Description of the Med 09 Research Cruise

Introduction

This paper describes a research cruise called Med09, which is part of a long-term research program involving collaboration of a large number of European and North American scientists to address the priorities identified by ACCOBAMS and many international bodies regarding protecting cetaceans in the ACCOBAMS area (Mediterranean and Black Seas) and other areas from adverse effects of anthropogenic noise. Some effects of concern involve long term effects of chronic exposure to sounds, for example, of commercial shipping (Southall et al. 2005) or whale watching (Bejder et al. 2006). The only known case where acute exposure to sound has led to short-term lethal effects involves atypical mass strandings of beaked whales during naval sonar exercises. Cox et al. (2006) review the evidence associating strandings with sonar. They conclude that "current monitoring and mitigation methods for beaked whales are ineffective for detecting these animals and protecting them from adverse sound exposure." [p 177]

The Med09 cruise is specifically devoted to addressing the ACCOBAMS priorities

- to identify and improve the management of habitats that host sensitive species, such as beaked whales
- to map the range of doses of noise to which animals are exposed
- to define the exposure doses that might affect the welfare and survival of marine mammals
- to sponsor research in the ACCOBAMS area to test and improve Passive Acoustic Monitoring tools and techniques for detecting beaked whales, either for mitigation and scientific research

The cruise will survey for cetaceans using state-of-the-art passive acoustic methods to detect and localize beaked whales, and plans controlled exposure experiments which are carefully designed to meet the criteria suggested by ACCOBAMS. The Med09 cruise is part of a broad international research program on the effects of sound on marine life, which addresses priorities identified by ACCOBAMS and many international bodies including the European Science Foundation Marine Board (2008); the International Council for Exploration of the Seas Ad-Hoc Group on the Impact of Sonar on Cetaceans (2005); the UK Inter-Agency Committee on Marine Science and Technology (2006) and the US National Research Council of the National Academy of Sciences (1994, 2000, 2003, 2005). The research will be conducted in international waters under a scientific research permit from the Office of Protected Resources of the US National Marine Fisheries Service and with coordination with all relevant national and international authorities.

Background

The Med09 cruise is also part of a long series of research cruises of the RV Alliance designed to better understand cetacean populations in the Mediterranean, to test and improve passive acoustic monitoring methods, and to reduce the impacts of anthropogenic sound on marine

life. There have been 9 such cruises since 1999 as part of the NATO Undersea Research Centre's (NURC) projects Sound and Living Marine Resources (SOLMAR) and Marine Mammal Risk Mitigation (http://solmar.nurc.nato.int/solmar/index.html). These cruises have involved close collaboration since 1999 with Italian scientists from many institutions including Consiglio Nazionale Delle Ricerche (CNR) Istituto per le Scienze Marine (ISMAR), CNR- Istituto per lo studio dell'Oceanografia Fisica (IOF), Istituto Centrale per la Ricerca Applicata al Mare (ICRAM), Universita' degli Studi di Genova, Centro Interdisciplinare di Bioacustica e Ricerche Ambientali (CIBRA) of the Universita' degli Studi di Pavia, Tethys Research Institute, Acquario di Genova, Museo Civico di Storia Naturale di Milano, and Centro Studi Cetacei (CSC). The RV Alliance cruises have focused on acoustic and visual surveys of cetaceans along with collection of relevant oceanographic parameters for predictive habitat modeling. Many of these cruises have also supported efforts to study whales with tags that can record sound and movements. These tags, called Dtags, were developed at the Woods Hole Oceanographic Institution (WHOI), and have proven an invaluable tool to study species such as beaked whales that dive deep and are seldom visible from the sea surface (Johnson and Tyack 2003).

In addition to the RV Alliance cruises, the WHOI Dtagging team learned how to tag beaked whales through a collaboration with BluWest, an Italian whalewatching company, in the Gulf of Genoa during cruises each year from 2001 to 2005. The first *Ziphius* Dtagged was on 2 October 2002 (Figure 1), and we have consistently been able to Dtag *Ziphius* in the Ligurian Sea, with 2 *Ziphius* tagged in 2003, 5 in 2004, and 2 in 2005. These have provided important baseline data on diving and foraging in *Ziphius* (Tyack et al. 2006). As you can see in Figure 1, these tags are attached non-invasively using suction cups. A small vessel slowly approaches the whale until the tag can be attached using a pole. The tag then records data for less than a day. A radio transmitter on the tag allows the tag to be recovered after it releases from the whale, and then the data can be offloaded from the tag.

