

Assessment of Acoustic Adaptations for Noise Compensation in Marine Mammals

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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) survey the existing literature to 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 Dtag data from Southern right whales in Argentina. The Southern right whale population is present in large numbers (~700) in the austral spring in two adjacent gulfs, Golfo San José and Golfo Nuevo. Both gulfs experience similar weather conditions and are used by a single population of Southern right whales but differ in the level of human activity. Golfo San José has extremely low levels of human activity as it is an established marine sanctuary for the whales, and therefore is expected to have a close to 'natural' ambient noise structure. Golfo Nuevo in contrast has a commercial port (Puerto Madryn) on its western shore, with frequent transits of large container and transport vessels in and out of the gulf. Puerto Pirámides, a town on the northeastern shore has six companies that run whale watch trips during all daylight hours from June to December with smaller outboard engine vessels. Dtags will be attached to whales in both gulfs to compare the vocal behavior of the whales. Vessel traffic will be

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documented by both visual observers and continuous acoustic recorders in both bays to quantify and count the number of ships and levels of acoustic disturbance presented to the whales. These data will then be used to further test the general noise compensation hypotheses developed in the first part of the study.

WORK COMPLETED

Funds for this project were received in late June 2008 and initial work has begun on the project. Review of the existing published literature on noise compensation behavior of animals is currently underway. Copies of the existing Dtag data from North Atlantic right whales have been obtained and vocalizations from the tagged whales have been extracted. In late September 2008, a preliminary trip was made to Argentina to meet with local collaborators and plan logistics for the 2009 data collection for the project. During this trip, locations for tagging, acoustic recorder deployment, and visual observation posts for next year were identified.

RESULTS

The initial planning trip to Argentina yielded data for comparison of noise levels between the two bays. Preliminary recordings were made between September 18- September 24, 2008 in Golfo San José and Golfo Nuevo. Recordings were made from both vessel and land-based platforms when feasible and were limited to daylight hours totaling ~3.5 hours of recordings made in 13 recording sessions. Sea state conditions ranged from 1 – 4 during recordings, and right whales were always sighted within 1 km of the recording position. Recordings in both Golfo San José and Golfo Nuevo were made in locations proposed for tagging and focal follows in 2009. Additional recordings in Golfo Nuevo were made from the town pier in downtown Puerto Madryn (pop. ~50,000) where six right whales were sighted within 500 m of the pier. Preliminary PSD values obtained between sites are shown in Figure 1.

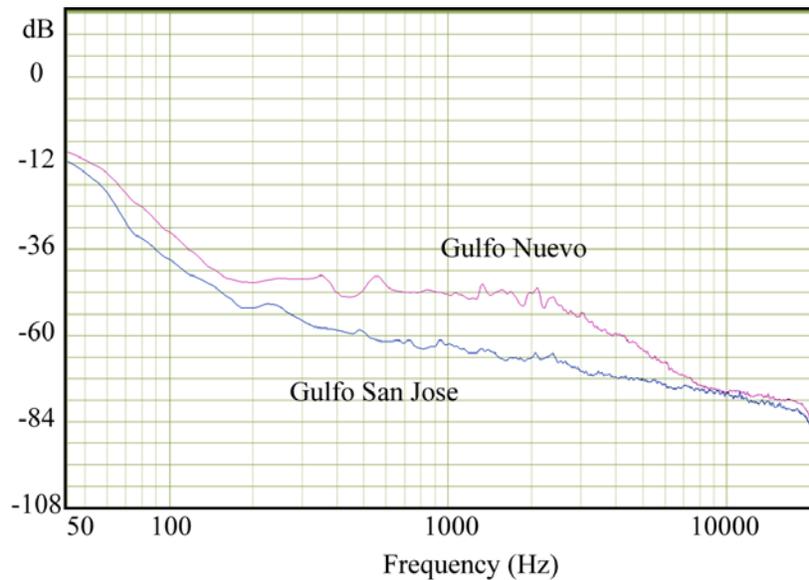


Figure 1. Measurements of the power spectral Density (PSD) of the ambient sound recorded in Golfo Nuevo and Golfo San José (relative dB/Hz).

