccessful tagging attempts. This value is detailed in Table IV.C-2-2.

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 IV.C.2-4) is listed in the summary table IV.C.2-1.

   For the six targeted species, this value is a combination of intentionally (Table IV.C.2-3) and incidentally (table IV.C.2-4) exposed animals.

Table IV.C.2-1 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 (no tag attachment) 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	113	81
Beaked whales (*Mesoplodon* spp.)	3	2	225	26
Cuvier's beaked whale (*Ziphius cavirostris*)	3	2	150	16
Pilot whales-short finned (*Globicephala macrorhynchus*)	6	3	203	31
Bottlenose dolphin (excluding mid-Atlantic coastal stock) (*Tursiops truncatus*)				18

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 (no tag attachment) 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	263	85
Killer whale (*Orcinus orca*)				11
False Killer whale (*Pseudorca crassidens*)				44
Pygmy killer whale (*Feresa attenuata*)				45
Melon-headed whale (*Peponocephala electra*)	3	2	299	810

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:

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.

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:

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.

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:

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 is not 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 break off. The probability that a CA will 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, we are 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.

The tagging goal for each species is listed in Table IV.C.2-2, 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 (OPR) 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 that we need for success depends on other factors as well.

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 we propose to count animals surfacing within a few body lengths of the focal animal. This subgroup size will be considered to be one-half of the total group size for most species (see Table IV.C.2-2 below). Since the group size of melon-headed whales tends to be much larger, the subgroup size will be considered to be 10 percent of the group size. Therefore, in order to estimate the potential number of incidental CA takes for melon-headed whales, we will multiply the number of tagging attempts by the subgroup size. Otherwise, for the other five species, the estimated number of CA takes equals D/E x F.

Table IV.C.2-2 Estimation of Incidental CA takes for BRS-07—outside of Bahamian territorial seas

A. Taxon	B. Tagging Goal	C. Est. tagging success rate	D. Number of tag attachment attempts: (B/C)	E. Estimated CA success rate	F. Estimated Sub-group size	G. Estimated Number of Incidental CA takes[6] (D / E)*F
Sperm whale	5	40%	13	33%	3	113
***Mesoplodon* spp.**	5	20%	25	33%	3	225
Cuvier's beaked whale	5	20%	25	33%	2	150
Short-finned pilot whale	9	40%	23	33%	3	203
Melon-headed whale	5	40%	13	33%	23	299
Risso's dolphin	5	40%	13	33%	7	263

<u>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:</u>

As can be seen in Table IV.C.2-3 below, the total targeted PB takes is larger than the goal number of PBs for 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; 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 will 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 this 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 will help to determine the thresholds for disturbance to these animals, and will help to estimate what kinds of

[6] Except for melon-headed whales whales, where D x F is used (see Page 63).

exposures elicit what kinds of behavioral reactions. For the purposes of estimating number of incidental harassment takes for this SRP, we will report all animals in the group of the study subject as potential harassment takes during PB experiments. As instructed by NMFS (OPR), 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 IV.C.2-3 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 IV.C.2-3 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 IV.C.2-4). 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, we propose 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/or sperm whales. In order to cover the possibility of unintentional exposure during PB, we are 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 will 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 IV.C.2-4 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 will 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 IV.C.2-1 include these values, as well as the intentional target animal PB take estimates presented in Table IV.C.2-3 above multiplied by 1.5.

Table IV.C.2-4 references:

Claridge D.E. 2006. Fine-scale distribution and habitat selection of beaked whales. University of Aberdeen, pp 127

Mattila, D. K., P. J. Clapham, O. Vasquez, and R. S. Bowman. 1994. Occurrence, population composition and habitat use of humpback whales in Samana Bay, Dominican Republic. Can. J. Zool. 72:1898-1907.

Mobley, J. R. J. 2004. Results of marine mammal surveys on U.S. Navy underwater ranges in Hawaii and Bahamas. Office of Naval Research, Arlington.

Mullin, K. D., and G. L. Fulling. 2004. Abundance of cetaceans in the Oceanic Northern Gulf of Mexico, 1996-2001. Marine Mammal Science 20(4):787-807.

Panigada, S., G. Nortarbartolo di Sciara, M. Panigada, S. Airoldi, J. Borsani, and M. Jahoda. 2005. Fin whales (*Balaenoptera physalus*) summering in the Ligurian Sea: distribution, encounter rate, mean group size and relation to physiographic variables. JCRM 7(2):137-145.

Reilly, S. B., and V. G. Thayer. 1990. Blue Whale *Balaenoptera musculus* Distribution in the Eastern Tropical Pacific. Marine Mammal Science 6(4):265-277.

Schilling, M. R., I. Seipt, M. T. Weinrich, A. E. Kuhlberg, and P. J. Clapham. 1992. Behavior of individually-identified sei whales *Balaenoptera borealis* during an episodic influx into the southern gulf of maine in 1986. U S Natl Mar Fish Serv Fish Bull 90(4):749-755.

Silber, G. K., M. W. Newcomer, P. C. Silber, H. Pérez-Cortés M, and G. M. Ellis. 1994. Cetaceans of the northern Gulf of California: distribution, occurrence, and relative abundance. Marine Mammal Science 10(3):283-298.

C.2.b. Narrative account of research

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 (33-49 ft) to allow for tag attachment and/or photo-identification. Following the recommendations of NMFS (OPR), we are requesting as takes, and will report, all approaches within this range, even though we see no sign of behavioral disruption during many such approaches. 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 will be particularly conservative. Another reason for the conservative approach is that a goal of this research is to define situations associated with disruption of behavior. It is appropriate that this permit authorize any potential takes, because subtle signs of disruption of behavior may be found in post-test analyses.

Tag: 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. It usually takes several of these touches for what we would consider a successful tag attachment. Sometimes when the tag touches the whale, there is no obvious 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 we have 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.