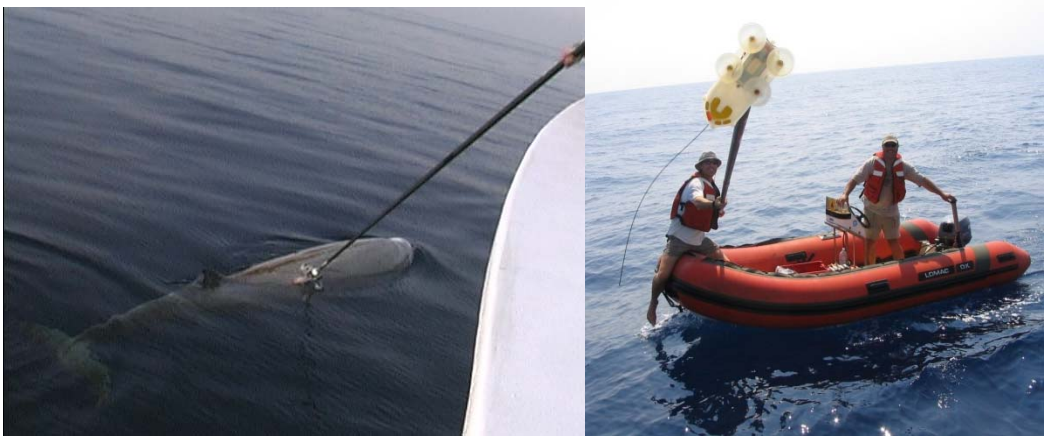

Figure 1. Left: First tag attached to in the Ligurian Sea, 2 October 2002 (Photo Credit: Patrick Miller, taken under NMFS Permit # 981-1575). Right: Close up of suction cup attachment for the Dtag.

Description of the Med 09 Research Cruise

The Med09 cruise is designed as part of an integrated research program on behavioral responses of beaked and other whales to sonar and other sounds. This program started with research on beaked whales on an established acoustic range, with a combination of experimental and opportunistic studies that started in 2006. An array of 80 hydrophones are mounted on the seafloor on this range, enabling the calls of whales to be detected and located over about 600 sq mi in the Tongue of the Ocean in the Bahamas Islands. This research was conducted in collaboration with the Bahamas Marine Mammal Research Organisation, which has a long term study involving surveys, sightings, and photoidentification of natural markings to identify individual animals. In combination with extensive baseline research, the experimental studies used 3 short (< 12 minute) exposures to define a statistically significant response of two Blainville's beaked whales to three stimuli: a mid-frequency naval sonar signal, a noise stimulus with the same overall frequency bandwidth and timing as the sonar signal, and calls of mammal eating killer whales. These whales were tagged with Dtags, which can record sound at the whale, along with depth and movement. The playbacks were designed to define the minimum exposure required to start disrupting the behavior of the whales. When a beaked whale started echolocating to find prey during a deep foraging dive (Johnson et al. 2004; Madsen et al. 2005; Tyack et al. 2006), a playback was started with the source level so low that the whale could barely hear the signal. This led to a received level of sound recorded by the tag on the whale of about 80 dBrms re 1 µPa as is visible just before 1400 on Figure 2. The level of the playback was then slowly increased until either the whale was heard on the range hydrophones to stop clicking or a maximum source level of 211 dBrms re 1 µPa at 1 m (from the source) was reached. With the whale at a range of typically about 1 km away, this led to a maximum exposure received at the whale of about 150 dBrms re 1 µPa. Figure 2 shows that the exposure for MFA sonar was increased to about 144 dBrms re 1 µPa while that for the ORCA signal was increased only to 126 dBrms re 1 µPa because the playback was stopped early soon after the whale stopped clicking. Whales exposed to these playbacks stopped clicking early, with fewer attempts to capture prey than unexposed whales ($p<0.01$). They then ascended more slowly and for a longer time than unexposed whales ($p<0.01$). This kind of disruption of foraging behavior has regulatory significance in the US, and can be used to estimate sound exposure levels that start to disrupt behavior. There is no evidence that the playback posed any risk to this whale, which has been resighted up to a year after the playback.

