Deep Diving Cetacean Behavioral Response Study MED 09

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LONG-TERM GOALS

Mediterranean 09 (MED 09) is part of a continuing international interdisciplinary effort to better understand behavior and the effects of sound on beaked whales and other cetaceans. The long term goals of this multi-disciplinary scientific endeavor are to provide a wide variety of basic oceanographic and biological data and urgently needed behavioral response measurements as part of a long-term international research program that addresses many of the priorities identified by scientific reviews (National Research Council, NRC 1994, 2000, 2003, 2005; the International Council for Exploration of the Seas, ICES AGISC 2005; the UK Inter-Agency Committee on Marine Science and Technology, IACMST 2006, Southall et al. 2007), the report of a technical workshop on beaked whales (Cox et al. 2006) and international bodies such as an Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) regarding the understanding and protection of cetaceans from adverse effects of anthropogenic noise, including sonar. Particularly notable among these efforts were tagging, followed by sound controlled exposure experiments on beaked whales and large delphinids at a naval testing acoustic range in the Bahamas in 2007 and 2008 (referred to as Behavior Response Studies, or BRS).

OBJECTIVES

The BRS experiments conducted in 2007 and 2008 demonstrated that we have developed a safe protocol to study minimum exposures that disrupt behavior. The emerging science clearly calls for studying responses of whales outside of an acoustic range, with presumably much less regular exposure to sonar. To support this work, we must continue to test and improve passive acoustic monitoring techniques and develop data archiving and display tools that merge acoustic and visual observations geo-spatially in real time. There is a high priority for work with Cuvier's beaked whales, *Ziphius cavirostris*, in the Mediterranean because most evidence for risk of stranding during sonar exercises involves this species and waters in or near this area (Frantzis, 1998 and 2004, Cox et al 2006 and Littardi 2004).

The primary objectives of the MED 09 sea trial were:

- Develop and validate methods for off range controlled exposure experiments (CEE)

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14. ABSTRACT

Mediterranean 09 (MED 09) is part of a continuing international interdisciplinary effort to better understand behavior and the effects of sound on beaked whales and other cetaceans. The long term goals of this multi-disciplinary scientific endeavor are to provide a wide variety of basic oceanographic and biological data and urgently needed behavioral response measurements as part of a long-term international research program that addresses many of the priorities identified by scientific reviews (National Research Council, NRC 1994, 2000, 2003, 2005; the International Council for Exploration of the Seas, ICES AGISC 2005; the UK Inter-Agency Committee on Marine Science and Technology, IACMST 2006, Southall et al. 2007), the report of a technical workshop on beaked whales (Cox et al. 2006) and international bodies such as an Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) regarding the understanding and protection of cetaceans from adverse effects of anthropogenic noise, including sonar. Particularly notable among these efforts were tagging, followed by sound controlled exposure experiments on beaked whales and large delphinids at a naval testing acoustic range in the Bahamas in 2007 and 2008 (referred to as Behavior Response Studies, or BRS).

15. SUBJECT TERMS

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- Demonstrate shipboard passive acoustic monitoring (PAM) for real time detection, classification and localization during at-sea surveys
- Develop real time geo-spatial tools that integrate and archive cetacean acoustic and visual observations
- Identify and improve management of habitats that host sensitive species (consistent with ACCOBAMS)
- Collect environmental data to support habitat modeling and ambient noise data to determine the background noise in their habitat
- Map the range of doses of noise to which animals are exposed

APPROACH

I was one of 3 co-Principal Investigators for the MED 09 project, along with Dr. Peter Tyack Woods Hole Oceanographic Institution's (WHOI) Marine Mammal Center for Research and Conservationfrom and Dr. Brandon Southall, senior scientist at Southall Environmental Associates. The at-sea measurements made during the cruise included the detection of marine mammals using visual observers and PAM, both for possible tagging and also to increase scientific data on their presence and abundance in the Western Mediterranean. Along with measuring oceanographic parameters, the survey mapped the ambient noise distribution to the activities producing it. These data will be used, among other things, to help develop predictive models of the distribution of beaked whales and how their distribution may be affected by anthropogenic noise. The role of the SPAWAR Systems Center (SSC) Pacific team was to intergrate the interdisiplinary teams participating in the project, prepare and implment the test plan, develop geo-spatial tools that display real time acoustic and visual marine mammal observations, collect ambient noise data to analyze post test to evaluate correlations with local shipping and marine mammal observations and jointly, with the co-PIs, perform public outreach and education. Key individuals from SSC Pacific include C. Kyburg and R. Carlson.

