

## Tagging and Playback Studies to Toothed Whales

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### LONG-TERM GOALS

There has been growing recognition that atypical mass strandings of beaked whales may coincide with naval exercises that use mid-frequency sonar, but the causal chain of events from sound exposure to stranding has not been elucidated. Even less is known about potential risks to other species of odontocetes or for other signals. The proposed research is part of a collaborative research program whose long-term goals are to:

- Compare responses of beaked whales vs other odontocetes to playbacks of mid-frequency sonar sounds vs other anthropogenic signals.
- Conduct combined visual and acoustic surveys for beaked whales and other cetaceans along with collecting oceanographic data for input into models to predict beaked whale distributions based upon characteristics of their habitats.

The ultimate goals will be to predict the distribution of species at risk from sonar, to define dose: response curves for risk to beaked and other whales for exposure to naval sonars, and to suggest improvements for monitoring and mitigation. Ana Cañadas from the Alnilam Marine Research Center describes the habitat modeling efforts in her annual report to ONR as part of this broader program. More playbacks of sonar have been conducted to large delphinids such as pilot whales, *Globicephala* sp, than to any other species of cetacean, but interpretation of the effect of sonar has been hampered by our lack of understanding of baseline behavior and reasons for behavioral transitions. This project includes two cruises in the Alboran Sea to develop methods to better understand baseline behavior of pilot whales and how they respond to threats. Some delphinids appear to have social defenses against threats in addition to flight reactions, so our work focuses on social behavior and communication in addition to basic transitions of behavioral states. The long term goal of this part of the work is to understand baseline behavior well enough to interpret observed variation in responses to sonar playbacks.

### OBJECTIVES

The objectives of this study, which involved tagging and playbacks to pilot whales in the Alboran Sea, were to build upon the successful field work of 2010 by:

- Increasing the sample size of baseline data on pilot whales
- Conducting playback experiments to tagged pilot whales
- Increasing the number of simultaneously tagged pilot whales to study social communication
- Refining methods to visually locate several animals simultaneously

All of these objectives were met.

## **APPROACH**

This study included a 6 week research cruise in 2009 on the NATO RV Alliance in the western Mediterranean Sea and two research cruises in 2010 (Med10) and 2011 (Med11) using smaller vessels to study pilot whales in the Alboran Sea. We had already conducted survey and tagging research (including tagging a *Ziphius*) in 2008 at this site, in collaboration with the NATO Undersea Research Centre, using their research vessel Alliance and staff. We collaborated in the fieldwork with Ana Cañadas and other biologists from the Alnilam Marine Research Center from Madrid Spain. The following organizations and personnel are also engaged in the Med11 sea trial:

Visual Teams: Woods Hole Oceanographic Institution (WHOI), United States; Alnilam Marine Environment Research and Education Centre, Spain; Acoustic Source: We had maintained the option to use an acoustic source provided NUWC Newport, but the portable source was not ready in time for this field work, so we used a Lubell speaker from WHOI. DTag: WHOI provided the DTag equipment, tag boat operator, tagger, and tag technicians.

## **WORK COMPLETED**

During this year, we have analyzed data from the Med10 cruise and presented the results at the European Cetacean Society in Cadiz, Spain during March, and the 3rd Symposium on Acoustic Communication by Animals at Cornell University in August. This project also involves analyzing the behavior of beaked whales, and we published the first paper on responses of beaked whales to sonar playbacks (Tyack et al. 2011) and on the communication signals of beaked whales (Aguilar et al. 2011). The Med11 cruise took place from 18 August to 7 September 2011. When weather conditions allowed, the team went from Agudulce harbor early in the morning to arrive in pilot whale habitat by first light. A faster vessel was used in 2011 compared to 2010, and this gave us more time in whale habitat even during short weather windows. This approach was cost effective in terms of vessel use and allowed for efficient analysis time during bad weather.

Our approach for studying social communication involves simultaneously tagging several whales. Once many animals are tagged and the locations of the tagged animals documented, it becomes possible to locate any sounds detected on enough tags. However, it is critical to be able to locate all of the whales within the group to sort out patterns of association, call and response. We have worked with an engineer expert in stereophotogrammetry to develop a system that can georeference locations of all whales visible from the boat. The system uses GPS to pinpoint the camera location, a heading sensor for camera heading, and stereophotogrammetry to measure range to each target. Figure 1 shows how well this system can work when whales are near the surface.