The opportunistic studies of beaked whale foraging dives detected on the acoustic range during sonar exercises were able to estimate exposure at animals that continued to echolocate while foraging, but the opportunistic passive acoustic monitoring was not able to monitor responses of whales once they silenced. Other opportunistic studies have used tags that can record location of the whale every few hours, but cannot record either exposure or subtle behavioral responses. Thus the opportunistic studies are not an alternative to experimental studies of tagged whales, but rather both opportunistic and experimental studies complement one another to provide a fuller picture of responses of whales to sonar and other anthropogenic sounds.

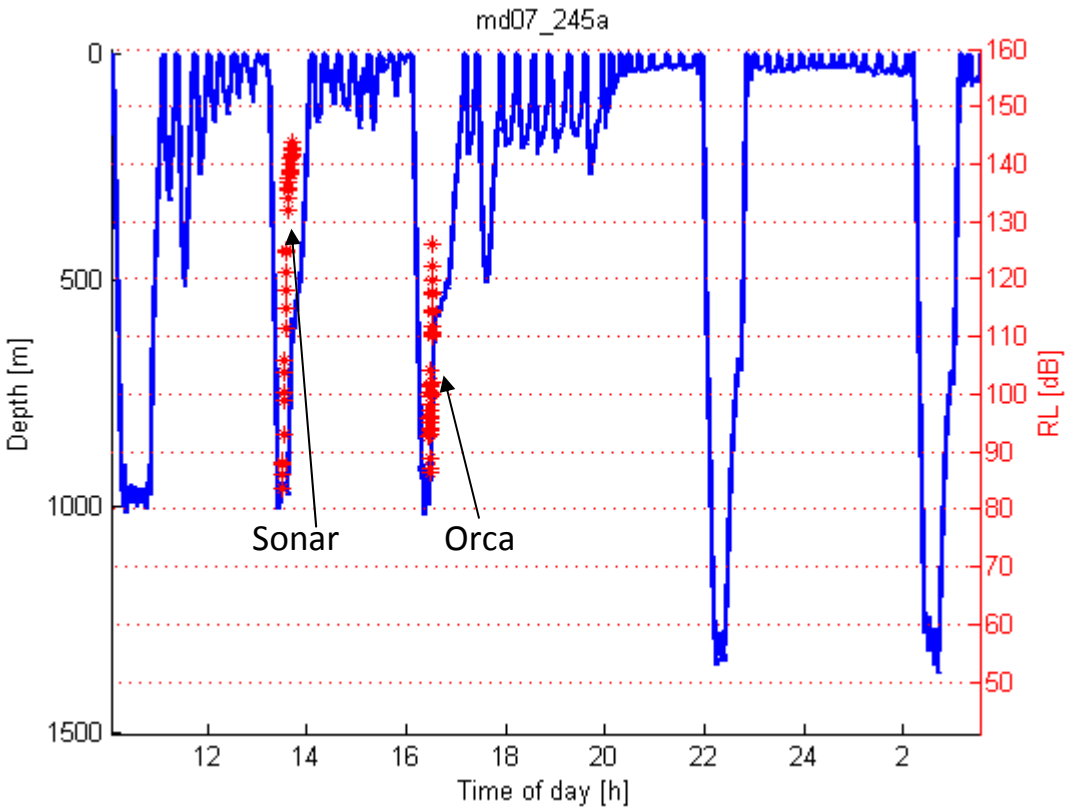

Figure 2. Experimental Protocol for Controlled Exposure Experiments to beaked whales. The blue line marks the dive profile of a tagged Blainville's beaked whale, *Mesoplodon densirostris*. The first dive is a pre-exposure dive. During the second dive, a sonar sound was played back slowly increasing in level. The red pluses mark the rms value of the received level for each ping received at the whale. During the third dive, calls of killer whales were played back, with the increasing received level at the whale also indicated by the red pluses.

After two years of field work on an established acoustic range, we are confident that we have created an experimental protocol that is safe for beaked whales and that can define the exposure required to elicit a significant behavioral response from the whales. However, these data come from a site where beaked whales on the acoustic range routinely hear naval sounds including sonars, and where there is no evidence that beaked whales are at risk from stranding during sonar exercises. If these data are going to be used to establish safe exposure criteria valid for other sites as well, it is essential to include data from a site where whales are less experienced with sonar. The stranding evidence suggests the strongest link between sonar and strandings involve *Ziphius* near the Mediterranean, so this population would be the most important to study to make sure that criteria are conservative.

