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Fine-Scale Focal Dtag Behavioral Study of Diel Trends in Activity Budgets and Sound Production of Endangered Baleen Whales in the Gulf of Maine

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LONG-TERM GOALS

The long-term goals of this project was to obtain crucial baseline data on the normal diel activity budgets of endangered baleen whale species including time spent at the surface, residency time and rate of horizontal travel, and rates of sound production. These data can be used to assess both visual and passive acoustic detectability to aid in their detection to protect them from vessel collisions and harmful exposures to man-made sounds. These data also provide information on normal behavior necessary to interpret any potential disturbance responses to human activities.

OBJECTIVES

The primary goal of this project was to obtain fine-scale behavior data from two endangered baleen whale species, the humpback whale (*Megaptera novaengliae*) and the right whale (*Eubalaena glacialis*), on the Stellwagen Bank National Marine Sanctuary through suction-cup attachment of sound and orientation recording tags (Digital Archival Tag - Dtag), which records subsurface movements and sound production by the whale. The specific objectives of this three year study were to use these tag data to: 1) determine the diel trends in dive profiles and horizontal movement patterns for tagged humpback and right whales on the Stellwagen Bank National Marine Sanctuary; 2) determine the sound production behavior of individual tagged humpback and right whales on the Stellwagen Bank National Marine Sanctuary; and 3) examine the relationship among anthropogenic noise, conspecific sounds, and tagged whale behavior for humpback and right whales on the Stellwagen Bank National Marine Sanctuary.

APPROACH

The approach for this study utilized a combination of techniques to obtain data on the behavior of individual whales and their surrounding environment. The primary method in the study involved Dtag attachment to document the activity budgets, movement patterns, and sound production of humpback and right whales on and around the Stellwagen Bank National Marine Sanctuary on three cruises from 2008-2010. These data were collected using the Dtag (Johnson and Tyack 2003) in collaboration with the Woods Hole Oceanographic Institution in three field trails in the summer of 2008 and the spring of 2009 and 2010. When possible, parameters measured by the Dtag were be related to external cues including: 1) trends in prey biomass distribution in the water column from an active acoustic monitoring station and prey data collected by collaborator Dr. Joseph Warren; and 2) social sounds from conspecifics and man-made noise sources through the use of AIS ship tracking and collaboration with the NOPP led by Dr. Christopher Clark at Cornell University. These combined datasets will be used to infer diel trends in natural behavior of the whales, how the whales respond to man-made noise sources in their environment, and the effectiveness of passive acoustic monitoring in detection and tracking of individual whales.

This project brings together collaborators from a number of institutions with specialized expertise in different aspects of this project. The major participating institutions in the data collection and analysis include the Pennsylvania State University Applied Research Laboratory (Susan Parks & Jennifer Miksis-Olds), the Stellwagen Bank National Marine Sanctuary (David Wiley), and the Woods Hole Oceanographic Institution (Alessandro Bocconcelli). Additional data on prey distribution is being collected by Stony Brook University (Joseph Warren). Data integration is planned through a collaborative effort with the NOPP led by Dr. Christopher Clark at Cornell University, involving the Stellwagen Bank National Marine Sanctuary (Leila Hatch) and the Northeast Fisheries Science Center of the National Marine Fisheries Service (Sofie Van Parijs).

WORK COMPLETED

The first cruise occurred in June and July 2008 and involved Dtag attachment to humpback whales in the Stellwagen Bank National Marine Sanctuary. The second cruise occurred in April 2009 and involved Dtag attachment to both right whales and humpback whales in and around Stellwagen Bank National Marine Sanctuary. The third cruise occurred in April 2010 and involved Dtag attachment to both right whales and humpback whales near the Stellwagen Bank National Marine Sanctuary.

