

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

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

David Wiley

Stellwagen Bank National Marine Sanctuary
175 Edward Foster Rd., Scituate, MA 01938
phone: (781) 545-8026 x 211 email: David.Wiley@noaa.gov

Award Number: N00014-08-1-0630

LONG-TERM GOALS

The long-term goals of this project are 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 data on normal behavior, necessary to interpret any potential disturbance responses to human activities.

OBJECTIVES

The primary goal of this project is 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 are 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 utilizes a combination of techniques to obtain data on the behavior of individual whales and their surrounding environment. The primary method in the study involves Dtag attachment to document the activity budgets, movement patterns, and sound production of humpback

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 2009		2. REPORT TYPE		3. DATES COVERED 00-00-2009 to 00-00-2009	
4. TITLE AND SUBTITLE Fine-scale Focal Dtag Behavioral Study Of Diel Trends In Activity Budgets And Sound Production Of Endangered Baleen Whales In The Gulf Of Maine				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) The Pennsylvania State University, Applied Research Laboratory, P.O. 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 The long-term goals of this project are 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 data on normal behavior, necessary to interpret any potential disturbance responses to human activities.					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 7	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

and right whales on and around the Stellwagen Bank National Marine Sanctuary on three cruises from 2008-2010. These data will be collected using the Dtag (Johnson and Tyack 2003) in collaboration with the Woods Hole Oceanographic Institution in three field trials in the summer of 2008, and the spring of 2009 and 2010. When possible, parameters measured by the Dtag will be related to external cues including: 1) trends in prey biomass distribution in the water column from an active acoustic monitoring station; and 2) social sounds from conspecifics and man-made noise sources through 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.

The first cruise occurred in June and July 2008 and involved Dtag attachment to humpback whales on the Stellwagen Bank National Marine Sanctuary. A second cruise occurred in April 2009 and involved Dtag attachment to both right whales and humpback whales on and around the Stellwagen Bank National Marine Sanctuary. The goal of these field studies was to establish baseline tag data to correlate tag records with surface observations and to establish protocols for integration of the multiple datasets used for this study. These datasets include individual whale behavior from tags, trends in prey from the active acoustic moorings, AIS tracks of ships moving through the sanctuary during tagging, and noise and conspecific vocalization data from the ongoing NOPP project.

In year 3, we will continue to attach Dtags to both right whales and humpback whales in April and early May. Tag data will be analyzed to assess the activity budget, movement patterns and vocalization rates of the whale. The goal is to attach tags in the afternoon to allow for collection of both day and night-time data. Focal follows will be conducted of whales carrying the tag during daylight hours to obtain surface positions of the whales and to establish baseline data to correlate tag records with surface observations. Tag attachment to both species is planned to allow for comparisons of the behaviors of the two species. The active acoustic mooring will be deployed for the duration of this trial to monitor movement of potential prey items vertically in the water column. These data sets will be integrated to assess whale movement patterns related to sounds in the environment (both natural and man-made) and to prey movements vertically in the water column over time.

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 (Joe 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

During the second year of the project, a research cruise involving the active acoustic mooring deployment and suction cup tagging of right whales and humpback whales was conducted on and around the Stellwagen Bank National Marine Sanctuary from April 1 – April 28, 2009. Dtags were successfully attached and recovered from 7 right whales and 1 humpback whale, resulting in ~ 29

hours of movement and acoustic data. The one humpback whale tag was attached to a whale within the recording units from the NOPP array (Figure 1) and this dataset resulted in 17 hours of acoustic and movement data from the whale, providing data from a complete evening/night/dawn cycle.