The problem of managing risks to beaked whales from anthropogenic sound is clearly important for the Mediterranean Sea and the contiguous Atlantic area. With the exception of one stranding during a sonar exercise in Bahamian waters (Evans and England 2000), the

majority of beaked whale strandings reported to coincide with sonar exercises have occurred in or near the Mediterranean (Italy 1963 (Anon 1963, Podesta et al. 2006); Canary Islands 1985, 1988, 1989 (Simmonds and Lopez-Jurado 1991); Greece 1996 (Frantzis 1998); Madeira 2000 (Freitas 2004)). The dominant species reported to strand coincident with sonar exercises is Cuvier's beaked whale, *Ziphius cavirostris*. This suggests a high priority for studies that can help define safe exposure limits for *Ziphius* in the Mediterranean.

ACCOBAMS

The primary intergovernmental body focusing on conservation of cetaceans in the Mediterranean is ACCOBAMS. On the day before the second meeting of the ACCOBAMS Scientific Committee in Istanbul during November 2003, there was a 'brainstorming' meeting about the effects of anthropogenic sound. Tyack (2003) presented information on ongoing research on effects of anthropogenic sound on cetaceans in the Mediterranean, and described controlled exposure experiments and their role in managing the risk sound poses to cetaceans. In its web pages describing ACCOBAMS activities with respect to anthropogenic noise, ACCOBAMS (http://www.accobams.org/2006.php/pages/show/46) states:

> There is now general acceptance that mass strandings of cetaceans, and most notably of beaked whales (family Ziphiidae) may result from military sonar activities, also within the Agreement area. It was recognised that a number of monitoring and research projects need to be initiated to address questions related to the possible effects of anthropogenic noise in the ACCOBAMS area, including:
>
> - mapping of local ambient noise,
> - the assessment of potential acoustic risk for individual target species, and
> - the carrying out of targeted, well-defined experiments to identify and quantify actual and potential risk for individual species.

In considering the effects of anthropogenic noise, ACCOBAMS (2007) has produced several resolutions. ACCOBAMS Resolution 3.10 1b, 1c, 2 and 3 state that

> 1b) Particular attention should be given to the management of habitats that host sensitive species, such as beaked whales;
> 1c) Priority should be assigned to high-quality research to map the range of doses of noise to which animals are exposed and to define the exposure doses that might affect the welfare and survival of marine mammals. Specific research is also required to characterize human activities that produce or might produce underwater noise;
>
> 2. *Encourages* Parties to sponsor research in the ACCOBAMS area to detect and localize beaked whales by passive methods.

3. *Being aware* that controlled exposure experiments on beaked whales can carry significant levels of risk, Parties contemplating such activities in the ACCOBAMS area should inform the ACCOBAMS Scientific Committee in advance of any commitment of resources and should permit them only when stringent criteria are met, including: (1) the exhaustion of all possible alternatives, such as the opportunistic study of beaked whales in established acoustic ranges; (2) the availability of monitoring methods with a high probability of detecting both target and non-target animals in real time, across the area of potential exposure; and (3) an experimental design that is sufficient to satisfy clear, specific management objectives and is part of a long-term study of population status and health;

The Med09 cruise

The Med09 research cruise will be conducted in the western Mediterranean Sea with scientists from Italy, the UK, the US, and Spain, including Gianni Pavan (Centro Interdisciplinare di Bioacustica e Ricerche Ambientali (CIBRA) of the Universita' degli Studi di Pavia), who has prepared for the ACCOBAMS Secretariat, the Guidelines to address the issue of the impact of anthropogenic noise on marine mammals in the ACCOBAMS area. While the cruise will leave from La Spezia Italy, within the Pelagos Sanctuary, it will only involve passive acoustic monitoring and visual observations while transiting to outside the sanctuary waters. No controlled exposure experiments will take place in Sanctuary waters. The first phase of the cruise will take place primarily in international waters near Spain and the second phase of the cruise will end in the Tyrrhenian Sea outside of the Pelagos Sanctuary. The cruise will have several different science goals. There will be a survey component designed to use passive acoustic methods and visual observers to detect and localize beaked and other whales. Along with measuring physical and biological oceanographic parameters including prey density, the survey will also map noise and link noise to the human activities producing it. These data will be used to help develop predictive models of the distribution of beaked and other whales and how this may be affected by noise. Ana Cañadas of Alnitak has taken the lead for the ACCOBAMS habitat modeling effort, and she will oversee the survey design for this phase of the cruise to make sure it optimizes the data to meet the goals of the density estimation and habitat modeling efforts. These results are critical for managing the habitats of sensitive species, such as beaked whales, to reduce the impact of noise. When conditions are appropriate, the cruise plans to conduct controlled exposure experiments with beaked and other whales. These experiments are designed to define the exposure doses that start to disrupt the behavior of whales, and they will only be conducted after stringent criteria, including those suggested by ACCOBAMS Resolution 3.10, are met.

