Multibeam Echosounders (MBES) Webinar Questions
September 18, 2024 | 12:00pm ET
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What is the threshold between "shallow water" and "Deep water" surveys, and i there a continuum between them in terms of frequencies?
There is no fixed threshold between deep and shallow water. Surveys that operate in waters that are coastal or on the continental shelf would typically be considered shallow water. As we move off the continental shelf onto the slope and deeper waters starting around 300-600m or greater, the surveys tend to be considered deep water.

Like most sonar systems, multibeam echosounders (MBES) operate best with a high signal-to-noise ratio. As a MBES operates in deeper water the signal spreads more and is absorbed by the seawater, resulting in a weaker return echo. If the echo is too weak, the system cannot distinguish, or detect, the signal. To help prevent this, the MBES will use lower frequencies as depths increases because lower frequencies are more resilient to seawater absorption. However, a given multibeam echosounder has a limited operational bandwidth. For example, a shallow water system with a center frequency of 200kHz might be able to use frequencies ranging from 150-400kHz. When the water is too deep for the 150kHz signal to have a positive signal-to-noise ratio, it becomes necessary to switch to a system that uses a lower center frequency i.e. a 70kHz medium water multibeam. Changes in operating frequencies requires changes in the array lengths to maintain the same performance. This is why the deep-water systems have low operating frequencies and large array lengths.

Can Mike explain how the Kongsberg whale warning mode works?
Kongsberg systems allow the user to modify the source level of the system in two ways:
1. The source level can be statically reduced by 10dB or 20dB.
2. The deep-water systems have what is called a "soft start". The MBES will start at a lower source level (-20dB) and slowly over time (roughly a half hour) increase to a normal operating source level.

Has there been measurement of MBES in the field are we dependent on modelling to understand impact?
There have been plenty measurements of various MBES systems. You can see a few examples here:
https://dosits.org/animals/effects-of-sound/anthropogenic-sources/multibeam-echosounder/

What does the radiation pattern / SPL look like above an AUV?
The radiation pattern for AUV based SONAR systems will be specific to the source on the AUV. While not quite an AUV, we have an example of the beam pattern from a towed side-scan sonar system here:
https://dosits.org/galleries/technology-gallery/observing-the-sea-floor/side-scan-sonar/

Does this method have any impact on living organisms, like fishes, marine mammals or others?
Hilary's talk addressed the potential impacts on beaked whales and provided an overview of other relevant scientific work. You can also read more on this page on the DOSITS website: https://dosits.org/animals/effects-of-sound/anthropogenic-sources/multibeam-echosounder/

For the 2017 MBES survey images, were there any other vessels in the test site during data collection?
There were no other vessels on the hydrophone range during the 2017 or 2019 MBES survey. The time periods for the MBES surveys were specifically chosen when there was no Naval activity on the range. There were most certainly vessels that passed by off the range, and in some instances the sound from close vessel pass byes was captured on the range hydrophones.

What is the distance between the hydrophones in the Navy survey area?
It varies, but generally 2-6 km.

It seems like there are received sound level variations that are not associated with the vessel track line.
It's possible the hydrophones were picking up other acoustic sources of varying amplitude and frequency across the range. Sources such as calls from high frequency cetaceans, passing vessel noise, and other unidentifiable sound sources would be picked up by the array. This is a great example of the complexity of soundscapes and why it is important to study them. More detail on the acoustic data set during the 2017 survey is available in:

Kates Varghese, H., X. Lurton, M. Smith, J. L. Miksis-Olds, and L. Mayer. (2024). "Soundscape Assessment of a Deepwater (12 kHz) Multibeam Mapping Survey," A. N. Popper et al. (eds.), *The Effects of Noise on Aquatic Life*, https://doi.org/10.1007/978-3-031-10417-6_76-1

And a more comprehensive assessment is available in Chapter 5 of:
Kates Varghese, H.S.C. 2021. "The Effect of Deep-Water Multibeam Mapping Activity on the Foraging Behavior of Cuvier's Beaked Whales and the Marine Acoustic Environment." *Doctoral Dissertations*. 2648. Freely available from: https://scholars.unh.edu/dissertation/2648

Multibeam is avoidable using in the ocean. Are there any methods or using guide for the users to reduce the impact on the marine life?
There are regional policies regarding the use of sound in the ocean that aim to protect marine life. You can read more about regional policies here: https://dosits.org/decision-makers/ocean-policies/

Is beaked whale GVP an indicator of foraging success, or just foraging behavior?
It is just an indicator of foraging behavior. By looking at changes in foraging behavior we can assess whether anything has fundamentally changed that would indicate a departure from baseline for these animals.