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 activity 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 permitted research will 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 (328-1,640 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

(0.53-1.1 nm). The FF is conducted with a goal of not affecting the behavior of the focal animal. However, following recommendations of NMFS OPR), we are requesting as takes, and will 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): The Phase I PB experiments will 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 animal subject will be limited to less than a maximum sound exposure level, which will be set below levels that might cause injury. We propose a maximum RL at the whale of 170 dB SPL for underwater MF coherent sounds. We will take all scientifically reasonable precautions in controlling the SL of the PBs to ensure the RL at the animal will not exceed the maximum RL above. Before starting each PB, we will 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. See Subsection IV.C.3 of this application for additional research protocol information. 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 (see Subsection IV.D below) is observed at one exposure level, responses at that exposure will be carefully studied before exposure level is increased. This design minimizes the exposure necessary to define the relationship between exposure and possible responses.

Justification of proposed sample sizes

The DTAG2 provides continuous unbiased and fine-grained sampling of animal vocal and motor behavior to an unprecedented level. Data from each set of deployments on a new species have opened up whole new areas for study. For example, once we had tagged 10 sperm whales, we discovered that one adult male fed not in the water column, but within a meter of the seafloor. Once we had tagged several tens of sperm whales, we had a large enough sample size to note several whales bottom feeding, including whales that would feed in the water column and the bottom on the same dive. Similarly, analysis of the diving behavior of the first ten beaked whales tagged revealed an unusual pattern of slow ascent, suggesting there may be some constraint that requires a slow ascent (Tyack et al. 2006a). But by the time we had tagged 15 beaked whales, some individuals broke this mold and surfaced as fast as descent. This means that the slow ascent is unlikely to be driven by constant physical factors, but rather may be context-dependent. If presented the opportunity in the field, these examples show how useful it is to tag multiple individuals of a species. Similarly, the responsiveness of whales to sound stimuli can vary depending upon their age/sex class, the behavioral context, and their experience with similar sounds. Valid prediction from experiments requires covering a broad enough range of these factors.

Baseline tagging also provides data critical for NMFS and others to correct their visual sighting data by a correction factor derived from the dive, surfacing, and blow patterns of the species. Both efforts require a variety of age/sex classes to be tagged, to capture normal variability in their responsiveness and/or diving behavior, and demands a large enough sample size to accurately estimate variation in dive behavior. Each PB is designed so that responses of each subject can be compared to its own pre-exposure behavior. However, it is also useful to verify that the pre-exposure behavior is representative of baseline. All of these considerations suggest an ideal goal of about 20 playbacks (with an estimated 2 occurring outside Bahamian territorial seas). When we can tag more than one animal in a group, this allows us to monitor their distance and social interactions, providing strong benefits for PBs. For sperm whales, we have been able to tag three whales at a time, for beaked whales, two, and for pilot whales, 10. Because of the benefits of this multiple tagging, we account for this number in requested takes.

We are not expecting to tag all these animals. The subjects for each experiment will be determined by the available animals on site at the time of the experiment. Given a duration of 42 experimental days for Phase I (BRS-07), and assuming bad weather on at least half the days, it is unlikely we will be able to conduct more than 20 playbacks total (with an estimated 2 occurring outside Bahamian territorial seas), but not knowing what will be our target species, nor how many animals may be available, we are requesting the full sample size for each species to be able to take full advantage of field opportunities, depending upon what animals we encounter.

The number of estimated takes derives from the number of attempts required to tag and the number of animals that may be taken intentionally and incidentally during each activity. Only a percentage of CAs yield a successful tag attachment, and only a percentage of tag attachments last long enough to obtain sufficient data. We will normally make only three CAs per day to an individual. After that, we will break off and find another individual to attempt to tag. When one approaches a focal animal, other individuals might be near enough to the focal animal to be considered part of the CA. Similarly, when one conducts a PB to a focal whale, other animals in the area may also be exposed to the sounds. One goal of the PBs is to determine what exposures may lead to enough behavioral disruption to constitute a “take” by harassment.

Tagging success rate is broken down into two components. There is the percentage of CAs that yield a tag touch and the percentage of tags that touch the animal and last long enough to be considered a successful attachment. Many of the times when the tag touches the animal and falls off soon thereafter, the vessel approach will only involve a CA and no FF. On the other hand, some animals may not be tagged long enough for us to consider it a fully successful tag attachment, but long enough for us to have started a FF. Our FF protocol is designed so that the observation vessels do not affect the behavior of the followed animals.

We have now been tagging sperm whales with DTAGs for five years and can use past experience to estimate tagging success. About 4 out of 10 tags that touch the animal attach for long enough for PB studies. This yields an attachment success rate of about 40 percent. At this rate, we would need to request 50 tag attachments for these species in order to meet a goal sample size of 20, 100 attachments for a goal of 40. Our success rate in close approaches (CAs) with sperm whales for tagging depends upon how easily approachable they are. For some groups, we may approach several individuals the maximum of three times, with no opportunity to tag. In other situations, the success rate is much higher. On average, one out of three CAs allow us to touch the animal with a tag, yielding a percent success rate for touching an animal with a tag.

Based upon our own experience tagging beaked and pilot whales with the DTAG, we will assume 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 our field work, we estimate 4 CAs are required for one chance to touch an animal with a tag. During our field work with *Ziphius* in the Ligurian Sea, we followed groups that grew to up to 7 individuals. However, animals are often sighted alone. For this BRS, we assume 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 our calculations.

Playback Takes

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, we hope for a sample size of 40 focal tagged individuals (with an estimated 4 occurring outside Bahamian territorial seas) for this Phase I (BRS-07).

We propose 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, we 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. We would continue to increase the RL until an identifiable behavioral reaction was observed. Thereupon, the exposure will 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 will the Research Team propose increasing animal exposure levels. The maximum RL we 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 our potential PB subjects are social and are likely to be sighted in groups. We will obtain as much data as possible from other animals within the group, but the primary unit for statistical analysis will 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 will be estimated by counting all animals within the group of the focal animal as exposed. We will 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 will 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 will 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 our abilities 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 we 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 we assume only one animal subject per PB, so that we can achieve a goal sample size of 20 animal PB subjects by conducting 20 PBs (with an estimated 2 occurring outside of Bahamian territorial seas).

For unintentional (incidental) PB takes, we use 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, we use 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 IV.C.2-4. For the Phase I 2007 research, we have erred on the conservative side with this calculation methodology. Revised calculations will be done for the proposed Phase II 2008 research.

