

### *Possible Effects of Mid-Frequency Sonar Signals*

A multi-beam bathymetric sonar (Atlas Hydrosweep DS-2, 15.5-kHz) will be operated from the source vessel at most times during the Hess Deep survey. Sounds from the multibeam sonar are very short pulses, occurring for 1–10 msec once every 1 to 15 sec, depending on water depth. Most of the energy in the sound pulses emitted by this multi-beam sonar is at high frequencies, centered at 15.5 kHz. The beam is narrow (2.67°) in fore-aft extent, and wide (140°) in the cross-track extent. Each ping consists of five successive transmissions (segments) at different cross-track angles. Any given mammal at depth near the trackline would be in the main beam for only one or two of the five segments, i.e. for 1/5<sup>th</sup> or at most 2/5<sup>th</sup> of the 1–10 msec.

Navy sonars that have been linked to avoidance reactions and stranding of cetaceans (1) generally are more powerful than the Atlas Hydrosweep, (2) have a longer pulse duration, and (3) are directed close to horizontally (vs. downward for the Hydrosweep). The area of possible influence of the Hydrosweep is much smaller (a narrow band below the source vessel). Marine mammals that encounter the Hydrosweep at close range are unlikely to be subjected to repeated pulses because of the narrow fore-aft width of the beam, and will receive only limited amounts of pulse energy because of the short pulses.

### *Masking by Mid-Frequency Sonar Signals*

There is little chance that marine mammal communications will be masked appreciably by the multibeam sonar signals given the low duty cycle of the sonar and the brief period when an individual mammal is likely to be within its beam. Furthermore, in the case of baleen whales, the sonar signals do not overlap with the predominant frequencies in the calls, which would avoid significant masking.

### *Behavioral Responses Resulting from Mid-Frequency Sonar Signals*

Marine mammal behavioral reactions to military and other sonars appear to vary by species and circumstance. Sperm whales reacted to military sonar, apparently from a submarine, by dispersing from social aggregations, moving away from the sound source, remaining relatively silent and becoming difficult to approach (Watkins *et al.*, 1985). Other early and generally limited observations were summarized in Richardson *et al.* (1995, p. 301ff).

More recently, Rendell and Gordon (1999) recorded vocal behavior of pilot whales during periods of active naval sonar transmission. The sonar signal was made up of several components each lasting 0.17 sec and sweeping up from 4 to 5 kHz. The pilot whales were significantly more vocal while the pulse trains were being emitted than during the intervening quiet periods, but did not leave the area even after several hours of exposure to the sonar.

Reactions of beaked whales near the Bahamas to mid-frequency naval sonars were summarized earlier. Following extended exposure to pulses from a variety of ships, some individuals beached themselves, and others may have abandoned the area (Balcomb and Claridge, 2001; NOAA and USN, 2001). Pulse durations from these sonars were much longer than those of the LDEO multi-beam sonar, and a given mammal would probably receive many pulses. All of these observations are of limited relevance to the present situation because exposures to multi-beam pulses are expected to be brief as the vessel passes by, and the individual pulses will be very short.

Captive bottlenose dolphins and a white whale exhibited changes in behavior when exposed to 1 sec pulsed sounds at frequencies similar to those that will be emitted by the multi-beam sonar used by LDEO (Ridgway *et al.*, 1997; Schlundt *et al.*, 2000), and to shorter broadband pulsed signals (Finneran *et al.*, 2000, 2002). Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure or to avoid the location of the exposure site during subsequent tests (Schlundt *et al.*, 2000; Finneran *et al.*, 2002). Dolphins exposed to 1-sec intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1  $\mu$ Pa rms and belugas did so at received levels of 180 to 196 dB and above. Received levels necessary to elicit such reactions to shorter pulses were higher (Finneran *et al.*, 2000, 2002). Test animals sometimes vocalized after exposure to pulsed, mid-frequency sound from a watergun (Finneran *et al.*, 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway *et al.*, 1997; Schlundt *et al.*, 2000). The relevance of these data to free-ranging odontocetes is uncertain. In the wild, cetaceans sometimes avoid sound sources well before they are exposed to the levels listed above, and reactions in the wild may be more subtle than those described by Ridgway *et al.* (1997) and Schlundt *et al.* (2000).

LDEO is not aware of any data on the reactions of pinnipeds to sonar sounds, although it is likely the pinniped species can detect these sounds given their hearing abilities (Kastak and Schusterman, 1995, 1998, 1999; see also a review in Richardson *et al.*, 1995). Some harp seals (*Pagophilus groenlandicus*) seemed to alter their swimming patterns (exhibited avoidance) when they were exposed to the beam of an echosounder, nominally operating at 200 kHz (Terhune, 1976); that frequency is above the range of effective hearing of seals. However, there was significant energy at lower frequencies that would be audible to a harp seal (Richardson *et al.*, 1995). The behavior of ringed (*Phoca hispida*) and Weddell (*Leptonychotes weddelli*) seals fitted with acoustic pingers, transmitting at 60 to 69 kHz, did not seem to be affected by the sounds from these devices. Mate (1993) described experiments where aperiodic 12–17 kHz sound pulses of varying duration were effective, at source levels of 187 dB, in reducing harbor seal abundance near fish hatcheries (although a few older seals may have habituated and foraged nearby with modified techniques such that they were not seen as frequently). For California sea lions, the same system produced a dramatic initial startle response but was otherwise ineffective. Mate (1993) noted that many marine mammals will react to moving sound sources even if strong stationary sources are tolerated. Mate also noted that, by not using swept frequencies, this experimental acoustic source lost the illusion of motion that would have been simulated by Doppler-like frequency sweeps.

In summary, cetacean behavioral reactions to military and other sonars appear to vary by species and circumstance. While there may be a link between naval sonar use and changes in cetacean vocalization rates and movements, it is unclear what impact these behavioral changes (which are likely to be short-term) might have on the animals. Data on the reactions of pinnipeds to sonar sounds are lacking, but the few reports available on their reactions to other pulsed sounds suggest that they too would exhibit either no, or short-term, behavioral responses. Therefore, as mentioned previously, because simple momentary behavioral reactions that are within normal behavioral patterns for that species are not considered to be a taking, the very brief exposure of cetaceans to signals from the Hydrosweep is unlikely to result in a “take” by harassment.