

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE 2008		2. REPORT TYPE		3. DATES COVERED 00-00-2008 to 00-00-2008	
4. TITLE AND SUBTITLE Cetaceans and Naval Sonar: Behavioral Response as a Function of Sonar Frequency (WHOI)				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA, 02543				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Cetaceans and Naval Sonar: Behavioral Response as a Function of Sonar Frequency

Peter L. Tyack

Woods Hole Oceanographic Institution

266 Woods Hole Road, MS #50

Woods Hole MA 02543

phone: (508) 289-2818 fax: (508) 457-2041 email: ptyack@whoi.edu

Grant Number: N00014-08-1-0661

LONG-TERM GOALS

This is an international cooperative research program to quantify the behavioral reactions of cetaceans and herring to controlled presentations of military sonar signals at 2 different frequencies (LFAS:1-2 kHz and MFAS:6-7 kHz), and relevant control sounds within Norwegian waters. The ultimate goal is to use these data to help establish safety limits for sonar operations.

OBJECTIVES

The targeted species are herring and killer whales, through we will also opportunistically study pilot and minke whales as well as other deep-diving odontocetes. Specific research tasks are:

1. Determination of behavioral response thresholds by approaching a tagged whale while transmitting sonar signals until a behavioral reaction is observed.
2. Description of behavior during sonar exposures versus baseline and controls, and interpretation of the biological significance of any observed behavioral change.
3. Exploration of how response thresholds vary at different sonar frequencies, and in relation to reported hearing thresholds at the tested frequencies.
4. Continued monitoring of killer whale usage of the Vestfjord basin in relation to FLOTEx naval exercises, to relate reactions to experimental sonar exposure with possible effects from actual exercises.

APPROACH

The approach for this research involves a research cruise with the following tasks:

Primary tasks:

1. Tag several species of cetaceans with sensors recording behavior (DTAG or Norwegian tag), and thereafter execute controlled exposure experiments (CEE) where the tagged animals are exposed to acoustic signals simulating LFAS and MFAS signals.

2. Execute control experiments where tagged animals are either approached by the sonar ship but without any active transmission, or killer whale sound playback experiments.

3. Expose herring feeding in the area to LFAS, MFAS and orca signals while monitoring behavioral reactions of the herring using high frequency sonars.

Secondary tasks:

1. Do CTD and XBT measurements in the study area.

2. Tag animals and record natural undisturbed behavior.

Part of the work of the WHOI team will not only involve helping analyze data from this field work, but also integration of results with other research programs.

WORK COMPLETED

The 2008 cruise used the RV Sverdrup II, with the Socrates sound source capable of broadcasting LFAS at 209 dB re 1 μ Pa at 1m and MFAS at 197 dB re 1 μ Pa at 1m. The weather was excellent with 16 days of SS 0-2, 5 borderline days with SS3, and only two unworkable days with SS>3. There were a total of 26 Dtag deployments (96 h of tag recordings) to killer, pilot and sperm whales, with 9 MFAS, 7 LFAS, 2 orca and 5 silent control playbacks. 14 pilot whales were Dtagged, and 4 CEEs were conducted with tagged pilot whales. These involved playbacks of MFAS-LFAS, LFAS-MFAS-silent, and two Silent-LFAS-MFAS. Three sperm whales were tagged, with one MFAS-LFAS + baseline CEE. One killer whale was tagged and one MFAS-LFAS-Silent-ORCA-MFAS + baseline CEE was conducted. 6 CEEs of LFAS-MFAS-Silent and 3 orca playbacks were also conducted with herring.

RESULTS

A clear response was found for herring exposed to killer whale playbacks. Some part of the herring school separated from the main school and there was a general increase in the depth of the school. There was an increase in swim speed of the herring near the ship and towed sound transducer independent of the signal type (including silent approaches). This response is probably to the hydrodynamic signal generated from the ship and/or tow body. Responses of the cetaceans to CEEs are being analyzed. Playbacks to killer whales in both 07 and 08 demonstrated avoidance responses to MFAS, but much weaker responses to LFAS.

IMPACT/APPLICATIONS

The success of this project in achieving large numbers of playbacks for several stimulus types and several species affirms the role of CEEs in effects studies. This project continues to build a strong international team, platform, and technology with excellent skills for developing and conducting studies on the effect of sonar on marine life. The results show little adverse effect of sonar on herring, and the differential response of killer whales to low vs mid-frequency sonar suggests potential use of frequency as a mitigation measure.

RELATED PROJECTS

Behavioral Response of Odontocetes to Playback of Anthropogenic and Natural Sounds (N00014-07-1-0988) is part of a collaborative research program that aims to study how tagged beaked whales respond to mid-frequency sonar compared to control sounds, and to compare responses of beaked whales vs other odontocetes to playbacks of mid-frequency sonar sounds vs other anthropogenic signals. Ultimately the study aims to define dose: response curves for risk to beaked whales and other whales for exposure to naval sonars, and to suggest improvements for mitigation.

PUBLICATIONS

Shapiro, A. D., Tyack, P. L., and Solow, A. R. Testing for orientation responses of individual sperm whales to a varying sonar exposure level. *Journal of Theoretical Biology*. [refereed]

Tyack, P. Implications for marine mammals of large-scale changes in the marine acoustic environment. *Journal of Mammalogy* 89:549-558. [published, refereed]

Nowacek D. P., Thorne L. H., Johnston D. W., Tyack P. L. Responses of cetaceans to anthropogenic noise. *Mammal. Review* 37:81-115. [published, refereed]

Ciany, C. M., Rooney, J. III, Zurawski W. C., and Tyack, P. The Validation of Novel Mid-Frequency Sonar Signals Design to Reduce the Impact on Marine Mammals. *Journal of Underwater Acoustics* [refereed]