<u>Description of techniques and equipment used to approach and tag animals</u>

(a) The kinds, numbers, and sizes of samples to be taken and the sampling method:

Tissue samples to be taken from marine mammals involve the collection of skin that may adhere to the tags. When tags are recovered, we will carefully inspect for any sloughed skin that may have adhered to the greasy coating of the suction cup used for attaching the tag. Any such skin will be collected for genetic analyses (Amos et al., 1992). Thus the maximum number of samples would equal the number of tagging takes for each species as indicated in Table IV.C.2-2.

Sampling method

The sampling method would be using electronic tags. The DTAG2 is the name we have given to a miniature solid-state acoustic recording tag. We have built two versions of the DTAG. 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. These modifications improve its performance for smaller marine mammals, and those that may produce higher frequency sounds. The DTAG2 has been used successfully for routine tagging of beaked and pilot whales, and 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.

(b) The marks, electronic or visual tags, or other attached instruments to be used, including their dimensions, weights, method of application, location of attachment, the expected duration of attachment, and method of release.

The dimensions of the second version of the tag (DTAG2) are approximately 4.25 in x 1.6 in x 0.9 in (11 cm x 4 cm x 2 cm) for the plain tag, and 8 in x 4.1 in x 1.4 in (20 cm x 10 cm x 4 cm), for the tag in its faired housing. The metric weight of the tag, including attachment, is 330 g (12 oz) in air, and it is slightly buoyant in water. DTAG2 has a modular audio acquisition section and can be assembled with a high performance stereo ADC (24 bits, 192 kHz/channel) suitable for odontocetes other than *Kogia* or porpoises. The sensor suite of DTAG1 has been retained on DTAG2.

We have designed a fairing for odontocetes that has been used successfully with beaked (Johnson et al. 2004, Madsen et al. 2005, Tyack et al. 2006a) and sperm whales (Watwood et al. 2006). 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 DTAG2 are fully programmable. DTAG2 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). We believe that non-invasive attachment mechanisms are the most appropriate to meet our target life of hours to a day or two. The most appropriate non-invasive attachment method for using our 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, we 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. Our 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 will follow a general model. Where possible, an observation and tracking vessel (OV) will use visual observation and acoustic monitoring to follow an animal selected for tagging. The observers will 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) will approach the animal as cautiously as possible while still achieving a position to allow attachment of the tag. During and after attachment, the OV will 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 will recover the tag after it releases from the animal. Where PBs are planned, they will 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. We will take photos of all animals tagged, and where possible, tagging attempts, and tag location on the animal. We will 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 are 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
We 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 hr, and our 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, we have 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 is 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.

(c) Any drugs or other substances to be used, including the name, dosage, purpose, and method of administration.
Not applicable; no drugs will be used under this SRP.

(d) Frequency and period of time each animal may be restrained and the method of restraint.
Not applicable; no animals will be restrained under this SRP.

(e) Methods of tissue sampling and types of samples to be taken from each animal.
See (a) above and Subsection IV.C.5 below.

(f) In the case where unweaned pinniped pups will be taken, identify measures that will be used to ensure pups are returned to their mothers.
Not applicable; no pinniped pups will be taken under this SRP.

<u>Taking of Marine Mammal Parts or Specimen Samples</u>

As described above, tissue samples to be taken from marine mammals involve the collection of skin that may adhere to the tags. When tags are recovered, we will carefully inspect for any sloughed skin that may have adhered to the greasy coating of the suction cup used for attaching the tag. Any such skin will be collected for genetic analysis (Amos et al., 1992) for our own project and collaborators. Thus, the maximum number of samples would equal the goal for animals successfully tagged for each species as indicated in Table IV.C.2-2. Skin samples from beaked whales will be shared between the Bahamas Marine Mammal Research Organization (BMMRO) located in the Bahamas, and Dr. Merel Dalebout, at the University of New South Wales in Australia, who is studying molecular systematic relationships and species diversity in beaked whales. BMMRO is undergoing a study of beaked whale population structure in the Bahamas and Dr. Dalebout is studying molecular systematic relationships and species diversity in beaked whales. Her analysis may be necessary in some cases for species identification, and will help in her research on genetic analysis of population structure of beaked whales. Skin samples of sperm whales will also be made available to Dr. Daniel Engelhaupt of the University of Durham, U.K. Skin samples from other species can be sent to the National Marine Mammal Tissue Bank, or other NMFS-designated research facilities.

IV.C.3. Additional Information for Removing Animals from the Wild into Captivity and Research or Enhancement on Captive or Rehabilitating Animals

Not applicable; no marine mammal will be removed from the wild under this SRP.

IV.C.4. Lethal Take

Not applicable; no intentional or unintended lethal takes are anticipated to occur under this SRP.

No known unintended mortality has arisen from similar tagging or PB activities and none is expected in the research covered under this SRP. The tag attachments we are 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 will be made to ensure that PB exposures do not pose a risk to the subjects, and a primary effort of Phase I will 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 man-made underwater MF sounds. The PBs are designed to define the minimum exposure required to elicit the behavioral responses to be used as an indicator. They will start with low levels of exposure at the subject(s) and will 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 will be monitored in real-time, and RLs at the subject will not be increased if animals show an unusual cessation of vocalization so that we can determine how long it takes the animals to return to normal vocal behavior. The tags will allow us 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.

IV.C.5. 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 griseus*)	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

(c) Statement and documentation of the status of collected materials:

None of the collected materials will involve capturing an animal. They will be small samples of sloughed skin that are byproducts of the tagging, or that may be seen floating in the water and collected with a dip net near where a whale surfaced. Samples will include documentation concerning how the sample was taken, and samples will be taken and held in compliance with the laws of the country of exportation. See IV.C.2.b above for proposed skin sample destinations in and outside the U.S.

IV.D. <u>RESEARCH EFFECTS AND MITIGATION MEASURES</u>

D.1. Effects

The tagging of animals may evoke short behavioral responses such as sudden movement, turning or rolling. The longest effect of tagging we have been able to detect 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).