The three-frequency, active acoustic mooring station (AWCP mooring) was successfully deployed in the Stellwagen Bank National Marine Sanctuary for 18 days in 2008 (June 27 - July 14, 2008), 16 days in 2009 (16 days (April 2 – April 18, 2009), and in Cape Cod Bay for 17 days in 2010 (March 28 – April 13) to detect right and humpback whale prey. During each 15 minute cycle, all frequencies (125 kHz, 200 kHz, and 460 kHz) sampled simultaneously for 5 minutes. Vertical plankton tows of the full water column and the top 5 m of the water column were made using a 150 micron mesh net immediately after deployment and before retrieval of the mooring station. Detailed analysis has been completed on the temporal and vertical spatial distribution of acoustic targets in the water column in each year. The mooring data set has been integrated with net and acoustic sampling collected by Dr. Joseph Warren (Stony Brook University).

Significant progress has been made on the analysis of data collected during the study and these results have been presented at several scientific conferences which are listed below. Papers are in preparation for submission, or are currently submitted for each of these scientific presentations:

- Weinrich, M., Cholewiak, D., Friedlander, A., Hurst, T., Parks, S., Thompson, M., Ware, C., Wiley, D. Underwater behavior of associated humpback whales in the southern Gulf of Maine.
- 18th Biennial Conference on the Biology of Marine Mammals, Quebec City, Canada, October 12-18, 2009.
- Parks, SE, Clark, CW, Johnson, M, Tyack, PL. Simultaneous acoustic tag and seafloor acoustic recorder detection of right whale calls in the Bay of Fundy and Cape Cod Bay. North Atlantic Right whale Consortium Meeting 2009, New Bedford Whaling Museum, New Bedford, MA.
- Palmer, K., Parks, SE, Wiley, D, Weinrich, M, Tackaberry, J, Bocconcelli, A, Friedlaender, A. (2010). Vocal behavior of North Atlantic humpback whales during reunion events on Stellwagen Bank (A). Joint 159th ASA Meeting and noise-Con 2010, Baltimore, MD, 19-23 April 2010, Journal of the Acoustical Society of America. 127, 1894.
- Parks, SE, Wiley, D., Warren, J., Weinrich, M., Bocconcelli, A. Behavioral differences in water column usage and sound production of North Atlantic right and humpback whales in April 2009 and 2010. North Atlantic Right whale Consortium Meeting 2010, New Bedford Whaling Museum, New Bedford, MA.
- Parks, SE, Wiley, D, Weinrich, M., Bocconcelli, A. Behavioral differences affect passive acoustic detectability of foraging North Atlantic right and humpback whales. 160th ASA Meeting, Cancun, Mexico, 15-19 November 2010.
- Lin, Y, Newhall, AE, Parks, SE, Sound propagation modeling of right whale calls in Cape Cod Bay. 160th ASA Meeting, Cancun, Mexico, 15-19 November 2010.
- Warren, J.E., Parks, S.E., Miksis-Olds, J.L. Distribution and spatial characteristics of zooplankton and nekton aggregations in Cape Cod Bay during the spring of 2010. 160th ASA Meeting, Cancun, Mexico, 15-19 November 2010.

RESULTS

A total of 18 humpbacks and 16 right whales were tagged over the three years of the study, providing over 150 hours of fine-scale behavioral and acoustic data (Figure 1). Successful overnight deployment of tags was achieved with 5 humpback whales (2 during summer 2008, 1 each spring of 2009 and 2010). All right whale tags detached early due to either the social interactions or swimming behavior of individual right whales, resulting in no night behavioral data for right whales from this effort. Given our experience, tag longevity with the 2nd generation suction cup Dtag is not sufficient to obtain overnight data. It is possible that the next generation for the Dtag, which was intended to be used in this study but unavailable due to development delays, may have better longevity. Alternate attachment mechanisms may be necessary to obtain night data on the diving behavior of foraging right whales. Data from the tags have been analyzed for vocalizations and diving behavior of the whales.