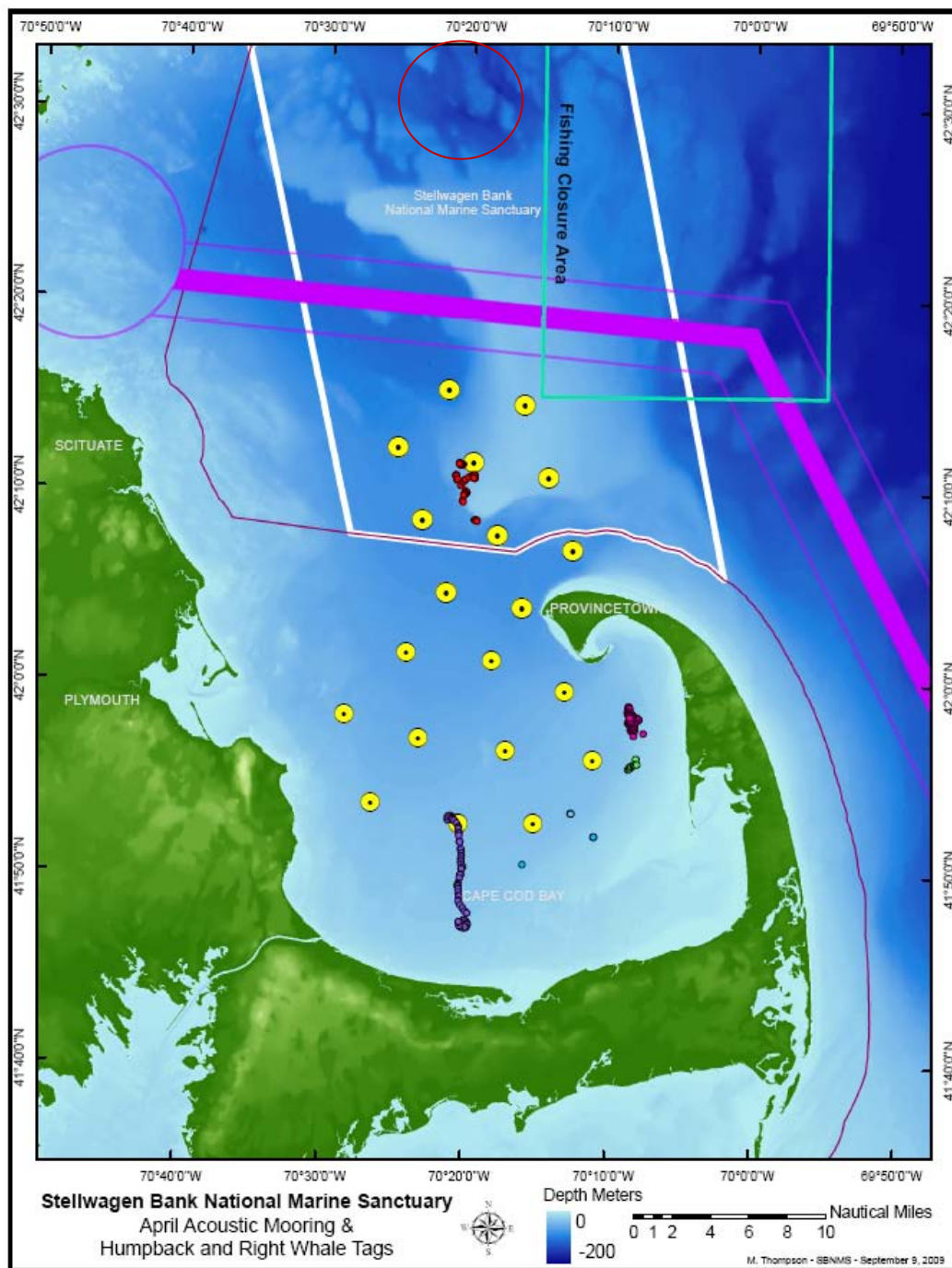


Figure 1. Surface positions of whales tagged during the April 2009 Stellwagen Bank National Marine Sanctuary Cruise. The yellow circles represent positions of the bottom-mounted acoustic recording array from the collaborative NOPP project. The humpback whale positions are shown in the small red dots near the top of the map. Map created by Michael Thompson, Stellwagen Bank National Marine Sanctuary.

The three-frequency, active acoustic mooring station (AWCP mooring) was deployed in the SBNMS for 16 days (April 2 – April 18, 2009) to detect right and humpback whale prey. 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. Plankton samples were stored in a 10% buffered formalin solution for later species identification and counting. The mooring was set in approximately 30 m of water with the instruments at a depth of 25 m. The sampling protocol was designed to sample in 15 minute cycles that were repeated for the duration of the deployment. During each 15 minute cycle, all frequencies (125 kHz, 200 kHz, and 460 kHz) sampled simultaneously for 5 minutes. Upon retrieval, data from the AWCP sensors were downloaded and verified for proper instrument function.

Significant progress has been made on the analysis of data collected during the first cruise in the summer of 2008 and on the development of methods to integrate Dtag and bottom mounted recordings were tested with an existing dataset, resulting in presentations at major international meetings:

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, S.E., Clark, C.W., Johnson, M., Tyack, P.L. Simultaneous acoustic tag and seafloor acoustic recorder detection of right whale calls in the Bay of Fundy, 157th Meeting of the Acoustical Society of America, Portland, OR, 18-22 May, 2009.

RESULTS

Data from the second research cruise have been analyzed for vocalizations and diving behavior of the whales. Table 1 summarizes the horizontal travel distance for the tagged whales from April 2009.

Table 1. Summary of the horizontal travel distances for a subset of tagged humpback whales from April 2009. Initial results indicate that all of the tagged whales stayed within a general area when exhibiting foraging behavior, rather than swimming in straight line directional travel.