*Figure 1. Georeferencing locations of pilot whales at the surface from small follow boat.*

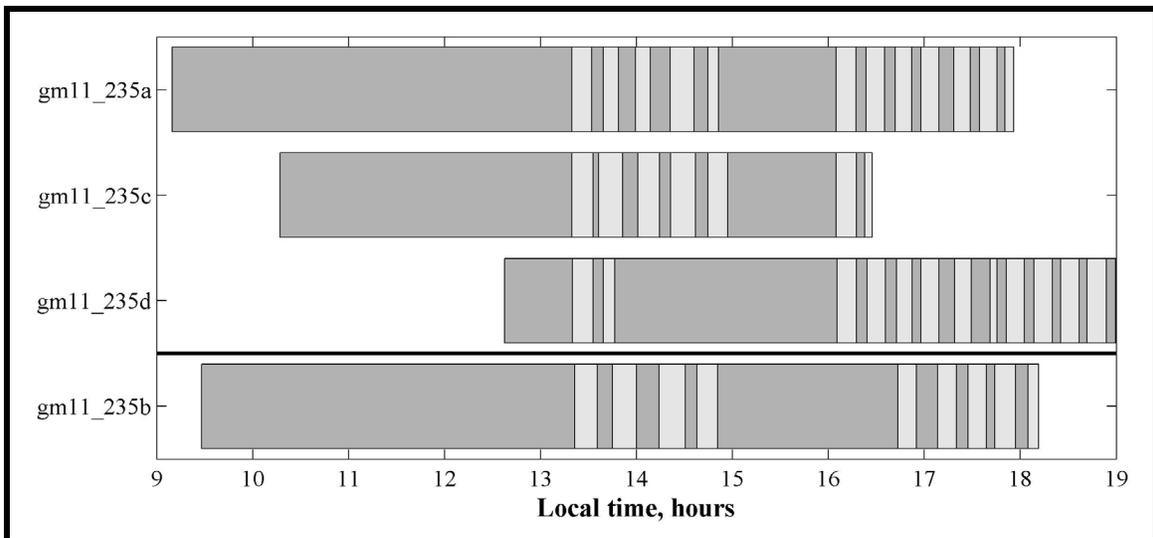
*Table 1. List of pilot whales tagged and playbacks conducted in Med '11 cruise.*

<b>Med '11 Overview</b>				
<b>Date</b>	<b>Tag-on Duration</b>	<b>Tag On</b>	<b>Tag Off</b>	<b># Playbacks</b>
<b>18-Aug-11</b>				
gm11_230a	04:13:30	10:16:11	14:29:41	0
gm11_230b	04:14:05	10:58:50	15:12:55	0
<b>23-Aug-11</b>				
gm11_235a	08:46:15	9:09:30	17:55:45	0
gm11_235b	08:43:13	09:27:50	18:11:03	0
gm11_235c	06:10:00	10:16:00	16:26:00	0
gm11_235d	16:24:00	12:36:00	05:00:00	0
<b>29-Aug-11</b>				
gm11_241a (v3)	05:20:33	11:00:57	16:21:30	2
gm11_241b (v3)	05:23:21	11:13:38	16:36:59	2
gm11_241c	15:22:03	17:13:52	08:35:55	0
gm11_241d	07:58:16	18:06:33	02:04:49	0
gm11_241e	07:26:48	19:33:51	03:00:39	0
gm11_241f	00:01:57	20:03:12	20:05:09	0
<b>5-Sep-11</b>				
gm11_248a	05:49:32	09:20:00	15:09:32	0
gm11_248b	14:29:11	09:34:19	00:03:30	0
gm11_248c	14:24:33	09:48:52	00:13:25	0
gm11_248d	10:19:23	14:04:34	00:23:57	0
gm11_248e	06:29:30	17:15:02	23:44:32	0
<b>7-Sep-11</b>				
gm11_250a	06:46:11	10:56:49	17:43:00	2
gm11_250b	06:36:23	11:05:29	17:41:52	2

