

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188		
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PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.						
1. REPORT DATE (DD-MM-YYYY) 15-04-00		2. REPORT DATE Final		3. DATES COVERED (From - To) 01-06-98 to 30-09-99		
4. TITLE AND SUBTITLE Acoustic ecology and remote acoustic monitoring of a minke whale population				5a. CONTRACT NUMBER		
				5b. GRANT NUMBER N00014-98-1-0859		
				5c. PROGRAM ELEMENT NUMBER		
				5d. PROJECT NUMBER		
6. AUTHOR(S) Gedamke, Jason Costa, Daniel P.				5e. TASK NUMBER		
				5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of California at Santa Cruz Santa Cruz, CA 95064				8. PERFORMING ORGANIZATION REPORT NUMBER Org. 447627 Fund 22701		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Office of Naval Research Program Officer Robert Gisinier ONR 335 Ballston Centre Tower One 800 N. Quincy St. Arlington, VA 22217-5660				10. SPONSOR/MONITOR'S ACRONYM(S) ONR		
				11. SPONSORING/MONITORING AGENCY REPORT NUMBER		
12. DISTRIBUTION AVAILABILITY STATEMENT Approved for public release						
13. SUPPLEMENTARY NOTES						
14. ABSTRACT Sound is the most effective means of communication in the ocean. A uniquely inquisitive minke whale population on the northern Great Barrier Reef presents an unprecedented research opportunity to study minke acoustics. In 1997, we used vessel-based recordings to link the minke to a wide variety of sounds. In 1998 and 1999, we expanded the study to include a remote acoustic array to monitor and track one particularly interesting vocalization that can be used for long distance communication. Our vessel-based recordings have given us the largest database of minke sounds yet reported. By matching the acoustics with observed behaviors, group structure and identification data, we are beginning to shed light on the possible functions of these sounds. Our remote array work is revealing how these sounds are used over larger scales by allowing us to localize and track the movements of vocalizing animals. We have been able to look at the physical and acoustic interaction between multiple vocalizing whales for distances of over 5 km and times longer than 2 hours.						
15. SUBJECT TERMS Acoustics, tracking, vocalizations, sonobuoys, minke, behavior						
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON	
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U	UU	2	Jason Gedamke	
					19b. TELEPHONE NUMBER (Include area code) (831) 459-4133	

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FINAL REPORT

Grant #: N00014-98-1-0859

PRINCIPAL INVESTIGATORS: Dr. Daniel P. Costa & Jason Gedamke

INSTITUTION: University of California at Santa Cruz

EMAIL: costa@biology.ucsc.edu & jgedamke@cats.ucsc.edu

GRANT TITLE: Acoustic Ecology and Remote Acoustic Monitoring of a Minke Whale Population

REPORTING PERIOD: 06/01/98-9/30/99

AWARD PERIOD: 8/25/98-9/30/99

OBJECTIVE: Our objective was to study the acoustic behavior of minke whales on their suspected winter breeding grounds. We investigated functional and behavioral significance of acoustics by linking individual whales with their vocalizations, determining source levels and spectral characteristics of vocalizations, and acoustically tracking animals' movements and interactions with other vocalizing animals. Additionally we hoped to design, test, and if feasible, implement a passive acoustic method of monitoring and tracking minke whales. This method could be used to gather previously unattainable information for population assessments, study of distribution, migratory and movement tracks, and reactions to human disturbance.

APPROACH: A dual approach was utilized: 1) Minke whale vocalizations were recorded during vessel encounters with whales off the coast of northeast Australia in June-July of 1998 and 1999. 2) An island-based acoustic monitoring and tracking system was used in June and August of 1998 and 1999 to make remote recordings of minke whales.

Minke whales in this newly described Great Barrier Reef (GBR) population seek and maintain long, close contacts with boats. Recordings were made in the presence of circling minke whales aboard the vessel "Undersea Explorer" with a calibrated, two-dimensional hydrophone array (5 HTI hydrophones, flat +/- 2dB 50-32000kHz). Underwater video, and surface and in-water observers were used to link vocalizations to individual behaviors and information about group size, composition and behavior. Spectral characteristics, received levels and source levels of vocalizations, were determined in Canary 1.2, Cornell's bio-acoustic software. Vocalization time of arrival differences at hydrophones along the array were used to localize sound sources. Vocalizing individuals were tracked and their interactions (location, spacing, acoustics) with other vocalizing whales in the group were determined.