The goal of the PB experiments is to determine what levels of sound exposure may elicit behavioral reactions that can be used as a safe indicator of risk during and/or after a PB of a series of short transient sounds with low duty cycle. 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. 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 will 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 will 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.

<u>Effects of Incidental Harassment</u>

It is possible that CAs of one animal for tagging might affect the behavior of other animals nearby. In previous tagging experience, we 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. We do not anticipate reactions lasting more than a minute to these incidental approaches. Similarly, when we conduct a FF with a tagged whale, the FF vessel will 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 we anticipate no harassment from this activity.

The primary activity that might cause incidental harassment involves the PB experiments. These experiments are designed so that the FF animal will 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 will 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 will help estimate the potential for incidental harassment at this site.

We request takes under this Phase I (BRS-07) SRP 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 we will use our visual and acoustic monitoring to document any incidental disturbance reactions. Transmissions will 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 will have only minor short-term effects on the individual subjects. The PB experiments will only be detectable over a tiny portion of the seasonal range of the species present in the study area. Therefore, the proposed research will 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 will 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. Our 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 will 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. We follow the PB subjects after exposure to monitor for return to baseline behavior, and we will modify the PB protocol if there is any evidence of longer term changes.

IV.D.2. Measures to Minimize Effects

The basic goal of the PBs covered in this permit is to determine the lowest exposure of transient transmissions of underwater sound, that predictably elicit selected indicator responses from subjects. Our 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 we control in our experiments is the RL of sound at the test subject, and we will model and measure underwater sound propagation to predict and control exposure at the animal.

In the past few years, we started each PB with a SL yielding a relatively low RL at the indicator animal; e.g., a level of 120 dB SPL. After we 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 will be increased either by increasing the SL or by having the PB vessel slowly approach the subject.

Also, acoustic monitors at AUTEC will 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 will record the RLs near the whales. The movement and vocal behavior of beaked whales exposed to underwater MF coherent sound sources will be compared to silent control conditions, and this comparison will be used to help establish minimum exposures associated with detectable reactions, and also with typical high levels of exposure not associated with risk. This will 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 our selection of a maximum exposure level involves our concern not to expose animals to sounds that might cause physiological harm or injury. We recognize that there may be some circumstances where animals will 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 Sound Exposure Level (for definition of SEL, see text box at end of Subsection IV.A above) as the criterion for evaluating exposure in terms of auditory injury.

The primary features we will control in our PB experiments are the duration and RL (SPL) of sound at the test subject, and we will model or measure underwater sound propagation in order to predict and control exposure at the animal. We will establish a maximum RL above which we will 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 our exposures will be below the level indicating a potential for injury, we 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 OPR 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**.

We will establish a maximum RL above which we will 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 we propose, with low duty cycles, we believe 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, we propose a maximum RL of 170 dB for PB signals from underwater coherent MF acoustic sources. We will 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 will 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 will 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 will record the RLs near the whales. The movement and vocal behavior of beaked whales exposed to underwater coherent sounds will be compared to silent control conditions, and this comparison will be used to help establish minimum exposures associated with detectable reactions. This will minimize the potential of any unexpected effects of experimental exposures during BRS activities on the AUTEC range.

The RL at the animal will 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 will typically last 1-3 hr, to complete the range of exposures up to the RL goal should no response be observed.

<u>Necessary vs. unnecessary disturbance</u>

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 our ignorance of sound levels that may cause disturbance. The key for the proposed work is to develop a safe indicator response; this disturbance level will be necessary to inform policy-makers to protect these species. We will 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 US 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 this Phase I SRP application, we propose to not expose animals to levels above those treated as safe by regulatory agencies (in this case, 170 dB SPL).

<u>What will be done to avoid or minimize disturbance?</u>

Our 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. We will 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 we must continue increasing exposure until we detect significant disturbance of a biologically important behavior. Even if we have not detected such a response, we will limit exposure to levels below those thought to pose a risk of injury (in this case, 170 dB SPL). In addition, as discussed above, we plan to limit maximum exposure to within the range that is currently mitigated or treated as safe by regulatory agencies. The maximum exposure level we propose for our Phase I PBs is a RL at the animal of 170 dB SPL for underwater MF coherent sounds. We plan playbacks to last on the order of 1-3 hours to test whether normal behavior may soon resume, even during exposure, and we plan to follow post-exposure behavior carefully to monitor for how long it may take to return to baseline. In the past few years, we 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 will be done if evidence of disturbance is observed?

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 we will break off the CA and select a different subject. If after three CAs, we are not able to attach a tag, we will 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 we obtain evidence of an identifiable behavioral reaction during a PB, we will 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 we can identify and move the OV close enough, we will continue to follow the focal animal and will 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), we will suspend PBs, and communicate with NMFS (OPR) to develop a protocol to ensure that future PBs would limit exposure to levels below those likely to expose animals to any such risk.

IV.D.3. Monitoring effects of activities

What criteria will be used to judge when a disturbance occurs?

Observers will 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 will 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 will come from data from the DTAG2. We will 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 will 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 will 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.

IV.D.4. Alternatives

Explain why there are no feasible alternative methods for obtaining the data or information being sought.

A major goal of this field research is to determine how animals thought to be vulnerable, respond to man-made noise, which is pervasive in their environment. Acoustic monitoring of responses of toothed whales to ongoing anthropogenic sound on the AUTEC range will occur prior to Phase I (BRS-07) of this research. 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 will 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.

IV.E. RESOURCES NEEDED TO ACCOMPLISH OBJECTIVES

Types and operational characteristics of the research vessels

This field work will require vessels to perform several different functions: FF, tag attachment, animal/tag tracking, animal and vessel observation, PB, and acoustic monitoring. In some cases, the same vessel can play more than one role. Functionally, they are:

Tag attachment vessel (TAV)

Tag delivery will be conducted to minimize the potential for disturbing the animal. We propose to use small maneuverable vessels for tag attachment. We 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. We propose 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. We will 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, we will have a data link between them to allow each platform to plot the locations of ships and animals in near-real-time. These data will 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 will 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. We will 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 will be supplemented by the standard AUTEC platform reconstruction data, coupled with the best estimate of animal underwater location from the range hydrophone data.

