REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED
21-05-2004	Final Report	8/12/02 - 4/15/03

4. TITLE AND SUBTITLE
Analysis of Acoustic Data Under Response of Sperm whales to Air Gun Sounds in the Gulf of Mexico

5a. CONTRACT NUMBER

5b. GRANT NUMBER
N00014-02-1-0187

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
MPL/SIO/UCSD
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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
800 N. Quincy St.
Arlington VA 22217-5000

10. SPONSOR/MONITOR'S ACRONYM(S)
ONR

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AILABILITY STATEMENT
Distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
Self-explanatory

20040526 050

15. SUBJECT TERMS
sperm whale, ocean acoustics, inversion, tracking, marine mammals

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Aaron Thode
Unclass.	Unclass.	Unclass.	UL		19b. TELEPHONE NUMBER (Include area code) 858-822-4864

FINAL REPORT

GRANT #: N00014-02-1-0187 (see also N00014-02-1-0448)

PRINCIPAL INVESTIGATOR: Aaron M Thode

INSTITUTION: Marine Physical Laboratory, Scripps Institution of Oceanography

GRANT TITLE: Analysis of Acoustic Data Under Response of Sperm Whales to Air Gun Sounds in the Gulf of Mexico

AWARD PERIOD: 12 August 2002 - 15 April 2003

OBJECTIVE: To field-test an automated procedure for passively tracking sperm whales in three-dimensions, using natural vocalizations recorded on two towed arrays, deployed either alone or in conjunction with dive tags. The algorithms would permit automated tracking of multiple animals over complete dive cycles, producing statistically significant sample sizes for evaluation of controlled-exposure studies. When used in conjunction with a dive tag, the algorithm would permit better resolution tracking of animals detected on both the tag in array, effectively increasing the number of animals tracked by the tag.

APPROACH: Previous work by the PI had shown that 3D tracking of sperm whales is possible using a single towed array, using multi-path reflections from the ocean surface and bottom. However, the resulting algorithm was difficult to automate and required substantial effort by a human, yielding only one 3D trajectory per ten hours of work. In addition, the bottom returns were detected only sporadically, during times when the animals were in their initial descent to presumed foraging depth. During feeding and/or social behavior the bottom returns are usually absent.

To overcome these difficulties, a new algorithm was been developed, using two spatially-separated towed arrays deployed from a single vessel to record both the direct and surface reflections of sounds. The automated detection and classification of direct and surface paths is considerably simpler than that required for bottom returns, but requires information about the array depths to be effective. The results would have lower depth resolution than those obtained using bottom returns, but could be computed automatically, reducing the processing time to an estimated 15 minutes per trajectory. Thus the technique is designed to produce large numbers of low-resolution tracks, as opposed to a single high-resolution track generated by an tagged animal. The technique will also only work on acoustically active animals.

If one of the animals present has an acoustic tag, the algorithm can be extended to time-sync the tag with the array record, effectively creating a large-aperture array. This approach would provide much more precise localizations of all vocalizing animals, at the cost of requiring a tagged animal to be present.

ACCOMPLISHMENTS: The localization algorithms were written and tested in simulation in 2002, under ONR grant N00014-02-0448. The automated data extraction algorithms were written using both MATLAB and the software package Ishmael (written by David Mellinger of Oregon State University under ONR support). The algorithms were successfully tested on field data in 2002 and 2003 under this grant and support from the Minerals Management Service (MMS). A peer-reviewed publication has resulted from this work, and MMS and the North Pacific Research Board (NPRB) are currently funding research that exploits this technique.

CONCLUSIONS: The use of surface-reflected multipath to track sperm whales in range in depth has been found to be a robust technique that can be used with either a towed horizontal array or a bottom-mounted vertical array. The technique was found to be easily automated, using standard signal-processing software found in the public domain.

SIGNIFICANCE:
The demonstration of the technique is expected to yield 1-3 trajectories per half-hour of recording time, if a group of animals is being followed. Over the course of a night (7 hours) one might reasonably expect to obtain at least 25 tracks, a credible sample size for studying variables such as dive descent time, maximum depth obtained, and the depth at which "creak" sounds begin. The success of this algorithm would provide an inexpensive and rapid way of collecting statistically significant numbers of animal track for future environmental impact studies conducted by the division and other interested parties. Some of these predictions are being tested in the Gulf of Mexico in 2004, as part of the Sperm Whale Seismic Study (SWSS).

The algorithm used here is also being use to examine how sperm whales remove fish from longline fishing gear in the Gulf of Alaska, to gain insight into possible means of reducing the depredation without harming the animals.

AWARD INFORMATION: Work presented here lead to contracts with MMS and the North Pacific Research Board (North Pacific F0412) to apply the results of this research to sperm whale behavioral studies.

RELEVENT PUBLICATIONS AND ABSTRACTS:

1. Thode, A., Millinger, D.K., Martinez, A. (2002) Passive three-dimensional tracking of sperm whales using two towed arrays during the 2001 SWAMP cruise. Abstract presented at Dec 2002, Acous. Soc. Am. 144th conference proceedings, Cancun, Mexico.

2. Thode, A (2004) Tracking sperm whale (Physeter macrocephalus) dive profiles using a towed passive acoustic array. J. Acous. Soc. Am., in press.