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14. ABSTRACT This project proposed to make visual tracks of migrating whales to validate performance of a whalefinding sonar developed by Scientific Solutions, measure target strength of gray whales and study responses of migrating gray whales to the whalefinding sonar by using a theodolite on shore to observe and track individual whales as they migrate past the ship that would operate a high frequency whalefinding sonar. Due to a legal challenge to the process used by NMFS in issuing the research permit, testing of the whalefinding sonar was prevented, and the field team collected baseline data on the whale migration. In consultation with the program manager, the rest of the research effort was devoted to developing new analysis techniques for increasing the statistical power of controlled exposure experiments. These techniques were developed with a separate data set involved controlled exposures of mid-frequency sonar signals to deep diving sperm whales.					
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FINAL REPORT

DISTRIBUTION STATEMENT A

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Grant number: N00014-03-1-0334

PRINCIPAL INVESTIGATOR:

Dr. Peter L. Tyack

GRANT TITLE: Sonar Validation Study with Migrating Gray Whales

AWARD PERIOD: 15 January 2003 - 30 September 2005

OBJECTIVE: There were three primary objectives of this project:

- 1) Make visual tracks of migrating whales to validate performance of a whalefinding sonar developed by Scientific Solutions.
- 2) Measure target strength (ideally as a function of aspect) of gray whales
- 3) Study responses of migrating gray whales to the whalefinding sonar.

APPROACH:

The technical approach builds upon a well established experimental setting. This involves mooring a ship near the coastal waters of California where gray whales migrate during the winter and spring. Observers on shore use a theodolite to track individual whales or groups of whales as they migrate past the ship. In the proposed work, the ship would operate a high frequency whale-finding sonar. The shore observations both provide ground-truth data tracking the location of all the whales passing by the ship, and also provide a method that has proven sensitive for detecting avoidance responses of whales that hear a sound source.

ACCOMPLISHMENTS:

The field work was planned for January 2003 near Point Buchon California. Tyack amended his federal permit for scientific research on marine mammals to include this project, and he briefed the California Coastal Commission on the research. We assembled a field team to man two shore stations with theodolites to track the whales. The field team started collecting baseline whale tracks before the source vessel appeared, but before the source could operate, Lanny Sinkin of Hawaii requested from the US 9th District Court, a temporary restraining order to prevent testing of the whalefinding sonar. Judge Conti of the 9th district issued first a temporary and then a permanent injunction blocking the proposed research. The judge took issue with process used by NMFS in issuing the amendment to Tyack's permit. While the initial permit and an earlier amendment had been accompanied by an environmental assessment under NEPA, the NMFS Office of Protected Resources had determined that another EA was not necessary for this amendment. The judge ruled that all permits and amendments which might be viewed as controversial were required to be backed up by NEPA paperwork.

Due to uncertainties about the status of whether the project would be allowed to proceed, the shore observer team remained on site, and collected baseline data on the whale migration. The cost of the field effort thus could not be reduced during the legal proceedings. However, funds that would have been required for analyses to meet the original

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three objectives was redirected after consultation with the program manager to analyzing data from previous controlled exposure experiments.

This challenge not only blocked the proposed research, but also invalidated Tyack's permit, which was required for other funded projects as well. The requirements to attend two court hearings, and the preparation of a new permit, which was required because of the challenge against the proposed research, consumed considerable funds.

After consultation with the program manager, the remaining funds were redirected to help support the writing of a paper on controlled exposure experiments in general, and an analysis of previously collected data of a series of controlled exposure experiments on sperm whales using a mid-frequency sonar. There were only four such experiments, one per year over four years, and the goal of the new analyses was to extract as much statistical power from each experiment. Tyack worked with a WHOI/MIT Joint Program Student Ari Shapiro, and Andrew Solow of the Marine Policy Center at WHOI to develop a statistical model of how avoidance might scale with received level during each of these CEEs. The results are very promising and a paper is nearing completion for submission to a peer reviewed journal. These new methods promise significantly more statistical power from CEEs, each of which is expensive and time consuming.

CONCLUSIONS:

The lawsuit prevented the proposed research from being able to reach conclusions regarding the initial objectives regarding whale-finding sonars and gray whales. However, the lawsuit resulted in strong interest on the part of Congress and others, who expressed solid support for this kind of research. After the field work could not be carried out as planned, funding was redirected to analysis of existing data from CEEs of mid-frequency sonar sounds to sperm whales, and to more general work on controlled exposure experiments. The work to develop more powerful statistical models of responses of individual whales to exposures over an hour or so has been successful, and leads us to conclude that much more response information can be extracted from individual experiments, greatly expanding their power.