The primary findings from these analyses are summarized here:

a) Humpback whales spent less time in the upper 5 m of the water column than right whales, potentially indicating that right whales‟ foraging behavior increases their risk for ship strike (Figure 2).

b) Humpback vocalization rates were, on average, significantly higher than for right whales (Figure 3), making passive acoustic monitoring more effective for detecting humpback whales on the Stellwagen Bank National Marine Sanctuary and indicating that passive acoustic monitoring of right whales will be less effective when whales are actively foraging.

c) Humpback whales showed marked changes in diving/foraging behavior between day and night time hours (Figure 4). The potential for right whales to show a similar change in behavior indicate that further studies on the night time behavior of right whales is warranted and should be a high priority for future research efforts.

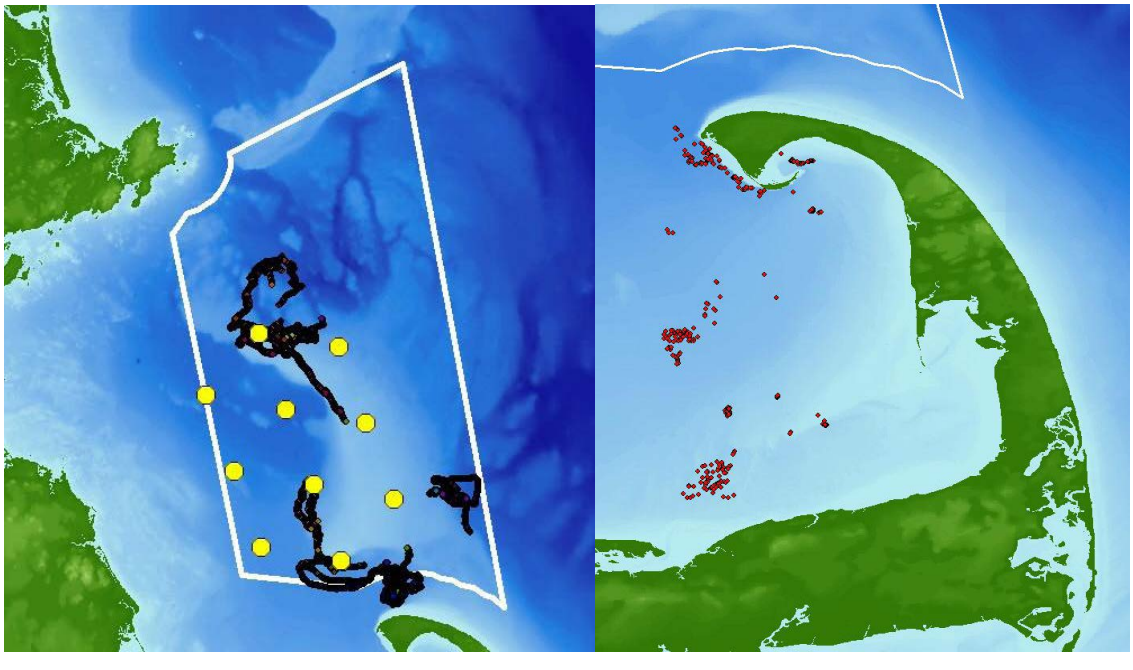

Figure 1. Maps showing the surface positions of tagged whales from 2008-2010. left) humpback whales from July 2008, right) right whales and humpback whales from 2010. The white line marks the edges of the Stellwagen Bank National Marine Sanctuary. The yellow dots mark positions of bottom acoustic recorders put in place by a NOPP project led by Dr. Christopher Clark at Cornell University. Maps created by Mike Thompson/SBNMS