The only audible man-made noise source in Golfo Nuevo was from small outboard engines in tourist diving/whale watching vessels, which were common in Puerto Pirámides and almost continuous in Puerto Madryn. No large vessels were observed to be transiting through Golfo Nuevo during these preliminary recordings. Both sites were extremely quiet compared to similar recordings made in the Bay of Fundy, Canada or Cape Cod Bay, Massachusetts. There is potential in these sites to investigate the impacts of individual vessel noise sources, rather than an overall raised ambient background noise.

Measurements of contact calls recorded in each gulf indicate no difference in the distribution of start frequencies (Figure 2), with frequencies similar to those described for recordings from Golfo San José in 2000 (Parks *et al.*, 2007). The high (> 300 Hz) peak frequency of the small outboard engine noise in the area and the shallow water depths of the whales near shore (often < 10 m) clearly limited the range of propagation of lower frequency sounds.

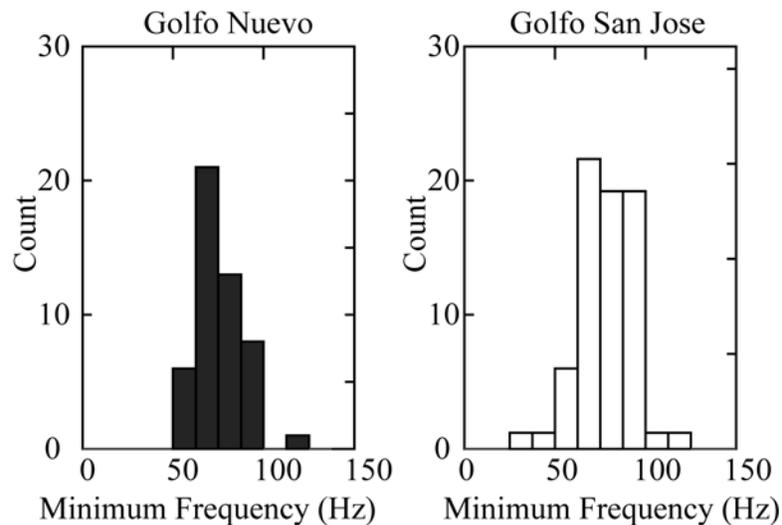


Figure 2. Measurement of the minimum frequency from right whale contact calls recorded in Golfo Nuevo (increased human activity) and Golfo San José (limited human activity) indicate no significant difference between the two gulfs in low noise conditions. Mean start frequency: Golfo Nuevo (N = 50) 77 ± 16 Hz, Golfo San José (N = 59) 78 ± 14 Hz. (t-test, $t = -0.49$, $df = 98.36$, $p = 0.625$).

Overall the planning trip to Argentina was successful. Numerous right whales were observed in each potential tagging location during each observation period. Many right whales were seen extremely close to shore (<100 m) and in extremely shallow water depths (<10 m) (Figure 3). Prolonged curious approach behaviors of juvenile whales were observed on two trips on whale watching vessels indicating that tag attachment and adequate sample size are likely to be achievable with this population of right whales. Clear differences in vessel traffic and associated noise levels were documented between the two gulfs. Both gulfs have adequate high land-based vantage points (40-60 m) for radio tracking of tagged whales and observations of vessel activities. Weather conditions were adequate for tag attachment operations on 4/9 days during the trip due to high winds, with weather anticipated to improve into later spring (October). Therefore tagging operations will be planned for late September/early October in 2009. Selection of the long-term recorder placement will need to take into account the limited transmission of low frequency sounds in shallow water close to shore.



Figure 3. A juvenile right whale swimming ~20 m off the beach in Golfo San José. Numerous right whales (5-10 groups) were visible close to shore in this location from September 17- September 24 2008.

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

M. P. Johnson and P. L. Tyack, 2003. A digital acoustic recording tag for measuring the response of wild marine mammals to sound. *IEEE J. Oceanic Eng.*, 28(1): 3–12.

Parks, S.E., Clark, C.W., Tyack, P.L. 2007. Short and long-term changes in right whale calling behavior: the potential effects of noise on communication. *Journal of the Acoustical Society of America*, 122(6): 3725-3731.