WORK COMPLETED

The SSC Pacific team coordinated technical input from 12 national and international teams providing personnel and equipment. I coordinated an international sea test planning meeting held in La Spezia Italy in April 2009. The MED 09 cruise plan was finalized and distributed in July 2009. Figure 1 shows the actual ship track during the cruise (29 July – 6 September 2009). In all, the ship traversed 5158nm of track lines, conducting both acoustic and visual surveys. In weather suitable for tagging, the primary objective of the visual and acoustic survey was to find appropriate animals for tagging, subsequent focal follow and controlled exposure. Preliminary data analysis shows a total of 200 hours of visual survey data was collected with 578 sightings (6412 animals) and 85.2 hours on focal follow yielding 15 focal follows. Over 550 hours of acoustic data was collected during the survey on the Centro Interdisciplinare di Bioacustica e Ricerche Ambientali (CIBRA), Università degli Studi di Pavia towed arrays and over 100 hours of data was collected on production sonobuoys for post test ambient noise data. CTD casts were taken at 56 sites, collecting temperature, salinity, oxygen and fluorescence data. A daily summary of events was posted at http://med09-expedition.blogspot.com/. SSC Pacific successfully fielded the Whale Identification Logging and Display (WILD) data collection system for the visual and PAM observers. Animal sighting locations and acoustic presence along the ship's track were transferred to an ArcView Version 9.3 GIS system for real time display in three locations on the NRV Alliance. All dynamic data was transmitted and received in standard NMEA

sentences and transmitted via UDP and stored in a geodatabase, then processed for standardized display.

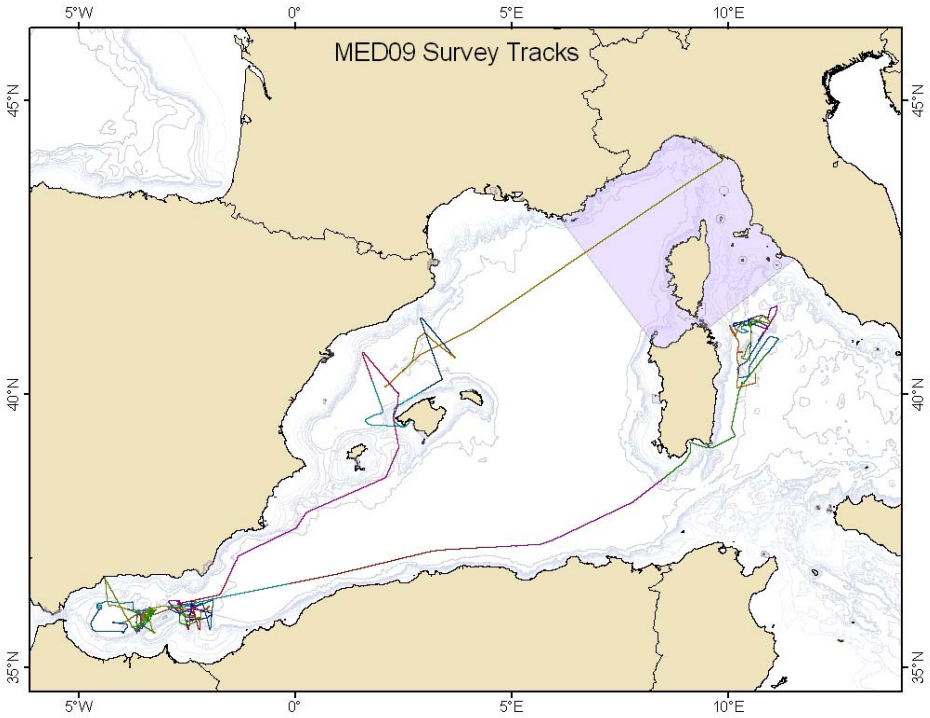

Figure 1. MED 09 sea trial actual ship track during the 29 July – 6 September 2009 time frame. The ship traversed 5158nm of track lines, conducting both acoustic and visual surveys. Purple region indicates the Pelagos Cetacean Sanctuary.

RESULTS

MED 09 was a successful demonstration of the ability to closely integrate visual and acoustic monitoring of beaked whales, off range. Significant advances were made in passive acoustic monitoring using multi-element towed arrays, a deep towed tetrahedral array, and wideband sonobuoys. Acoustic information from these different systems was integrated with visual observation data and displayed. The major new capabilities demonstrated during this cruise included integration of several shipboard acoustic systems for beaked whale detection and localization to provide sucessful off-range detection and focal follow of beaked whales.

The WILD system successfully demonstrated a novel new capability for marine mammal data collection and archiving that successfully integrated both acoustic and visual survey data in real time and displays and archives the data in a geo-spatial format. The type of real time data that was logged and displayed included:

- animal lat/long and direction of travel
- vocalization lat/long and relative signal strength
- acoustic bearing information
- continuous ship track
- tag boat and GPS buoy locations

- measure tool for field distance measurements
- each station has own GIS tools

Archival base maps were available that contained the following information:

- bathymetry
- planned track lines
- marine sanctuaries
- 0PAREA boundaries
- Territorial sea boundaries
- Ports
- Land
- Ferry and cargo ship routes

All of the dynamic and static parameters were displayed concurrently at 3 locations on the ship. Data management was achieved using automatic archiving in geodatabase format. Data transfer was accomplished via UDP protocol using standard NMEA strings.