DTAGs

The sampling method would be using electronic tags. The DTAG is the name we have given to a miniature solid-state acoustic recording tag. We have built two versions of the DTAG. 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.

Passive Acoustic Monitoring (PAM)

A unique resource of the AUTEC range is 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.

In order to use PAM to estimate the location of the whale subjects (particularly beaked whales) at depth, with respect to the sound source, additional underwater acoustic monitoring may be required. If necessary, we propose to use over-the-side PAM hydrophone array(s) with sufficient bandwidth to detect beaked whale clicks at depth. The acoustic signals from the array(s) would be radioed back to the PBV, which would use localization software similar to that installed at AUTEC to locate clicking whales precisely. These locations, coupled with sound propagation models, can be used to control the sound exposure at the animal.

This acoustic localization also can provide real time feedback on acoustic behavior and location of animals during playbacks.

IV.F. PUBLICATION OF RESULTS

The preliminary results in the form of a "Quicklook Report" will be made available to the general public approximately 60 days after Phase I (BRS-07) concludes. A final report is expected to be available in early 2009, which will include the results from both the Phase I (BRS-07) and Phase II (BRS-08) research experiments. In addition, the research results will be published in peer-reviewed scientific journals, such as the Journal of the Acoustical Society of America (JASA), Behavioral Ecology and Sociobiology, Marine Mammalogy, Marine Mammal Science, Acoustics Today, Nature, and Animal Behavior. The results will also be presented at the earliest possible opportunities at scientific seminars and conferences, such as the Acoustical Society of America (ASA), the European Cetacean Society, and the Society for Marine Mammalogy.

V. NEPA CONSIDERATIONS

<u>1. Will the research activity involve equipment or techniques that are new, or may be considered innovative or experimental? If yes, are they likely to be adopted by other researchers in the future?</u>

DTAG2 should be considered to be a relatively new and innovative scientific tool, but has been used extensively with beaked, sperm and pilot whales over the past years. We do not consider the PBs or behavioral response studies to be particularly new, they are well recognized among experts in animal behavior, marine biology and underwater acoustics.

The WHOI research team that has developed the DTAG is collaborating with other scientific and marine biology groups, but have no plans to sell the tag to other researchers. The PBs of the scale proposed here are unlikely to be adopted by many groups – few marine mammal research projects are conducted at the scale of the PBs covered by this SRP.

<u>2. Does the research activity involve the collection, handling, or transport of potentially infectious agents or pathogens, and/or does the activity involve the use or transport of hazardous</u>

substances? If so, provide a description of protocols to be used to ensure human safety from injury or zoonotic disease transmission.

The proposed research activity does not involve the collection, handling, or transport of potentially infectious agents or pathogens, and does not involve the use or transport of hazardous substances. See Subsection IV.C.5. above for information regarding the collection of skin samples and the handling and transport thereof.

3. If any of the research activities occur in or near unique geographic areas, would any aspect of the activities impact the physical environment, such as by direct alteration of substrate?

The AUTEC range in the Bahamas is not considered a unique geographic area, and is of no special importance to any particular species of marine mammals. It is known that the desired species are regularly detected there: beaked whales (Cuvier's and *Mesoplodon* spp.), sperm whales, melon headed whales, pilot whales and Risso's dolphins. Further, no part of the proposed research activity would impact the physical environment.

4. Will the research activity affect entities listed in or eligible for listing in the National Register of Historic Places, or cause the loss or destruction of scientific, cultural, or historic resources?

The proposed research activities will not affect any entities listed in or eligible for listing in the National Register of Historic Places, nor will it cause any loss or destruction of scientific, cultural, or historic resources.

5. Will the research activity include actions that might involve the transportation of any material, biological or otherwise, from one area to another (e.g., transport of animals or tissues, etc.)? If so, explain the types of activities and indicate any measure to prevent the possible introduction or spread of non-indigenous or invasive species.

See Subsection IV.C.5. above for information regarding the collection of skin samples and the handling and transport thereof.

VI. PREVIOUS AND OTHER PERMITS

A. PREVIOUS PERMITS

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.

B. OTHER PERMITS

This research will occur in the EEZ of another nation (Bahamas), and some of it will occur within that nation’s territorial seas. We will apply for the appropriate permits from the foreign controlling authorities for this research. Any import/export of tissue from CITES species will occur with a CITES permit.

VII. REFERENCES

Amos, W., H. Whitehead, M. J. Ferrari, R. Payne, and J. Gordon. 1992. Restrictable DNA from sloughed cetacean skin its potential for use in population analysis. Mar Mammal Sci 8(3):275-283.

Baird R. W., J. F. Borsani, M. B. Hanson and P. L. Tyack. 2002. Diving and night-time behaviour of long-finned pilot whales in the Ligurian Sea. *Marine Ecology Progress Series* 237:301-305

Barco, S. G., W. A. McLellan, J. M. Allen, R. A. Asmutis-Silvia, R. Mallon-Day, E. M. Meacher, D. A. Pabst, J. Robbins, R. E. Seton, W. M. Swingle, M. T. Weinrich, and P. J. Clapham. 2002. Population identity of humpback whales (*Megaptera novaeangliae*) in the waters of the US mid-Atlantic states. Journal of Cetacean Research and Management 4(2):135-141.

Barlow, J., E. Oleson, and M. McDonald. 2000. Deep, harmonic moans associated with Bryde's whales in several locations worldwide. Journal of the Acoustical Society of America 108(5, Pt. 2):2634.

Bearzi, G., R. R. Reeves, G. Notarbartolo di Sciara, E. Politi, A. Cañadas, A. Frantzis, and B. Mussi. 2003. Ecology, status and conservation of short-beaked common dolphins (*Delphinus delphis*) in the Mediterranean Sea. Mammal Review 33(3):224-252.

Berube, M., A. Aguilar, D. Dendanto, F. Larsen, G. Notarbartolo di Sciara, R. Sears, J. Sigurjonsson, R. Urban, and P. Palsbøll. 1998. Population genetic structure of North Atlantic, Mediterranean Sea and Sea of Cortez fin whales, *Balaenoptera physalus* (Linnaeus, 1758): Analysis of mitochondrial and nuclear loci. Molecular Ecology 7:585-599.

