

Assessment of Acoustic Adaptations for Noise Compensation in Marine Mammals

Susan E. Parks
The Pennsylvania State University
Applied Research Laboratory
P.O. Box 30
State College, PA 16804-0030
phone: (814) 865-7683 fax: (814) 863-8783 email: sep20@psu.edu

Award Number: N00014-08-1-0967

LONG-TERM GOALS

The proposed research will address the fundamental theoretical issue of noise compensation mechanisms in the vocal communication of marine mammals. Noise compensation mechanisms are important for improving signal transmission with an energy limited source. A better understanding of marine mammal noise compensation mechanisms can potentially provide effective means of improving signal transmission in a noisy marine environment and for assessing the impact of man-made sounds on the use of sound by marine mammals.

OBJECTIVES

The primary objectives of this project are to: 1) generate testable hypotheses of general vocal responses of marine mammals to particular noise types; and 2) test these hypotheses with data from two low-frequency baleen whale species in coastal shallow water environments using existing data from North Atlantic right whale (*Eubalaena glacialis*) acoustic tag recordings (Digital Archival Tag - Dtag) (Johnson and Tyack 2003) and new acoustic Dtag data collected from Southern right whales (*Eubalaena australis*).

APPROACH

The approach for this study is to first develop hypotheses about common mechanisms of noise compensation in marine mammals by investigating the matching of marine mammal signals to their acoustic habitats and general trends for noise compensation documented from different species of animals in response to noise sources in the environment. These hypotheses will then be tested using an extensive existing database of acoustic tag data collected from the North Atlantic right whale in the Bay of Fundy to determine what, if any, vocal compensation mechanisms were employed by North Atlantic right whales. The second stage of this study will involve collecting additional data from Southern right whales. Commercial shipping activity is significantly lower in the Southern hemisphere, providing the opportunity to compare the vocal behavior of a single species of right whale in areas with very low human activity to areas with active commercial ports in the same region. The primary proposed location to study the Southern right whale population was in Argentina, in two adjacent gulfs, Golfo San José and Golfo Nuevo. Both gulfs experience similar weather conditions and are used

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 30 SEP 2011		2. REPORT TYPE		3. DATES COVERED 00-00-2011 to 00-00-2011	
4. TITLE AND SUBTITLE Assessment of Acoustic Adaptations for Noise Compensation in Marine Mammals				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) Pennsylvania State University, Applied Research Laboratory, PO Box 30, State College, PA, 16804				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 Same as Report (SAR)	18. NUMBER OF PAGES 4	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

by a single population of Southern right whales but differ in the level of human activity. Due to permitting limitations, this portion of the data collection has been moved to a similar right whale population off the Southern coast of Brazil. Data collection is planned in multiple bays to compare the vocal behavior of individual whales in very low and moderate noise conditions. Vessel noise will be documented by continuous acoustic recorders in multiple habitat areas to quantify the levels of acoustic disturbance presented to the whales and any detectable changes in the calling behavior of the whales. These data will then be used to further test the general noise compensation hypotheses developed in the first part of the study and compare the vocal behavior between the two right whale species.

WORK COMPLETED

A literature review of existing vocal noise compensation mechanisms in mammalian species has been completed and a review manuscript is in preparation for submission to *Animal Behavior*. A propagation modeling study comparing transmission loss characteristics of a variety of marine mammal vocalizations in different shallow and deep water habitats is ongoing, with manuscript submission planned before the end of the year and presentation of results at the Society of Marine Mammalogy conference in Tampa, Florida in November 2011. Copies of the existing Dtag data from North Atlantic right whales were obtained and vocalizations from the tagged whales have been extracted. Measurements of call parameters (include duration, frequency content, and receive level) and noise levels have been completed and the resulting article was published online in the journal *Biology Letters* in July 2010. These results were presented at the Society of Marine Mammalogy conference in Quebec, Canada in October 2009, the Acoustical Society of America meeting in Baltimore, MD in April 2010, and at the 2nd International Conference on the Effects of Noise on Aquatic Life in Cork, Ireland in August 2010. A second publication resulting from the extended abstract for the talk at the Ireland meeting is currently in press to be published in 2011. Applications for permits for acoustic data collection in Brazil have been submitted through a Scientific Expedition process to Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq - Brazilian government agency that issues such permits) by Universidade Federal de Santa Catarina, with collaboration from Projeto Baleia Franca and Universidade Federal do Rio Grande do Norte, the Brazilian counterparts for this study with data collection planned to begin in October 2011.