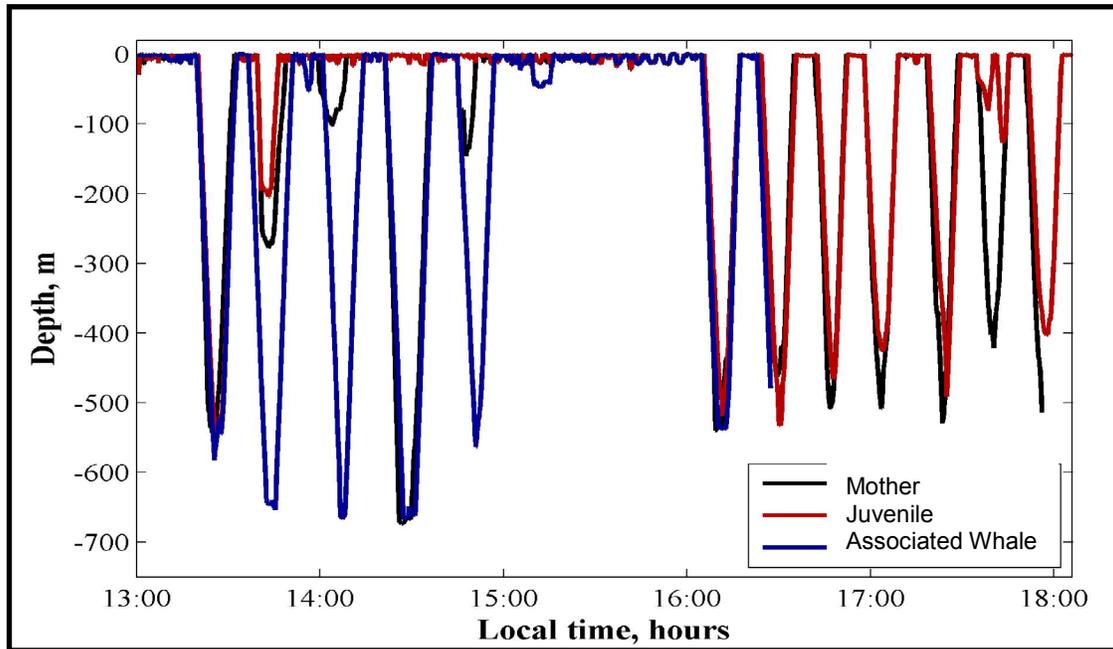
A total of 19 whales were tagged for a total of 156 hours of tag data. Of particular interest are the successes we had attaching tags to 4-5 animals within a group simultaneously, and the 2 playbacks which involved both killer whale sounds and a matching noise control stimulus.

## RESULTS

Over the past two years, this project has developed a powerful method to study the vocal repertoire and use of calls to maintain cohesion between individual pilot whales with differing social bonds. The pilot whales in the Alboran Sea typically approach the vessel for about 20-30 min at the start of a follow. This allows the observers to work out the patterns of association between individuals, and to select animals with different social bonds for tagging. For example, figure 2 shows synched diving (light gray bars) of three simultaneously tagged whales in one subgroup (top section) vs a whale from a different subgroup.