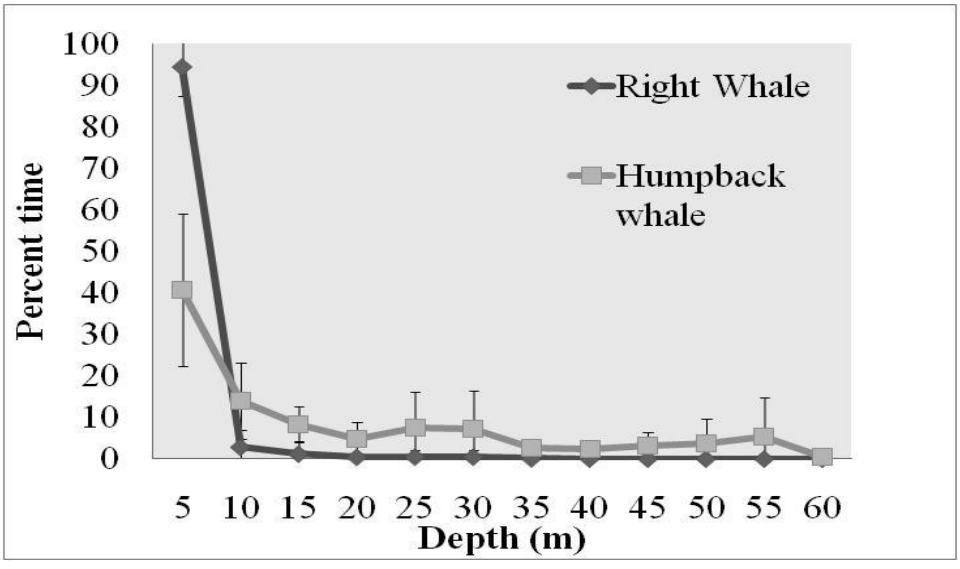

Figure 2. Comparison of percent time spent in 5 m depth bins showing that right whales spent significantly more time (> 90%) in the upper 5 m of the water column in April than humpback whales (< 40%).

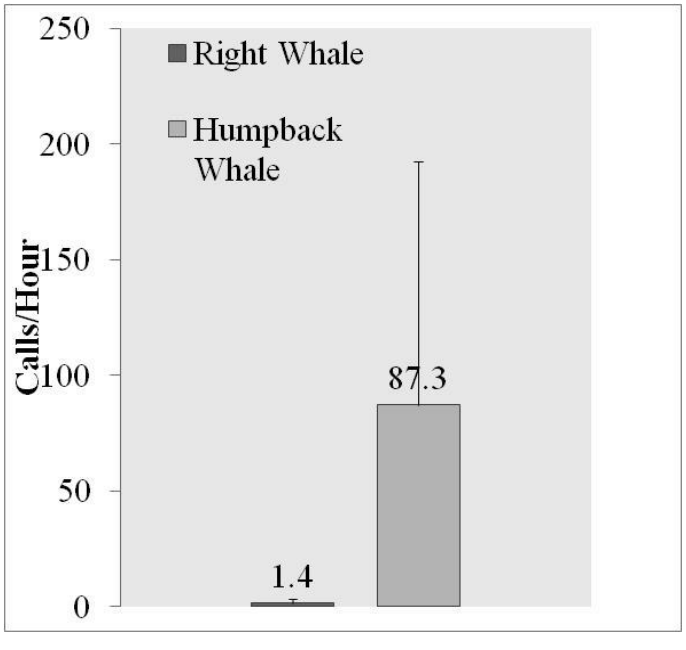

Figure 3. Comparison of call rate between tagged right whales and humpback whales from tag data collected between 2008-2010. Right whale average call rate was 1.4 calls/hr, compared to 87.3 calls/hr in humpback whales.