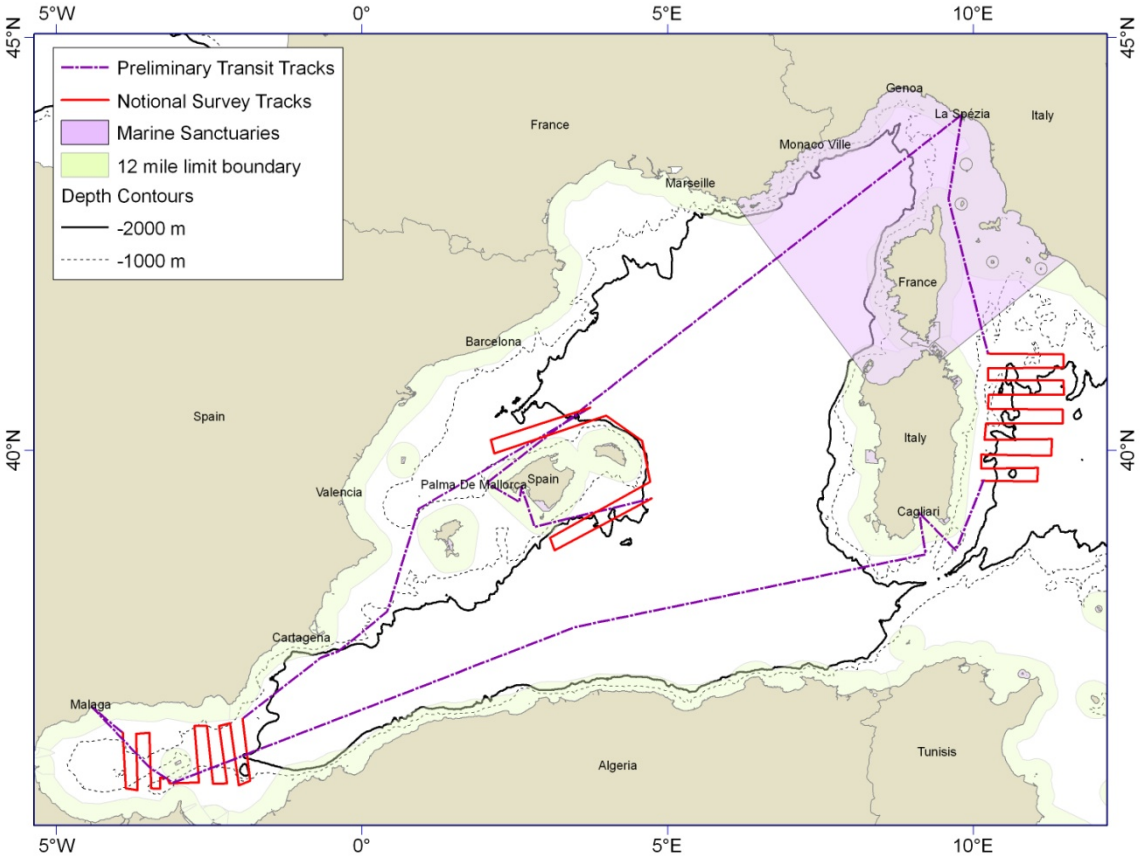

Figure 3. Notional Track for the Med09 cruise. The RV Alliance will leave La Spezia Italy within the Pelagos Sanctuary and transit out of the sanctuary to waters near the Balearic Islands of Spain. Depending upon weather conditions, the ship will follow survey tracks near the Balearic Islands, the Alboran Sea, and the Tyrrhenian Sea outside of the Pelagos Sanctuary. The survey track lines will be fine tuned in consultation with authorities who can identify areas of highest priority and with scientists who can optimize the survey protocol for estimating the density and abundance of cetaceans, and for providing input to predictive ecological models.