Figure 2 shows the output of the WILD system that provided the geospatial tools to integrate both visual and acoustic data in real time. The sequence began with the ship in the northwest (upper left) corner of the figure and moving along at 6 knots (shown by orange dots). As the ship moved to the southeast, a group of two adult beaked whales was spotted visually during their brief surface intervals. The red trianges marked "A" and "B" labels are multiple positions and direction of travel of the same two whales during two surfacings. A sonobuoy was dropped to monitor their vocalizations (small circle with crosshairs) after the animals went down on a deep feeding dive. The PAM devices on the ship began tracking the beaked whales acoustically. The red circles on the trackline indicate acoustic presence, relative strength (larger circles indicate stronger signals) and relative bearing (purple lines) when available provided by the CIBRA system. Using the WILD display, the ship was able to keep the group on the port side with very consistent detections. The tag boat was deployed prior to the group surfacing from the deep dive. When the animals re-surfaced (positions C1-C5), the tag boat was about 500m away, despite the fact that the animals were down for 79min and had moved 1500m. This group was followed by the visual observers during the multiple "shallow" dives (positions C6 – C35).

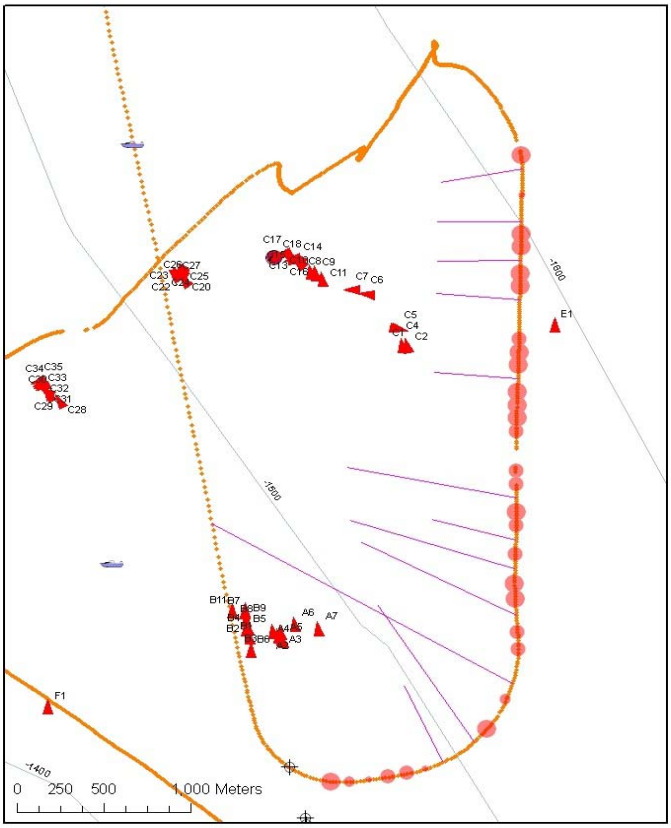

Figure 2. Output of the WILD system that provided the geospatial tools to integrate both visual and acoustic data in real time. Red trianges indicate beaked whale visual detections and location of travel. Red circles indicate relative strength of received acoustic vocalizations and purple lines display relative bearing. The track of the ship is shown in orange and the blue lines show the 1500 and 1600m batyhmetric contours.

Ambient noise data was collected along the survey track. Post test processing objectives are to compare visual and acoustic detections of cetaceans and the location of ships obtained with AIS in the western Mediterranean Sea. This analysis represents the first basin wide data collection of ambient noise data concurrently with cetacean occurrence to evaluate how their distribution may be affected by anthropogenic noise.

Significant lessons learned include that even with well integrated visual and acoustic monitoring and tagging teams, factors other than animal behavior can limit tagging and controlled exposure experiments. These limiting factors include daylight, weather, waterspace and permit restrictions, must be factored in the overall methodology and configuration for future BRS.

IMPACT/APPLICATIONS

Passive acoustic monitoring (PAM) techniques are being used to enhance visual surveys for both research cruises and to support monitoring requirements under the recently issued Final Rules for the

various Navy Range Complexes. The WILD software provides a layered approach for real time or post exercise analysis that integrates data obtained from all dynamic measurements.

TRANSITIONS

RELATED PROJECTS

This project worked directly with the WHOI co-Principal investigator/NMFS permit holder and tagging team in the development of visual survey and focal follow protocols used during MED 09. SSC Pacific customized WILD visual observer data entry display according to the function requirements put forth by the WHOI visual observers.

CIBRA provided two towed arrays used for PAM and the wide band acoustic data collection system. SSC Pacific coordinated closely with CIBRA on the acoustic data transfer to the WILD system which displayed animal presence, relative signal strength and bearing.

SSC Pacific worked closely with the NATO Undersea Research Centre (NURC) to coordinate the installation and operation of hardware and software used during the cruise to ensure accomplishment of all technical objectives. SSC Pacific defined all track lines and operating areas and provided them to NURC to obtain water space access. Operations of the acoustic source were coordinated through NURC with the waveforms generated by SSC Pacific.

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PUBLICATIONS

PATENTS

HONORS/AWARDS/PRIZES