RESULTS

An acoustic recording tag, the Dtag, was used to record the noise levels received by individual whales and the vocalizations they produced in the Bay of Fundy, Canada. These data were used to assess the variability in the received levels (and therefore source level), duration and frequency content of calls produced by the tagged whale in varying ambient noise environments. Results from the analysis of the 2001-2005 Dtag data from the Bay of Fundy indicate that individual call production is modified in increased ambient noise conditions with changes to call intensity. Individual whales producing multiple calls showed increases in received call amplitude in increasing ambient noise conditions (Figure 1). These results are consistent with previous studies that have shown similar vocal modifications in odontocetes (Scheifele et al. 2005; Holt et al. 2009).

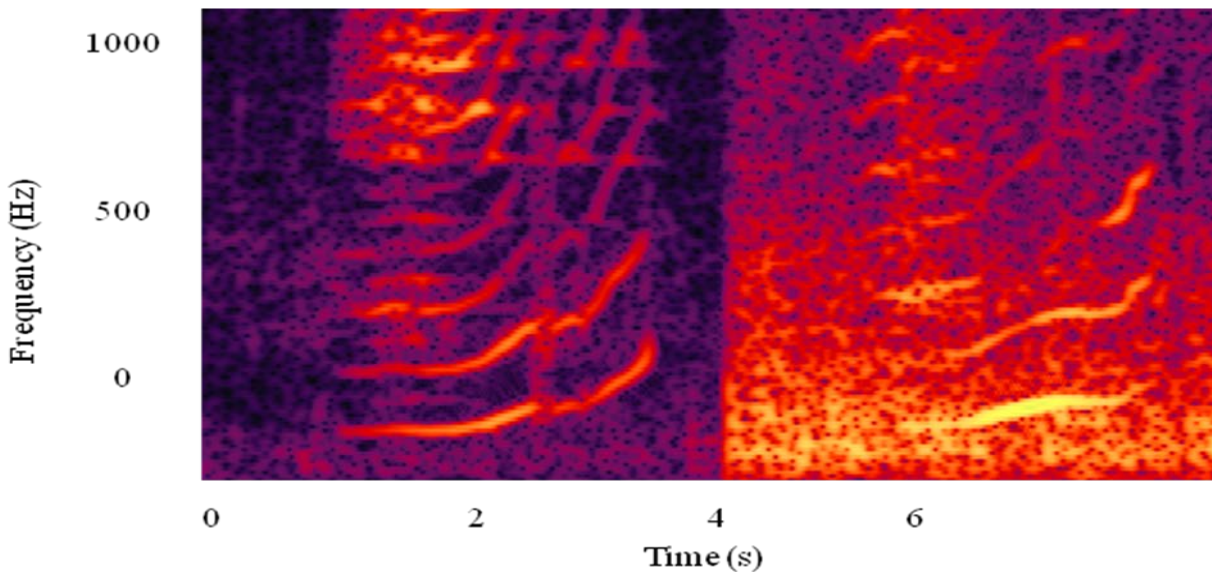


Figure 1. *Spectrograms of two upcalls from a single North Atlantic right whale illustrating increased call intensity in the higher noise recording.*

IMPACT/APPLICATIONS

This study will lead to a better understanding of the existence of acoustic adaptations in right whale vocalizations and the types of vocal compensation mechanisms that they employ for coping with increased ambient noise conditions, including both natural and man-made sound sources. This project is a first step in developing a general theory regarding noise compensation mechanisms in marine mammal species.

RELATED PROJECTS

None.

REFERENCES

- Holt MM, Noren DP, Veirs V, Emmons CK, Veirs S (2009) Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. *Journal of the Acoustical Society of America* 125:EL27-EL32
- Johnson MP, Tyack PL (2003) A digital acoustic recording tag for measuring the response of wild marine mammals to sound. *IEEE Journal of Oceanic Engineering* 28:3-12
- Scheifele PM, Andrew S, Cooper RA, Darre M, Musiek FE, Max L (2005) Indication of a Lombard vocal response in the St. Lawrence River beluga. *Journal of the Acoustical Society of America* 117:1486-1492

PUBLICATIONS

Parks SE, Johnson, M, Nowacek, D, Tyack, PL (2010) Individual right whale call louder in increased environmental noise. *Biology Letters*. Published online July 7, 2010 doi: 10.1098/rsbl.2010.0451