Survey Mode

Most of the Med09 cruise will involve a combined visual and acoustic survey for cetaceans in the areas identified with the notional survey tracks in figure 3. During 2008, NURC conducted preliminary surveys in the Alboran Sea as part of the Sirena08 cruise. Visual observers only made confirmed sightings of 10 Cuvier's beaked whales during the entire 20 day survey effort, but the passive acoustic monitoring systems had much higher detection rates, as indicated by the red dots on the track shown in Figure 4.

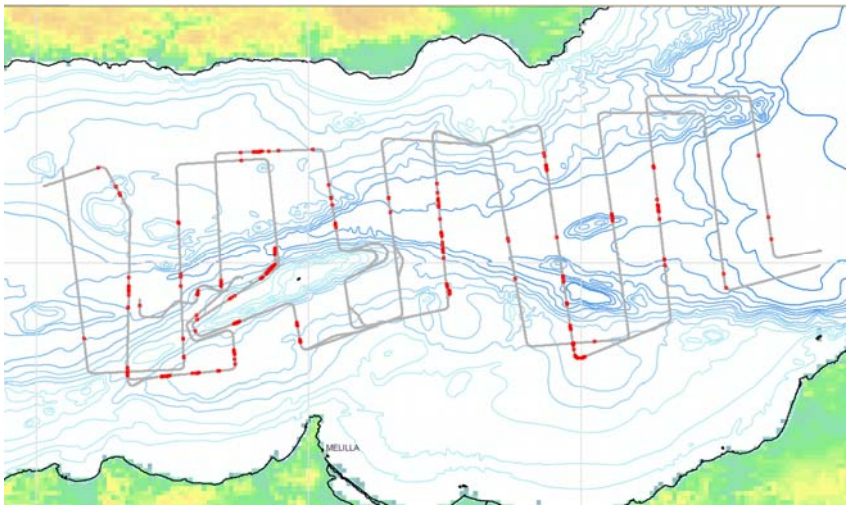

Figure 4. Acoustic detections of Cuvier's beaked whale, *Ziphius cavirostris*, during surveys in the Alboran Sea as part of the Sirena08 cruise of the RV Alliance. Courtesy of Gianni Pavan, CIBRA, University of Pavia.

During the survey phases of Med09, the RV Alliance will tow hydrophone arrays which will be monitored continuously day and night. The hydrophones will be used to detect and locate cetaceans, and also to document anthropogenic sounds such as shipping, pile driving, sonar, etc (see Tyack 2003 for extensive examples from earlier Alliance cruises). The hydrophones will be calibrated to allow quantification of the noise levels. During daylight hours, visual observers will be posted on the flying bridge of the Alliance with big eye binoculars to allow effective scanning and species identification at distance. The observers will use reticles on the binoculars to estimate the range to each marine mammal sighted, following a distance sampling protocol that will enable estimation of density and abundance of the species sighted. A precision echosounder will be used to measure the acoustic backscatter at different depths, which can be used to estimate the density of prey. Oceanographic parameters (temperature, salinity) of the water column will be measured regularly along the track line during the survey.

Data from the survey phases of the cruise will be important for

- establishing the density and abundance of cetaceans in the different areas
- measuring anthropogenic noise from different sources and in different habitats
- modeling features of the environment that predict habitat quality for different species
- evaluating whether anthropogenic noise affects the distribution of cetaceans given the other parameters measured

Controlled Exposure Experiments

The Med09 research cruise is part of a larger effort to protect marine mammals from adverse effects of anthropogenic sound. This is an international issue and there has been growing

recognition that effects of sound can pose risks to populations of marine mammals and other forms of marine life. Two primary methods have been developed to study the effects of sound on marine life. One method involves opportunistic observations of animals when they are exposed to sounds of actual human activities. This approach has the benefit of using the actual activity, but at the cost that it is difficult to control many factors about the exposure. This can make it difficult to compare potential responses to baseline undisturbed behavior, and can make it difficult to compare sensitivity of different species or to different specific sound stimuli. The experimental approach (CEE for controlled exposure experiments) can control exposure, but at the cost that the exposure may be less realistic, often because it may use just one sound stimulus out of the many sounds that may accompany an activity like a naval sonar exercise. The CEE approach is well designed to measure the minimum exposure required to elicit the observed response, and to compare whether different stimuli evoke similar responses and if so, whether they require different exposures to evoke the response (Tyack et al. 2004). The CEE design is also well suited to test for differential responsiveness of different species or age/sex classes or contexts. These two approaches, controlled experiments and opportunistic observations are therefore best seen as complementary rather than as alternatives (Tyack et al. 2004). We agree with ACCOBAMS SC4 document 18 that "In practice, research investigating the impacts of large sound sources has been most successful when it has utilized a suite of approaches including observations of controlled and uncontrolled sound exposures."[24] The Med09 cruise will include controlled sound exposures as part of a larger research program that includes just such a coordinated suite of approaches.