Date	Tag Event	Species	Tag attachment duration (hr)	Distance between tag attachment and retrieval (km)	Rate of travel (km/hr)
4/9/2009	EG09_99	Right whale	0.001	-	-
4/10/2009	EG09_100	Right whale	4.80	1.80	0.38
4/14/2009	EG09_104a	Right whale	0.60	1.00	1.67
4/14/2009	EG09_104b	Right whale	0.05	-	-
4/14/2009	EG09_104c	Right whale	0.17	0.38	2.28
4/17/2009	EG09_107a	Right whale	4.03	9.09	2.26
4/18/2009	MN09_108a	Humpback Whale	17.31	4.66	0.27
4/25/2009	EG09_115a	Right whale	2.1	7.17	3.41

There were clear differences in dive depth and behavior between the right whales and the humpback whale, with the right whales spending the majority of their time at a depth of ~ 2 m (Figure 2). This resulted in the right whales not being visible at the water's surface, but still being in a potentially hazardous depth with respect to collisions with vessels. The water depths were comparable between the humpback tagging and most of the right whale tag attachments (Figure 1).

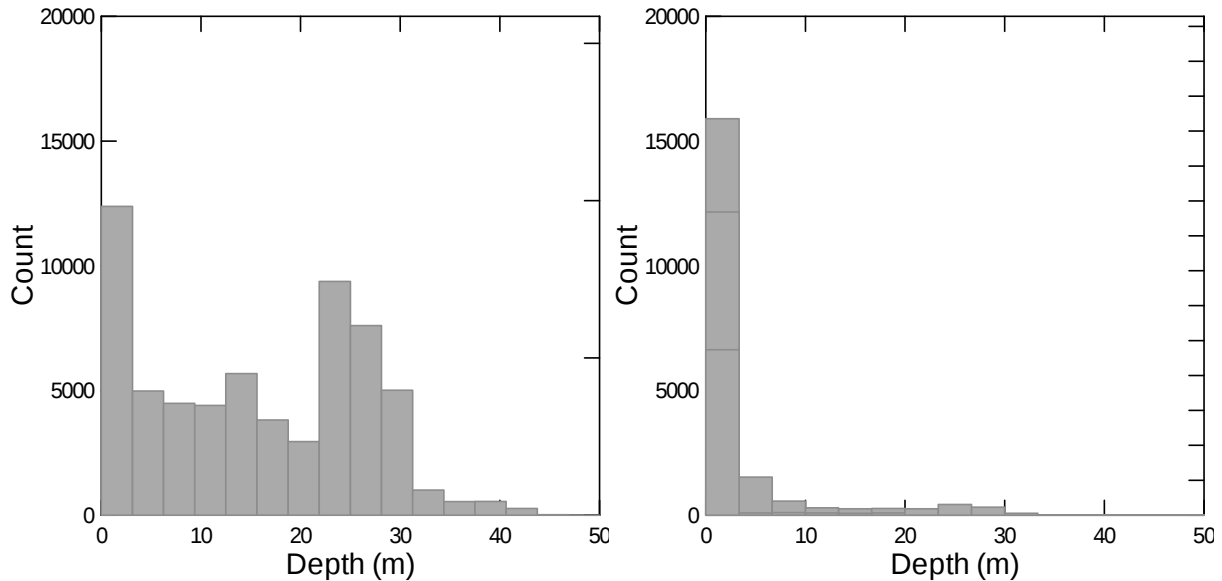


Figure 2. Distribution of depth (1 point/second) of a) a humpback whale and b) all right whales tagged in April 2009. Note that the right whales spent the majority of their time less than 5 m below the surface, while the humpback whale spent a significant amount of time away from the surface.

The vocalization rates of the tagged right whales were low, with only 14 upcalls produced by a single individual on April 17, 2009. The tagged humpback whale produced numerous non-song calls during foraging behavior. Distant humpback song was prevalent in the background of the humpback whale tag recording.

Data were successfully recorded for the entire deployment for all frequencies. Formatting of acoustic backscatter data for viewing with EchoView software has been completed. Detailed analysis will examine the temporal and vertical spatial distribution of acoustic targets in the water column and compare these data with those collected in 2008. A preliminary finding is an absence of vertical migration that was consistently noted from July 2008 (Figure 3). This corresponds to a difference in the diel trends in dive profiles from the humpback whales tagged near the active acoustic mooring in the July 2008 vs. April 2009 (Figure 4). Integration of this data set with net and acoustic sampling collected by Joe Warren (Stony Brook University) is planned for the coming year.