Bowles, A. E., M. Smultea, B. Würsig, D. P. DeMaster, and D. Palka. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. J. Acoust. Soc. Am. 96(4):2469-2484.

Buckland, S. T., K. L. Cattanach, and S. Lens. 1992b. Fin whale abundance in the eastern North Atlantic, estimated from Spanish NASS-89 data (IWC SC/43/Ba-2). Report of the International Whaling Commission 42:457-460.

Buckland, S. T., K. L. Cattanach, and T. Gunnlaugsson. 1992a. Fin whale abundance in the North Atlantic, estimated from Icelandic and Faroese NASS-87 and NASS-89 data (IWC SC/F91/F-2). Report of the International Whaling Commission 42:645-651.

Burgess, W. C., P. L. Tyack, B. J. LeBoeuf, and D. P. Costa. 1998. A programmable acoustic recording tag and first results from free-ranging northern elephant seals. Deep Sea Research Part II: Topical Studies in Oceanography 45(7):1327-1351.

Carwardine, M. 2000. Whales, Dolphins and Porpoises. Dorling Kindersley Handbooks. London.

CETAP. 1982. A Characterization of Marine Mammals and Turtles in the Mid- and North Atlantic Areas of the US Outer Continental Shelf, Final Report. No. Ref. No. AA51-CT8-48. Bureau of Land Management, Washington, D.C.

Clapham, P. J., J. Barlow, M. Bessinger, T. Cole, D. Mattila, R. Pace, D. Palka, J. Robbins, and R. Seton. 2003. Abundance and demographic parameters of humpback whales from the Gulf of Maine, and stock definition relative to the Scotian Shelf. Journal of Cetacean Research and Management 5(1):13-22.

Clark, C. W. 1995. Application of U.S. Navy underwater hydrophone arrays for scientific research on whales. Report of the International Whaling Commission 45:210-212.

Cox, T. M., T. J. Ragen, A. J. Read, E. Vos, R. W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernández, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houserp, T. 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. Journal of Cetacean Research and Management 7(3):177-187.

DOC and DON. 2001. Joint Interim Report Bahamas Marine Mammal Stranding Event of 15-16 March 2000.

Department of the Navy (DON). 2001. Final Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. Volume 1. Chief of Naval Operations. Washington, DC. January, 2001.

Donovan, G. P. 1991. A review of IWC stock boundaries. Report of the International Whaling Commission (Special issue 13):39-68.

Etter, P.C. 1991. Underwater Acoustic Modeling: Principles, Techniques and Applications. Elsevier Applied Science, London and New York.

Forcada, J., A. Aguilar, P. S. Hammond, X. Pastor, and R. Aguilar. 1994. Distribution and numbers of striped dolphins in the western Mediterranean Sea after the 1990 epizootic outbreak. Marine Mammal Science 10(2):137-150.

Forcada, J., A. Aguilar, P. S. Hammond, X. Pastor, and R. Aguilar. 1996. Distribution and abundance of fin whales (*Balaenoptera physalus*) in the western Mediterranean Sea during the summer. Journal of Zoology, London 238:23-34.

Forcada, J., G. Notarbartolo di Sciara, and F. Fabbri. 1995. Abundance of fin whales and striped dolphins summering in the Corso-Ligurian Basin. Mammalia 59(1):127-140.

Frankel, A. S. 2005. Gray whales hear and respond to signals 21 kHz and higher. 16th biennial conference on the biology of marine mammals. San Diego.

Frantzis, A., and D. Cebrian. 1998. A rare, atypical mass stranding of Cuvier's beaked whale. Cause and implications for the species' biology. European Research on Cetaceans 12:332-335.

Fulling, G. L., K. D. Mullin, and C. W. Hubard. 2003. Abundance and distribution of cetaceans in outer continental shelf waters of the U.S. Gulf of Mexico. Fishery Bulletin 101:923-932.

Gentry, R. L. 2002. Mass stranding of beaked whales in the Galapagos Islands, April 2000. National Marine Fisheries Service, Silver Spring.

Gisiner, R.C. 1998. Proceedings: Workshop on the Effects of Anthropogenic Noise in the Marine Environment. Office of Naval Research, 141 pp. (I am pretty sure about this one)

Goold, J. C., and P. J. Fish. 1998. Broadband spectra of seismic survey air-gun emissions, with reference to dolphin auditory thresholds. JASA 103(4):2177-2184.

Gordon, J., D. Gillespie, L. E. Rendell, and R. Leaper. 1996. Draft Report on playback of ATOC like sound to Sperm whales (*Physeter macrocephalus*) off the Azores.

Gucu, A. C., G. Gucu, and H. Orek. 2004. Habitat use and preliminary demographic evaluation of the critically endangered Mediterranean monk seal (*Monachus monachus*) in the Cilician Basin (Eastern Mediterranean). Biological Conservation 116(3):417-431.

Gunnlaugsson, T., and J. Sigurjonsson. 1990. NASS-87: Estimation of whale abundance based on observations made onboard Icelandic and Faroese survey vessels. Report of the International Whaling Commission 40:571-580.

Hanson, M. B., and R. W. Baird. 1998. Dall's porpoise reactions to tagging attempts using a remotely-deployed suction-cup attached tag. Marine Technology Society Journal 32(2):18-23.

HESS. 1997. Draft recommendations of the expert panel at the workshop on high-energy seismic sound and marine mammals. Workshop on High-energy Seisimc Sound and Marine Mammals, Pepperdine University, Malibu, CA.

Hohn, A. A., D. S. Rotstein, C. A. Harms, and B. L. Southall. 2006. Report on marine mammal unusual mortality event UMESE0501Sp: Multispecies mass stranding of pilot whales (*Globicephala macrorhynchus*), minke whale (*Balaenoptera acutorostrata*), and dwarf sperm whales (*Kogia sima*) in North Carolina on 15-16 January 2005. No. NOAA Technical Memorandum NMFS-SEFSC-537.

Horwood, J. 1987. The Sei Whale: Population biology, ecology and management. Croom Helm, New York.