Have MBES been used (or can be used) to map the freshwater/river systems?
Yes! MBES can and has been used to map freshwater systems. For example, MBES has been used to map the Great Lakes: https://nautiluslive.org/blog/2021/06/14/mapping-great-lakes-thunder-bay-national-marine-sanctuary

Hilary, you showed that GVP increased during and after the noise event compare to before it. What are your hypotheses to explain this trend?
One explanation is that the prey distribution at the Navy range, or the surrounding area, changed over the course of this study due to some external factor, such as the oceanographic conditions, that led to more favorable foraging conditions on the range. Local environmental conditions can affect prey densities and position in the water column. Due to the opportunistic nature of this work with the echosounder characterization study, only environmental parameters directly related to acoustic propagation were collected to support the source characterization work, which was not directly applicable to questions about prey dynamics.

Alternatively, it is possible that the MBES survey may have affected the behavior of the prey, squid, of the beaked whales. A previous study of squid abundance and distribution at the Southern California Navy range revealed large differences over small spatial scales that can have huge repercussions on a predator's decision to forage in a given area (Southall *et al.* 2019). Beaked whale foraging behavior is heavily dictated by prey abundance and distribution, so if MBES activity changed the dynamics of the prey, making them easier to hunt and/or capture, this could have led to the increase seen in foraging effort. Another consideration is that the increase in foraging effort could represent unsuccessful or aborted foraging attempts, compensated for by an increase in the number and intensity of foraging attempts. One explanation for aborted foraging attempts could be that the signal from the MBES masks or jams the animal's ability to discern its own echolocation signal. This seems unlikely for two reasons: 1) the MBES signal frequency falls outside the octave band in which the echolocation signal of this species lies, and 2) by this argument, an individual GVP would be shorter in duration and contain fewer clicks, which was not observed. In the absence of tagging or tracking individual animals and prey dynamics, these hypotheses or any additional interpretations of the cause and/or effect of increased foraging effort cannot be verified.

In addition, there is most certainly a degree of natural variation in behavior that needs to be considered. An attempt was made to account for such factors by considering longer analysis periods to get a better understanding of the natural variability in GVP characteristics.

Southall, B.L., Benoit-Bird, K.J., Moline, M.A., and Moretti, D. (2019). Quantifying deep-sea predator-prey dynamics: Implications of biological heterogeneity for beaked whale conservation. *Journal of Applied Ecology* 56, 1040-1049. doi: 10.1111/1365-2664.13334

Is it possible to conclude all marine mammals will not change its foraging area due this kind acoustic - frequency surveys?
The work conducted here was on a single species and a single multibeam echosounder during two three-day mapping surveys, meaning any extrapolation of these results, broadly, to other species and echosounders needs to be carefully considered. The scientific community recognizes that there is a myriad of factors that need to be considered on a case-by-case basis in predicting the effect a sound will have on marine life beyond just the physical characteristics of the signal. This includes the behavioral

state of the animal, the frequency range of best hearing of an animal, the duration of exposure, the proximity to the source, the perception of the character of a sound by the receiver, and the ambient acoustic conditions of the environment, among other factors. But the results presented from this empirical study assessing the effect of deep-water 12 kHz MBES mapping activity on goose-beaked whale foraging behavior should serve as an upper bound on the potential effect of geophysical echosounders on marine mammals. That is because the deep-water 12 kHz MBES is the loudest and lowest-frequency mapping system available, meaning its signals will have the largest spatial and temporal impact of any current geophysical echosounder. Goose-beaked whales have a frequency range of best hearing sensitivity that directly overlaps with the 12 kHz signal. In addition, this species has been shown to be quite vulnerable (i.e., stranding, reduced foraging) to other sonar sources (i.e., MFAS). And finally foraging behavior, studied here, represents a critical life-sustaining behavior of this species. Therefore, based on our current understanding of the myriad of important factors to consider when predicting the effect of anthropogenic sounds on marine life, the assessment of goose-beaked whale foraging behavior during deep-water MBES mapping should represent the upper bound on the potential behavioral effects on marine mammals related to echosounder signals.

What were the most powerful settings used for the MBES surveys that Hilary was presenting?
During the MBES Surveys, the 12 kHz MBES system was operated in typical fashion for the deep-water environment in which it was used. The effective source level under normal conditions for this depth range is from 235-240 dB re 1 µPa. No sound level reduction was used during the experiment. It is important to remember that this level is a figure for estimating system performance, and actual sound levels are lower near the sonar.