Does Sound from SONAR Interfere with Beaked Whale Vocalizations?

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Marine mammals and their acoustic environment

Have you ever experienced the frustration of trying to hear someone talk but surrounding noise is drowning out their voice? The acoustic environment in the ocean is similar to our daily surroundings and animals have to navigate this habitat. Like our daily surroundings, the ocean comprises diverse blends of natural and human-generated sounds, including waves, animal vocalizations, shipping traffic, industrial activities, and weather-related noise. Similar to how loud construction noise, music, or other people can hinder clear communication, beaked whales may face similar challenges due to the disruption caused by Sound Navigation and Ranging (SONAR).

SONAR is a technology developed in the 20th century used to detect and locate objects underwater by emitting sound waves and measuring the time it takes for them to bounce back after hitting an object. SONAR was developed in 20th-century naval warfare and navigation. There are two main types of SONAR: active SONAR, which transmits sound pulses and listens for echoes, providing real-time data for navigation and target detection; and passive SONAR, which listens for sounds generated by other sources to detect potential threats while remaining undetectable. Applications of SONAR include military operations, underwater exploration, fisheries management, and environmental monitoring, However, careful consideration must be given to potential environmental consequences on marine life due to noise pollution (NOAA). A way to analyze these consequences is to utilize spectrograms to see the effects of SONAR.

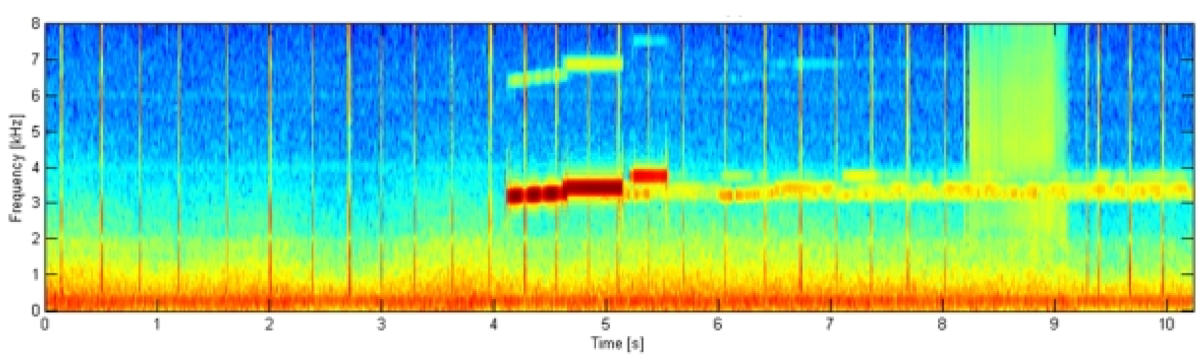

Figure 1. An example of a frequency spectrogram showing SONAR, background noise, and beaked whale vocalizations. Cooler colors (blue) indicate lower amplitude sound and warmer colors (red) indicate higher amplitude sound. The x-axis is time in seconds and the y-axis is the frequency of the sound in kHz.

Spectrograms are visual representations of sound frequencies over time. They provide valuable insights into the acoustic characteristics of sounds, displaying the intensity or amplitude of different frequencies within a sound signal (PSNS, Fig. 1). Most spectrograms, where time is represented on the horizontal axis, frequency on the vertical axis, and shading indicate the intensity of the sound at different frequencies and time intervals (Fig. 1). There are two different colors shown in the spectrogram, purple and orange, with orange representing Blainville beaked whale echolocation frequency, while purple represents a mid-frequency SONAR signal broadcast (Tyack).

Beaked whales are deep-diving marine mammals in the Ziphiidae family and are known for using echolocation. Echolocation is a biological SONAR system that allows these creatures to navigate and locate prey in their deep-sea habitats. Beaked whales emit high-frequency sound clicks, which travel through the water and bounce back when they encounter objects. By listening to echoes, beaked whales can build detailed mental maps of their surroundings, enabling them to forage efficiently and communicate with each other. Their echolocation capabilities are incredibly sophisticated, allowing them to dive to extraordinary depths (up to 3,000 meters) in search of squid and other prey (National Geographic).

Biologists, The Company of. "Extreme Diving in Mammals: Cuvier's Beaked Whale Breaks Record with 3 Hour 42 Minute Dive." SciTechDaily, 23 Sept. 2020, scitechdaily.com/extreme-diving-in-mammals-cuviers-beaked-whale-breaks-record-with-3-hour-42-minute-dive/.

Figure 2. A Blainville's Beaked Whale is shown surfacing to get air. Beaked Whales can typically dive for an hour before needing to resurface.

Despite their intriguing behaviors and crucial role in ocean ecosystems, beaked whales remain relatively understudied because of the depth they often reside in, and their elusive nature poses challenges for researchers seeking to unravel the mysteries of these captivating animals. In this paper, I look into whether SONAR could interfere with beaked whale vocalizations. To investigate this, I'll explore the potential overlap of sound frequency, amplitude, and duration between SONAR signals and beaked whale vocalizations, as well as the physical space and time of day when SONAR is employed.

Possible impacts of SONAR on beaked whales

A possible impact of SONAR on Beaked whales is the overlapping sound frequencies of echolocation used by beaked whales and SONAR. As shown in Figure 3, the Beaked whale echolocation sounds are often overlapping with the SONAR signals. This overlap shows that SONAR signals and beaked whale vocalizations share the same frequency range. The implications for beaked whales, whose complex vocalizations are essential to their communication, navigation, and prey detection, are raised by this resemblance, which raises serious concerns. For example, the masking effect is when overlapping frequencies from different sound sources make it difficult to distinguish or perceive weaker sounds in a noisy environment and can make it hard for beaked whales to utilize echolocation waves (Beaked Whale Wikipedia Contributors).