Jefferson, T., Leatherwood, S., Webber, M. 1993. Marine Mammals of the World. FAO UNEP, Rome, Italy.

Johnson, J.S. 2003. Presentation: SURTASS LFA Environmental Compliance Experience. Chief of Naval Operations (N774T). 16 May 2003.

Johnson, M., P. T. Madsen, W. M. X. Zimmer, N. A. de Soto, and P. L. Tyack. 2004. Beaked whales echolocate on prey. Proceedings of the Royal Society of London Series B-Biological Sciences 271:S383-S386.

Johnson, M., Madsen P.T., Zimmer W.M.X., Aguilar de Soto N., Tyack P.L. 2006. Foraging Blainville's beaked whales (*Mesoplodon densirostris*) produce distinct click types matched to different phases of echolocation. *Journal of Experimental Biology* 209:5038-5050.

Kastak, D., R. J. Schusterman, B. L. Southall, and C. J. Reichmuth. 1999. Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. Journal of the Acoustical Society of America 106(2):1142-1148.

Leatherwood, S., D.K. Caldwell, and H.E. Winn. 1976. Whales, dolphins, and porpoises of the western North Atlantic: a guide to their identification. NOAA Technical Report, National Marine Fisheries Service Circular 396.

Leatherwood, S., and R. R. Reeves. 1983. The Sierra Club Handbook of Whales and Dolphins. Sierra Club Books, San Francisco, CA.

MacLeod C.D., D'Amico A. (2006) A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise. *J. Cetacean Res. Manage*. 7:211-221

Madsen, P. T., M. Johnson, N. Aguilar de Soto, W. M. X. Zimmer, and P. Tyack. 2005. Biosonar performance of foraging beaked whales (*Mesoplodon densirostris*). J Exp Biol 208(2):181-194.

Madsen, P. T., M. Johnson, P. J. O. Miller, N. S. Aguilar, J. Lynch, and P. Tyack. 2006. Quantitative measures of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. The Journal of the Acoustical Society of America 120(4):2366-2379.

Malakoff, D. 2001. New sensors provide a chance to listen to the leviathan. Science 291(5504):577.

Malakoff, D. 2002. SEISMOLOGY: Suit Ties Whale Deaths to Research Cruise. Science 298(5594):722 - 723

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1983. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior/Phase I. BBN Rep. 563. Rep. from Bolt, Beranek, & Newman, Inc., Cambridge, MA, for U.S. Minerals Management Service, Anchorage, AK. Various pages NTIS PB-86-174174.

Malme, C. I., P. R. Miles, C. W. Clark, P. L. Tyack, and J. E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior, Phase II. No. 5586, for US MMS (NTIS PB86-218377). Bolt, Beranek and Newman.

Malme, C.I., P.R. Miles, P. Tyack, C.W. Clark, and J.E. Bird. 1985. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior/Phase II: January 1984 migration. BBN Rep. 586. Rep from Bolt, Beranek, & Newman, Inc., Cambridge, MA, for U.S. Minerals Management Service, Anchorage, AK. Various pages NTIS PB-86-218377.

Maybaum, H. 1993. Responses of humpback whales to sonar sounds. JASA 94(3):1848-1849.

McCauley, R. D., M.-N. Jenner, C. Jenner, K. A. McCabe, and J. Murdoch. 1998. The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: preliminary results of observations about a working seismic vessel and experimental exposures. APPEA Journal:692-706.

McGregor, P. K. 1992. Playback and Studies of Animal Communication. Plenum Press, New York.

Miksis, J. L., M. D. Grund, D. P. Nowacek, A. R. Solow, R. C. Connor, and P. L. Tyack. 2001. Cardiac responses to acoustic playback experiments in the captive bottlenose dolphin (*Tursiops truncatus*). Journal of Comparative Psychology 115(3):227-232.

Mitchell, E., and D. G. Chapman. 1977. Preliminary assessment of stocks of northwest Atlantic sei whales (*Balaenoptera borealis*). Report of the International Whaling Commission Special Issue 1:117-120.

Moore, M., C. Miller, M. Moss, R. Arthur, W. Lange, K. G. Prada, M. Marx, and E. Frey. 2001. Ultrasonic measurement of blubber thickness in right whales. JCRM Special Issue 2.

Mullin, K. D., and G. L. Fulling. 2003. Abundance of cetaceans in the southern U.S. North Atlantic Ocean during summer 1998. Fishery Bulletin 101(3):603-613.

Mullin, K. D., and G. L. Fulling. 2004. Abundance of cetaceans in the oceanic northern Gulf of Mexico, 1996-2001. Marine Mammal Science 20(4):787-807.

National Research Council. 1994. Low-frequency sound and Marine Mammals. National Academies Press, Washington, DC.

National Research Council. 2000. Marine Mammals and low-frequency sound: Progress since 1994. National Academies Press, Washington, DC.

National Research Council. 2003. Ocean Noise and Marine Mammals. National Academies Press, Washington, DC.

National Research Council. 2005. Marine Mammal Populations and Ocean Noise : Determining when noise causes biologically significant effects. National Academies Press, Washington, DC.

NMFS. 2003. Taking and Importing Marine Mammals: Taking marine mammals incident to conducting oil and gas expolration activites in the Gulf of Mexico. Federal Register 68(41):9991-9996.

Oleson, E. M., J. Barlow, J. Gordon, S. Rankin, and J. A. Hildebrand. 2003. Low frequency calls of Bryde's whales. Marine Mammal Science 19(2):407-419.

Palsbøll, P. J., M. Bérubé, A. Aguilar, G. Notarbartolo di Sciara, and R. Nielsen. 2004. Discerning between recurrent gene flow and recent divergence under a finite-site mutation model applied to North Atlantic and Mediterranean Sea fin whale (*Balaenoptera physalus*) populations. Evolution 58(3):670-675.

Reeves, R. R., B. S. Stewart, P. J. Clapham, and J. A. Powell. 2002. National Audubon Society Guide to Marine Mammals of the World. Alfred A. Knopf, New York, NY.

Reeves, R., and G. Notarbartolo di Sciara, (eds.). 2006. The status and distribution of cetaceans in the Black Sea and Mediterranean Sea. IUCN Centre for Mediterranean Cooperation, Malaga, Spain.