A remote acoustic monitoring system was also implemented using modified navy sonobuoys (ANSSQ-57Bs) and one particular minke vocalization that travels long distances (>5km) and has temporal and spectral qualities that make it ideal for localization. A remote array consisted of up to 5 sonobuoys and transmitted underwater sounds to a mountaintop Lizard Island based receiving station. A VHF antenna and receivers picked up signals from the buoys. Recordings on DAT tapes (1998) progressed to acquiring data on a custom built, wind-powered, multi-channel digital acquisition system (1999). Time of arrival differences of vocalizations at each buoy were again used to localize and track multiple sound sources simultaneously.

ACCOMPLISHMENTS: Over ten-weeks in two field seasons of vessel-based study, we encountered over 200 whales and had extended (up to 7 hours/encounter), close (<200m) contacts

with a large percentage. We recorded over 70 hours in the direct presence of minke whales bringing our total to 92 hours of recordings over three field seasons. A wide variety of vocalizations were recorded in different behavioral contexts and group sizes and compositions. Accurate source levels of vocalizations were calculated using localization information. Vocalizations were recorded that could be linked to individually identified animals and behaviors. Individual vocalizing animals were tracked for up to 5 near-continuous hours while circling the boat. Multiple vocalizing animals within a group were simultaneously localized and tracked to link their relative locations with the acoustic behavior occurring.

An acoustic transect was conducted to test for the presence of minke whales outside the GBR. While the recordings spanned 80 miles and were made at hours spanning day and night, no whales were clearly recorded outside the reef. This result indicates that the whales are either primarily within the back-reef waters of the GBR or that their acoustic behavior outside the reef is markedly different from in the back-reef waters.

In 1998, we developed, tested, and implemented the remote acoustic monitoring system utilizing naval sonobuoys. In 1999, we developed and built a wind-powered digital data acquisition system for more efficient data recording. Through two field seasons of the Lizard Island based work we have collected 500 hours of array recordings. We have localized and tracked at least 5 animals simultaneously within the array. We have determined these animals can acoustically communicate over at least 5 km in these waters and that there does not appear to be distinct diel patterns to their vocal behavior. We are also looking at the spacing and interaction between vocalizing animals to determine potential functions of the vocalization.

SIGNIFICANCE: A large population of inquisitive minke whales offers a unique research opportunity that has not been described elsewhere. Utilizing this population, we have recorded the largest and most detailed database of minke sounds yet reported. This research represents the first reported study linking the sounds of the minke whale with extensive visually observed behavior on its suspected breeding ground. One synthetic sounding minke vocalization is particularly complex and is unlike any previously reported baleen whale sound. It is strikingly similar to the N. Pacific "boing" that has been recorded for over 40 years with its source still unknown. Remote acoustic study has further revealed close similarities in vocalization length, structure, and repetition rate between the minke sound and the "boing". Minke sounds can now be used in varying passive acoustic studies from determining distribution of whales inside and outside the reef, to determining their range along the Australian coast and throughout the Southern Hemisphere. Remote acoustic study is a powerful and cost-effective method to study whale distribution, movements and migratory patterns, behavior, and to assess human disturbance.

PUBLICATIONS AND ABSTRACTS:

- Gedamke, J., D.P. Costa, and A. Dunstan. 1997. New vocalization definitively linked to the minke whale. *JASA* 102(5 pt. 2): 3121-3122.
- Gedamke, J., D.P. Costa, and A. Dunstan. 1999. Minke whale vocal behavior and remote acoustic tracking. *13th Biennial Conference on the Biology of Marine Mammals Abstracts*. pp. 65-66.
- Gedamke, J., D.P. Costa, and A. Dunstan. (in preparation) Verification of a complex new minke whale vocalization. (To be submitted to *JASA*)