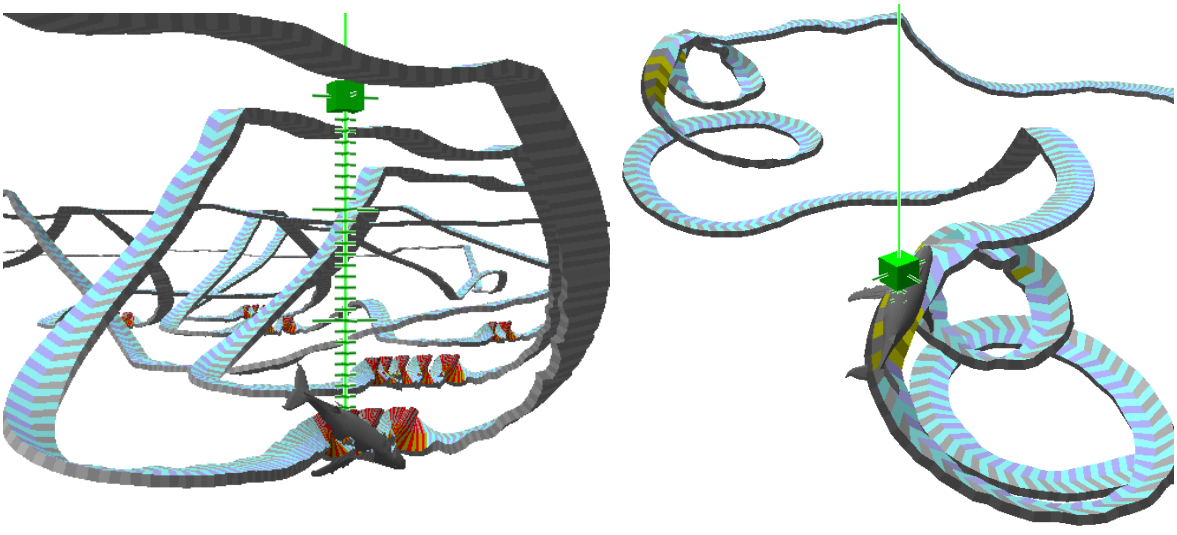

Figure 4. Diving behavior of an individual humpback whale a) during the night showing primarily bottom feeding and b) during the day showing primarily bottom feeding. This behavior made the whale more visible at the surface during daylight hours, and the whale spent less time at the surface at night when it would not be visible.

IMPACT/APPLICATIONS

The impacts of this work will provide baseline data on the "normal" behavior of two species of endangered baleen whales on their foraging grounds, including diel trends in vocal behavior and movement patterns. Data on these two aspects of behavior are necessary to improve the detection rate of whales through both visual and passive acoustic surveys. Additionally, a current knowledge gap of the "normal" behavior of particular marine mammal species makes it difficult to interpret any apparent behavioral changes resulting from response to naval activities. These data can be used to aid in the interpretation of future targeted disturbance studies and will help determine whether baleen whales spend more time at the surface at night, making them more vulnerable to vessel collision. These two species, the humpback whale (*Megaptera novaeangliae*) and the right whale (*Eubalaena glacialis*), were selected for several reasons. Both species are endangered, vulnerable to vessel collision and entanglement with fixed gear, and have a wide global distribution. Several humpback whale stocks are showing stronger recovery than right whales, despite overlapping habitat usage on the feeding grounds in the Northern hemisphere. One aim of the study is to determine if comparisons of the behavior between the two species may shed light on the reasons for the differences in recovery of the two populations. Our results indicate that the normal behavior of foraging right whales and humpbacks do differ significantly, both in terms of time spent at the surface or just below the surface, and in the sound production by feeding individuals.

RELATED PROJECTS

NOPP - "An Ocean Observing System for Large-Scale Monitoring and Mapping of Noise Throughout the Stellwagen Bank National Marine Sanctuary", led by Dr. Christopher Clark at Cornell University is collecting continuous acoustic recordings from passive acoustic recording devices distributed in an array in the Stellwagen Bank National Marine Sanctuary during the tagging cruise in this project. The

data collected in this study will provide ground truth data for the NOPP system when a tagged whale travels through the array. The NOPP array potentially can provide information about the location and levels of external acoustic cues that the tagged whale may be responding to. These analyses are on-going.

This project is working in close collaboration with two additional ONR funded projects, "Fine-Scale survey of right and humpback whale prey abundance and distribution" (Warren) and "Fine-scale Focal Dtag Behavioral Study in the Gulf of Maine" (Bocconcelli) to facilitate integration of the datasets on tagged whale behavior and regional prey abundance in the environment. Several joint-authored publications are anticipated to result from these collaborations.

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