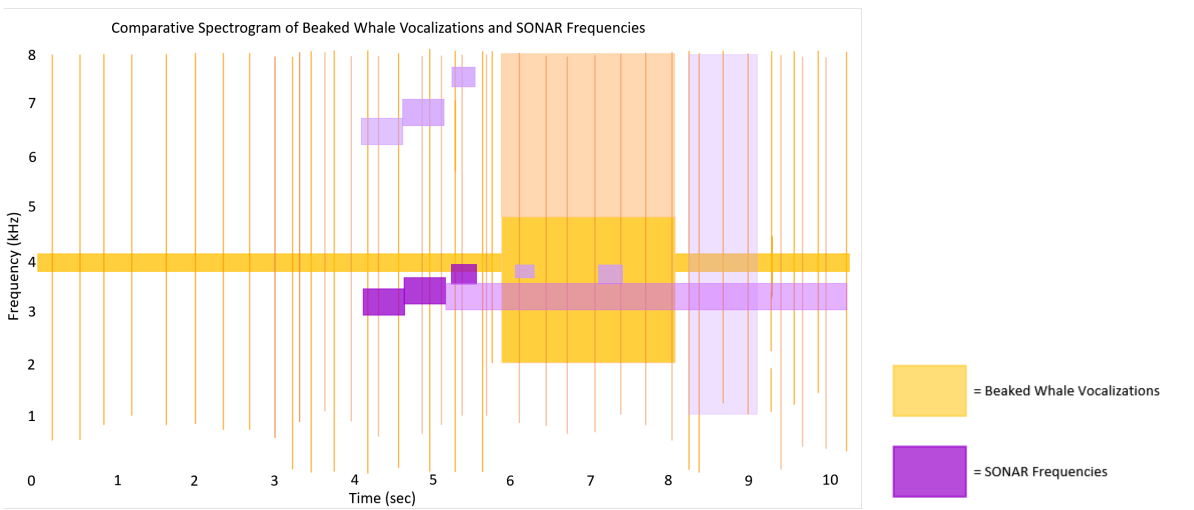

Figure 3. From 4 to 6 seconds, the louder SONAR sounds (dark purple) overlap with the beaked whale vocalizations in the 3-4 kHz frequency range.

Another impact of SONAR on Beaked Whales is the overlapping sound amplitudes of the echolocation used by beaked whales and SONAR. When looking at Figure 3, distinct patterns can be seen. For example, the spectrogram of SONAR signals exhibits high-amplitude bursts, generated by SONAR technology when mapping the ocean floor (NOAA). The composite spectrogram highlights the similarity in loudness between SONAR signals and Beaked whale vocalizations (Fig. 3). At specific points, the amplitudes of SONAR and whale sounds distinctly overlap, suggesting a convergence in acoustic energies within the same frequency range. This reinforces the claim that SONAR signals can have amplitudes that are similar to or exceed that of the naturally occurring vocalizations of Beaked whales. Such amplitude overlap holds implications for the delicate acoustic ecosystem shared by beaked whales, raising concerns about potential sound competition. This overlap could potentially influence how Beaked whales communicate, navigate, and interact within their underwater habitat, emphasizing the need for further research and the development of responsible guidelines for underwater sound use.

Beaked whales rely heavily on vocalizations to navigate, find mates, and locate prey in their deep-sea habitat. However, noise can disrupt these communication patterns as it overlaps with their vocalizations in the spectrogram. The similarity in frequency, amplitude, and duration

of these man-made noises can mask or distort beaked whales' calls, leading to reduced communication efficiency and ultimately affecting their social cohesion and foraging success.
Furthermore, spectrograms reveal how beaked whales are affected by noise pollution. Anthropogenic sounds above 120 decibels can cause temporary or permanent hearing loss in marine mammals, and the similarity in frequency and duration of noise events to their own vocalizations can exacerbate these effects (Finneran, Norton). Prolonged exposure to loud and continuous noise can lead to stress and physiological changes, which can impact the overall health and survival of beaked whales, particularly during vulnerable life stages like reproduction and calf rearing. A major source of these exposures comes from SONAR waves and ships that can reach over 200 decibels. In addition to communication disruption and noise-induced stress, spectrograms also provide insights into the potential displacement of beaked whales from their preferred habitats. As human activities generate persistent and intense sounds, beaked whales may alter their migration patterns or abandon feeding grounds to avoid these noisy areas, leading to potential changes in their ecosystem dynamics and the availability of prey resources.

Studying the detailed patterns in the sounds made by beaked whales and SONAR reveals a complicated relationship. We're wondering if SONAR might disrupt the whales' sophisticated echolocation, which they use for navigating, finding prey, and communicating. Echolocation works in specific frequency ranges, and it seems that SONAR signals might be intruding on the whales' acoustic space, possibly affecting their ability to echolocate effectively.

Conclusion

Spectrograms play a vital role in understanding the effects of human-generated noise on beaked whales. The frequency, amplitude, and duration similarity between beaked whale vocalizations and anthropogenic noises can have significant implications for their communication, foraging, and overall well-being. Conservation efforts should focus on minimizing noise pollution in critical beaked whale habitats to protect these fascinating creatures and preserve the delicate balance of marine ecosystems.

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