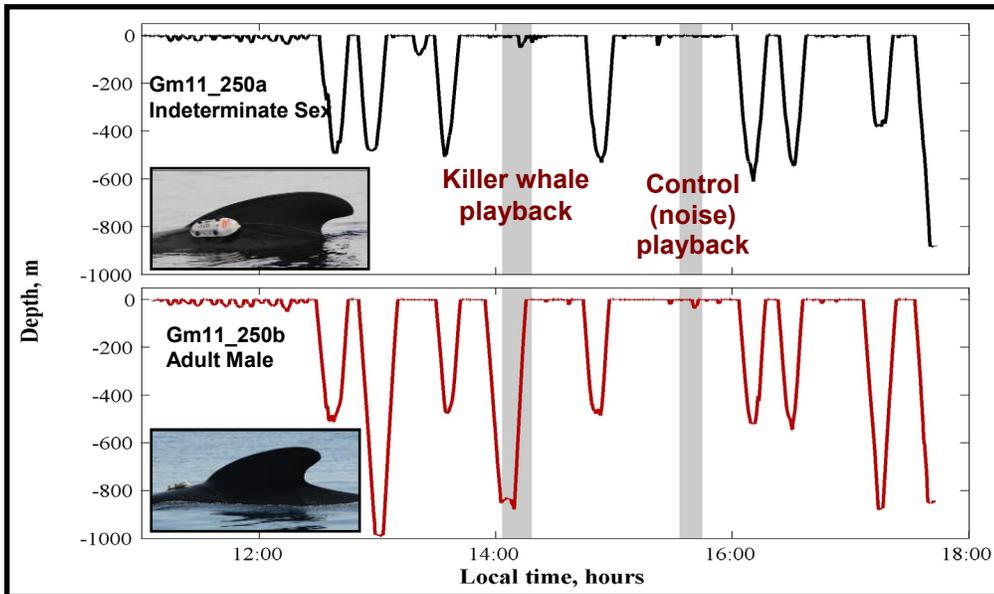


***Figure 2. Surface (dark gray) and dive (light gray) behaviors of 4 pilot whales simultaneously tagged on 23 August 2011.***



*Figure 3. Dive behavior of three pilot whales simultaneously tagged within the same subgroup.*

Figure 3 shows the actual dive profiles for the three pilot whales tagged within the same subgroup. Here the associated whale (blue line) made regular deep foraging dives during the first bout of dives. The mother (black line) and her juvenile (red line) accompanied the associated whale on the first dive, and the mother accompanied on the fourth dive, but otherwise they stayed nearer the surface. Our analyses of similar data from Med10 show that pilot whales use distinctive complex calls in exchanges as they ascend in order to join up with their subgroup, and the Med11 data offer a rich data set to extend these analyses of communication during separation and reunions.



**Figure 4. Dive profile of two simultaneously tagged pilot whales showing timing of playback experiments.**

Figure 4 shows the dive profiles of two whales that were exposed to a playback of killer whale calls followed by a noise stimulus that had the same timing and bandwidth as the killer whale calls, but was band-limited noise. During the start of the killer whale playback, the adult male was on a deep foraging dive, at least 800 m from the whales at the surface. By contrast, during the control playback the whales were together at the surface. By matching these contexts in a series of playbacks, we propose to tease apart the role of the context of separation and cohesion in mediating responses of these social delphinids to threats.

## IMPACT/APPLICATIONS

This project has created an exciting new method for studying social behavior. The system that we are developing for automatic measurement of the location of visually detected whales has enormous potential in combination with simultaneous tagging of multiple whales for simultaneously tracking how vocal communication modulates the spatial configuration of groups of animals with different individual-specific social relationships. Earlier methods have focused on the problems that observers have in tracking more than one individual at a time, so they have focused on single focal individuals or have dropped individual observations in order to record behavioral states of groups (Mann 1999). Neither method is well suited to studying how communication mediates individual-specific relationships.

This study has already identified how pilot whales use calling to reunite during separations, an insight that should help us to interpret variation in calling behavior observed during previous experiments playing sonar to pilot whales. We have identified specific behavioral states when we expect animals to call to reunite when faced with a threat, and we have started to conduct such context-specific playback experiments, such as that illustrated in fig 4. We expect that this project will contribute significantly to the long term goal of the BRS research program to understand whether and how delphinids may use

strategies for social defense against threats, and whether this provides a lower risk for stranding for this taxon. Such results will provide a critical scientific basis for acoustic criteria of harassment and risk of stranding.

## **RELATED PROJECTS**

3S<sup>2</sup> Behavioral response studies of cetaceans to navy sonar signals in Norwegian waters: ONR Grant Number: N00014-08-10661. Also involves playback of mid-frequency sonar and killer whale sounds to pilot and other whales.

BRS Social. Involves playback of sonar and killer whale sounds to a variety of cetacean species in the southern California region. Succeeded in the first two sonar playbacks to *Ziphius*.

## **REFERENCES**

Mann, J. 1999. Behavioral sampling methods for cetaceans: a review and critique. *Marine Mammal Science* 15:102–122.

## **PUBLICATIONS**

Tyack PL, Zimmer WMX, Moretti D, Southall BL, Claridge DE, Durban JW, Clark CW, D'Amico A, DiMarzio N, Jarvis S, McCarthy E, Morrissey R, Ward J, Boyd I. Beaked whales respond to simulated and actual navy sonar. *PLOS One* 6(3):e17009 [published, refereed]

Aguilar NS, Madsen PT, Tyack P, Arranz P, Marrero J, Fais A, Revelli E, Johnson M. 2011. No shallow talk: Cryptic strategy in the vocal communication of Blainville's beaked whales. *Marine Mammal Science* DOI: 10.1111/j.1748-7692.2011.00495.x [published, refereed]