Reid, J. B., P. G. H. Evans, and S. P. Northridge. 2003. Atlas of cetacean distribution in north-west European waters. Joint Nature Conservation Committee, Peterborough, U.K.

Rendell, L. E., and J. C. D. Gordon. 1999. Vocal response of long-finned pilot whales (*Globicephala melas*) to military sonar in the Ligurian Sea. Marine Mammal Science 15(1):198-204.

Ridgway, S. H., and S. R. Harrison, eds. 1985. Handbook of Marine Mammals. Academic Press Inc., London.

Ridgway, S., D. Carder, C. Schlundt, T. Kamolnick, and W. Elsberry. 1997. Temporary shift in delphinoid masked hearing thresholds. The Journal of the Acoustical Society of America 102(5):3102.

SACLANTCEN. 1998. Summary Record: SACLANTCEN Bioacoustics panel. La Spezia.

Schlundt, C. E., J. J. Finneran, D. A. Carder, and S. H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. Journal of the Acoustical Society of America 107(6):3496-3508.

Schneider, K., R. W. Baird, S. Dawson, I. Visser, and S. Childerhouse. 1998. Reactions of bottlenose dolphins to tagging attempts using a remotely deployed suction cup tag. Marine Mammal Science 14(2):316-324.

Simmonds, M. P., and L. F. Lopez-Jurado. 1991. Whales and the military. Nature 351(6 June).

Southall, B. L., R. Braun, F. M. D. Gulland, A. Heard, R. Baird, S. Wilkin, and T. Rowles. 2006. Hawaiian melon-headed whale (*Peponacephala electra*) mass stranding event of July 3-4, 2004. No. NMFS-OPR-31. National Marine Fisheries Service, Silver Spring.

Stevick, P. T., J. Allen, P. J. Clapham, N. Friday, S. K. Katona, F. Larsen, J. Lien, D. K. Mattila, P. J. Palsbøll, J. Sigurjonsson, T. D. Smith, N. Øien, and P. S. Hammond. 2003. North Atlantic humpback whale abundance and rate of increase four decades after protection from whaling. Marine Ecology Progress Series 258:263-273.

Stone, C. 2001. Marine Mammal observations during seismic surveys in 1999. No. 316. JNCC, Peterborough.

Swingle, W. M., S. G. Barco, T. D. Pitchford, W. A. McLellan, and D. A. Pabst. 1993. Appearances of juvenile humpback whales feeding in the nearshore waters of Virginia. Marine Mammal Science 9(3):309-315.

Thode, A., D. K. Mellinger, S. Stienessen, A. Martinez, and K. Mullin. 2002. Depth-dependent acoustic features of diving sperm whales (*Physeter macrocephalus*) in the Gulf of Mexico. The Journal of the Acoustical Society of America 112(1):308-321.

Torres, L. G., P. E. Rosel, C. D'Agrosa, and A. J. Read. 2003. Improving management of overlapping bottlenose dolphin ecotypes through spatial analysis and genetics. Marine Mammal Science 19(3):502-514.

Tyack, P. L., and C. W. Clark. 1998. Quicklook - Playback of low-frequency sound to gray whales migrating past the central California coast in January 1998.

Tyack, P. L., M. Johnson, N. A., Soto, A. Sturlese, and P. T. Madsen. 2006a. Extreme diving behaviour of beaked whale species known to strand in conjunction with use of military sonars. *J Exp Biol* 209(21):4238-4253.

Tyack, P. L., Johnson M., Zimmer W.M.X., Aguilar de Soto N., Madsen P.T. 2006b. Acoustic Behavior of beaked whales, with implications for acoustic monitoring. *Oceans 2006*.

Waring, G. T., E. Josephson, C. P. Fairfield, and K. Maze-Foley. 2006. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2005. No. NOAA Technical Memorandum NMFS-NE-194. Northeast Fisheries Science Center, NMFS, NOAA, U.S. Dept. of Commerce, Woods Hole, MA.

Watkins, W. A. 1986. Whale Reactions to Human Activities in Cape Cod Waters. Mar Mamm Sci 2(4):251-262.

Watkins, W. A., K. E. Moore, and P. Tyack. 1985. Sperm Whale Acoustic Behaviors in the Southeast Caribbean. Cetology 45:1-15.

Watwood, S. L., P. J. O. Miller, M. Johnson, P. T. Madsen, and P. L. Tyack. 2006. Deep-diving foraging behaviour of sperm whales (*Physeter macrocephalus*). Journal of Animal Ecology 75(3):814-825.

Weinrich, M. T., R. H. Lambertson, C. R. Belt, M. R. Schilling, H. J. Iken, and S. E. Syrjala. 1992. Behavioral Reactions Of Humpback Whales *Megaptera novaeangliae* to Biopsy Procedures. U S Natl Mar Fish Serv Fish Bull 90(3):588-598.

Whitehead, H. 1996. Babysitting, dive synchrony, and indications of alloparental care in sperm whales. Behav. Ecol. Sociobiol. 38(237-244).

VII. CERTIFICATION AND SIGNATURE

"I hereby certify that the foregoing information is complete, true, and correct to the best of my knowledge and belief. I understand that this information is submitted for the purpose of obtaining a permit under one or more of the following statutes and the regulations promulgated thereunder, as indicated in Section I of this application:

- The Endangered Species Act of 1973 (16 U.S.C. 1531-1543) and regulations (50 CFR 222.23(b)); and/or
- The Marine Mammal Protection Act of 1972 (16 U.S.C. 1361-1407) and regulations (50 CFR Part 216); and/or
- The Fur Seal Act of 1966 (16 U.S.C. 1151-1175).

I also understand that any false statement may subject me to the criminal penalties of 18 U.S.C. 1001, or to penalties provided under the Endangered Species Act of 1973, the Marine Mammal Protection Act of 1972, or the Fur Seal Act of 1966, whichever are applicable."

APPLICANT SIGNATURE: ____________________________

PRINT NAME: Dr. John Boreman

TITLE: Director, Office of Science and Technology, NMFS

DATE: 6 April 2007