SIGNIFICANCE:

The results of the lawsuit significantly changed the way the federal government permits research on marine mammals, forcing extensive analysis and paperwork under NEPA for every permit and amendment. The year after the research proposed here, the PI of the whalefinding sonar test redid the experiment without WHOI involvement, was challenged again in court by the same plaintiffs, and won the case, demonstrating that the response by NMFS and the researchers involves fully addressed the issues raised in the earlier case. Congress demonstrated significant concern about the outcome of the initial case by requesting a series of testimony, and demonstrated significant support for this kind of research. The scientific work under this grant accentuates the power of controlled experimental techniques to evaluate behavioral responses of marine mammals to sound, and highlights the importance of further development of methods and models to evaluate the biological significance of responses observed. The new analyses developed under this grant for evaluating responses of individual tagged whales to a series of short exposures highlights the promise of techniques that use

sensitive continuous measures of exposure and behavioral response to provide more detailed and powerful results describing how the response of an individual subject varies with the varying exposure history during a single experiment.

PATENT INFORMATION: N/A

AWARD INFORMATION: N/A

PUBLICATIONS AND ABSTRACTS:

Peer reviewed 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. Animal Social Complexity: Intelligence, Culture, and Individualized Societies. Harvard University Press

Papers in peer-reviewed scientific journals:

- 2004 Tyack, P; Gordon, J. and D. Thompson. Controlled exposure experiments to determine the effects of noise on large marine mammals. Marine Technology Society Journal, 37(4): 41-53.
- 2003 Zimmer W. M.X., M. P. Johnson, A. D'Amico, P. L. Tyack. 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.
- 2003 Johnson M. and P. L. Tyack A Digital Acoustic Recording Tag for Measuring the Response of Wild Marine Mammals to Sound. IEEE Journal of Oceanic Engineering 28:3-12.

Papers in prep:

- Shapiro, A., Solow, A. and P. L. Tyack. Analysis of orientation response of two sperm whales to controlled sonar exposures. For Proc Roy Soc B.

Technical Reports

Research Program to evaluate effects of manmade noise on marine mammals in the Ligurian Sea. Report to Scientific Committee of ACCOBAMS for discussion at Istanbul, Turkey. 19 November 2003.

Testimony to Congress (requested in part because of impact of lawsuit on research)

- 2003 Testimony to U.S. House of Representatives Committee on Resources Subcommittee on Fisheries Conservation, Wildlife,

and Oceans concerning reauthorization of the Marine Mammal Protection Act. 24 July 2003

- 2003 Testimony to the U.S. Senate Committee on Commerce, Science, and Transportation, Subcommittee on Oceans, Fisheries and Coast Guard concerning reauthorization of the Marine Mammal Protection Act. 16 July 2003
- 2003 Testimony to U.S. House of Representatives Military Readiness Subcommittee of the House Armed Services Committee concerning modification of the Marine Mammal Protection Act. 15 March 2003

Symposia Chaired:

Chaired session entitled The Effect of Man-Made Sound on Marine Mammals at the 138th meeting of the Acoustical Society of America, New Orleans 4 Nov 1999.

Co-chaired session with Peter GH Evans entitled Ziphiids and active sonar - research priorities to reduce risk to beaked whales from military sonar. Workshop associated with 19th annual conference of the European cetacean Society, La Rochelle France, 3 April 2005

Presentations:

- 2003 Tracking Responses of Sperm Whales to Experimental Exposures of Air Guns, Information Transfer Meeting, Minerals Management Service, New Orleans, 15 January 2003
- 2003 Controlled exposure experiments to determine safe exposure for beaked whales. Workshop on Active Sonar and Cetaceans, European Cetacean Society, Las Palmas, Canary Islands Spain, 8 March 2003
- 2003 "Responses of DTAGed Sperm Whales to CEE." Environmental Consequences of Underwater Sound Workshop/Symposium, San Antonio Texas, May 16, 2003.
- 2005 Environmental Consequences of Underwater Sound Symposium, 17 March 2005
- 2004 2005 Controlled Exposure Experiments with Sonar. Intergovernmental Conference on The Effects of Sound in the Ocean on Marine Mammals, Lerici, Italy, 3 May 2005