The top research priority identified by Cox et al. (2006) with regard to the beaked whale and sonar issue involves experiments that expose beaked whales to controlled exposures of sound. Most of the reports on marine mammals and underwater sound (Marine Board European Science Foundation 2008; the International Council for Exploration of the Seas, ICES AGISC 2005; the UK Inter-Agency Committee on Marine Science and Technology, IACMST 2006 and the US National Research Council 1994, 2000, 2003, 2005;) agree with the (Cox et al. 2006) report of a technical workshop on beaked whales and recommended an experimentally-based approach to addressing the need for new and reliable data on how beaked and other whales respond to sonar and other underwater anthropogenic sounds. For example the position paper of the European Science Foundation Marine Board (2008) in setting priorities states:

> Controlled exposure experiments have been suggested as a high research priority. The analyses suggest that characterizing the dose response relationship is an important pre-cursor to assessing the impacts on either individuals or populations. It further shows that opportunistic experiments are unlikely to be valuable unless there is an appropriate measure of the received sound at the level of the individual marine mammal. [p. 27]

The controlled exposure experiments proposed for the Med09 cruise are designed to test the exposure levels at which beaked and other whales respond to sonar and other sounds. These data are critical for assessing impacts. The species and stimuli are selected to test whether beaked whales are more sensitive than other toothed whales and to test whether they are

more sensitive to sonar signals than to other anthropogenic sounds. We plan to use actual naval sonar signals for the primary test, and will include noise stimuli with the same frequency range and timing as the sonar signals, but that sound very different. These signals will be broadcast using a research sound projector at much lower levels than actual sonars. The species to be tested will include Cuvier's beaked whale, *Ziphius cavirostris*, the species with the strongest evidence for strandings associated with sonar exercises, species such as pilot whales (*Globicephala spp.),* for which there are isolated reports of strandings associated with sonar exercises, and other large delphinids suitable for tagging such as false killer whales (*Pseudorca crassidens*), for which there is no evidence for strandings associated with sonar exercises. The contrasts between stimuli and species are critical for testing whether beaked whales are more sensitive than other species, and whether this sensitivity is specific to sonar or not.

We also propose to use a natural sound for playbacks, the sounds of killer whales, a known predator of beaked whales in the Mediterranean (Notarbartolo di Sciara 1987). We agree with the ACCOBAMS SC4 document 14 that playback of predator sounds can elicit strong responses, and that such playbacks must be selected with good reason and conducted with care. Our reason for including playback of predator sounds is based upon the growing realization that human-caused disturbance can be thought of as a form of anti-predation behavior (Frid and Dill 2002). The one beaked whale exposed to playback of killer whale calls silenced and showed prolonged avoidance behavior, swimming 20 km away over 10 hours. By contrast, the large delphinids exposed to the same playback did not show prolonged avoidance. Most delphinid groups increased their calling rate and showed increased social cohesion. These observations suggest that an anti-predator strategy that involves a flight response may be a risk factor for stranding compared to social defenses against predation. A few more such playbacks will help define this important risk factor, which may be relevant to determining whether and why beaked whales may be more at risk of stranding than other toothed whales in the same habitats.

It takes a special combination of favorable circumstances to conduct controlled exposure experiments under the stringent criteria applied for Med09. The weather and observation conditions must be good, an animal must be tagged for long enough to collect pre-exposure control data, and the passive acoustic monitors and visual observers must be able to follow the subject animals with other groups not too near. This means that even for a long cruise such as Med09, we are unlikely to have more than a few opportunities for beaked whale playbacks, perhaps a few more for other species. Thus the actual number of 12-minute exposures will be very low and limited to conditions where they will not have adverse impacts. The results of this specific cruise must be viewed in the context of a larger research program where each cruise builds up the sample size leading to a gradually improvement in our understanding of effects. The Med09 CEEs will supplement the small sample size of experiments conducted on beaked whales on the acoustic range during the Behavioral Response Studies of 2007 and 2008, with a critical expansion to studies of animals that do not live on an acoustic range.