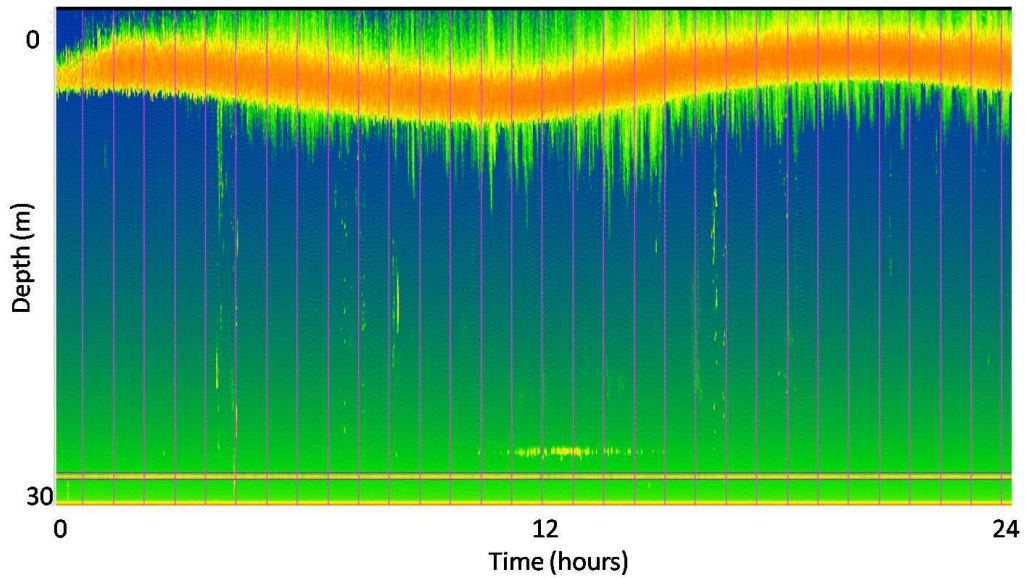


Figure 3. Acoustic backscatter at 125kHz on April 17, 2009. These data were representative of the water column for the week prior to the humpback tagging event, with little evidence of vertical migration of prey, but with multiple targets scattered throughout the water column.

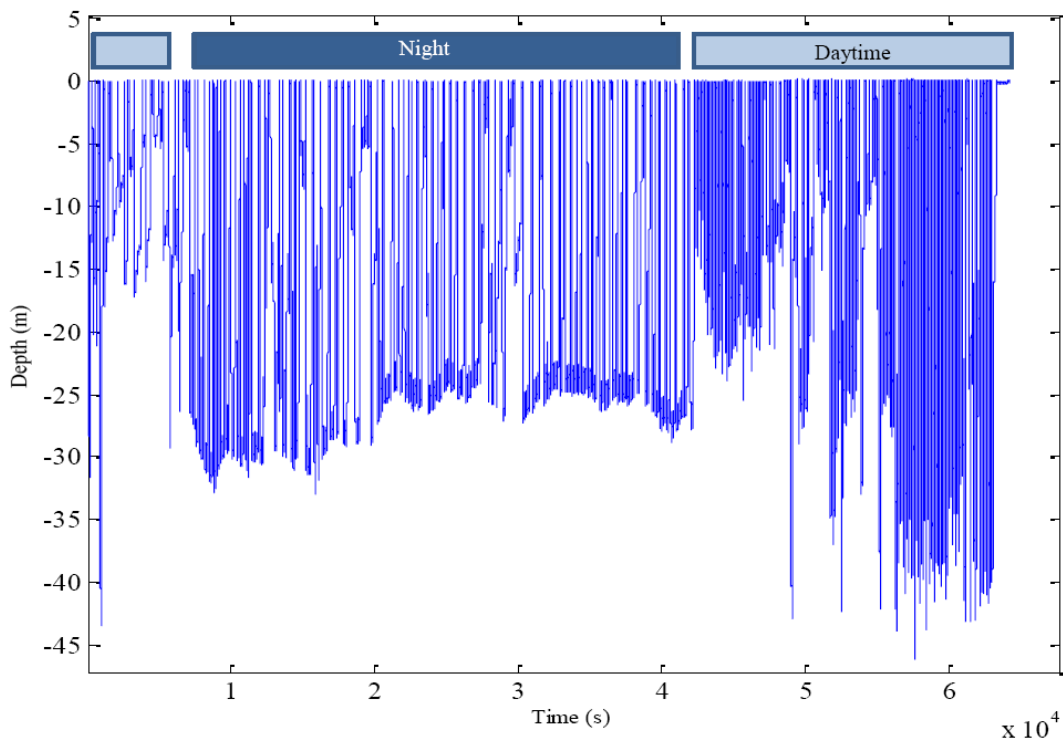


Figure 4. Dive profile from a tagged humpback whale in April 2009. Consistent with night-time tag data from the summer of 2008, the whale appears to switch dive behavior to the bottom at night. However, in April, the daytime dive depths are more variable than those seen in summer feeding behavior.

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*), have been 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.

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.

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.

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.