The successful protocol for controlled exposures to beaked whales on an acoustic range described above uses hydrophones mounted on the seafloor and cabled to land to monitor the

echolocation clicks of foraging whales in real time. By tagging beaked whales on the range, we can quantify the probability of detecting beaked whale clicks as a function of range, and we can routinely detect clicks out to a range of about 2-4 km with a maximum range of 6.5 km. We have developed two methods that can duplicate these passive acoustic monitoring capabilities outside of an acoustic range. The same group that developed the marine mammal monitoring system for the acoustic range is adapting the system to use acoustic signals from sonobuoys deployed from a ship instead of from hydrophones mounted on the seafloor. By deploying multiple sonobuoys around a tagged beaked whale when it is at the surface, it is possible to test whether other beaked whales are within detection range of the sonobuoys and also to listen for when the tagged whale starts producing echolocation clicks as it descends on a foraging dive. A second method for passive acoustic monitoring involves a small array of hydrophones arranged in a tetrahedron that can also be deployed from a ship. By timing when clicks arrive at the four hydrophones, one can calculate the bearing of the clicks. Adding a comparison of the times at which the direct path from the whale to the hydrophone and the path that reflects from the sea surface allows one to calculate the range and depth of the clicking whale (Thode 2005). This detection of onset of clicks and of when the whale stops clicking is important for the playback protocol, and the ability to locate the clicking whale provides control over the exposure level at the animal. For playbacks to other species such as pilot whales, these systems are also capable of recording vocal responses in real time.

Tagging requires calm seas and good weather conditions. In the conditions in which we could tag a whale for playback, visual observers on the flying bridge of the research vessel can typically sight dolphins and larger toothed whales, even difficult to sight species such as beaked whales, out to a range of several kilometers. These visual observations supplement the passive acoustic monitoring. This combination of monitoring methods yields a high probability of detecting the study animals and other animals in real time over the area where responses may occur.

The combination of controlled and opportunistic studies of responses of beaked and other whales to sonar and other sounds is designed to meet specific management objectives. For example, Southall et al. (2007) review data from diverse studies on responses of phocoenids to anthropogenic sound. The pooled data from these studies were sufficient to identify phocoenids as more sensitive than other odontocete species, and this has led to a criterion of 120 dB re 1 µPa for the onset of behavioral disruption when phocoenids are exposed to sonar, compared to a criterion of 160 dB for other cetaceans (NMFS 2009). Comparison of beaked and other whales to similar controlled exposures makes it possible to test whether beaked whales are more sensitive than other species. The lack of data on exposures that disrupt behavior in beaked whales has prevented the kinds of measures taken for porpoises. As Southall et al. (2007) state

> The controlled exposure experiments outlined above are essential to revealing the conditions and responses underlying this effect. Until such research is conducted, deriving science-based exposure criteria specifically for beaked

whales or other deep-diving cetaceans exposed to active sonar will prove difficult or impossible.

A critical management goal for the controlled exposure experiments in Med09 will be to add to the database to test whether beaked whales are more sensitive than other odontocetes, and whether their sensitivity is specific to sonar sounds or applies to other anthropogenic sounds. Our limited preliminary results suggest that beaked whales are more sensitive than other species, but that they are equally sensitive to the other anthropogenic sounds tested as to sonar. If validated by further work, these results will be critical for management of adverse effects of noise on marine mammals.

Conclusion

In conclusion, the Med09 cruise is part of a long-term research program involving collaboration of a large number of European and North American scientists to address the priorities identified by ACCOBAMS regarding protecting cetaceans in the ACCOBAMS area from adverse effects of anthropogenic noise. The cruise is specifically devoted to addressing the ACCOBAMS priorities

- to identify and improve the management of habitats that host sensitive species, such as beaked whales
- to map the range of doses of noise to which animals are exposed
- to define the exposure doses that might affect the welfare and survival of marine mammals
- to sponsor research in the ACCOBAMS area to test and improve Passive Acoustic Monitoring tools and techniques for detecting beaked whales, either for mitigation and scientific research

The cruise will survey for cetaceans using state-of-the-art passive acoustic methods to detect and localize beaked whales, and the planned controlled exposure experiments are carefully designed to meet the criteria suggested by ACCOBAMS. This research directly addresses the goals and priorities of ACCOBAMS and most international bodies that have reviewed the issue of the effects of anthropogenic sound on cetaceans, and it will have direct and important management consequences.

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