Diversity and occurrence of beaked whale echolocation signals in the Southern Ocean

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Abstract

Several species of beaked whales inhabit the Southern Ocean, but information on their abundance, distribution, and seasonality is scarce. However, beaked whales are the only cetaceans known to use frequency-modulated (FM) upsweep pulses to echolocate, and these signals appear to be species-specific in their spectral and temporal properties. Accordingly, passive acoustic monitoring has proven useful to investigate the behavioral ecology of these elusive species. Acoustic recordings were collected in Antarctic waters with both a towed hydrophone array as well as a bottom-moored High-frequency Acoustic Recording Package (HARP) deployed near Elephant Island that recorded between March and July 2014. The acoustic data revealed several beaked whale echolocation signal types of unknown origin. Of the numerous species of beaked whales known to occur in the survey area, an acoustic description has only been made for the FM pulses produced by Cuvier's beaked whales (*Ziphius cavirostris*). Signal characterization using custom MATLAB-based routines determined that three unidentified FM pulse types are distinctly different from the signal of Cuvier's beaked whales, and are also unlikely to belong to Arnoux's beaked whales (*Berardius arnuxii*). Southern bottlenose whales (*Hyperoodon planifrons*) likely produce the dominant beaked whale signal type BW29. The source of the less commonly detected signal BW37 is possibly Gray's beaked whales (*Mesoplodon grayi*), while the single encounter of the BW58 signal might belong to strap-toothed (*M. layardii*) or Shepherd's beaked whales (*Tasmacetus shepherdi*). Acoustic encounters over several months indicated differences among the species in diel and seasonal use of the Elephant Island area. Ongoing passive acoustic monitoring in the Southern Ocean will allow us to explore long-term relative abundance and distribution, as well as consistent seasonal and diel patterns, and will provide insight into the ecological role of beaked whales in an ecosystem that is undergoing rapid environmental transitions due to climate change.

Methods

- A High-frequency Acoustic Recording Package (HARP) was deployed near Elephant Island from March – July 2014 (Figure 1). Towed array recordings were also collected in this area during two shipboard surveys.

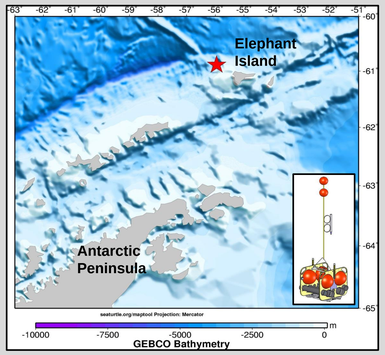


Figure 1: Bathymetric map of HARP deployment location (red star) at 762 m depth near Elephant Island. Inset: bottom-moored HARP configuration.

- Signal processing of the acoustic recordings was performed using custom MATLAB-based routines.
- Beaked whale frequency-modulated (FM) upsweep pulses were automatically detected and extracted, and the statistical parameters of these echolocation signals were calculated.

Results

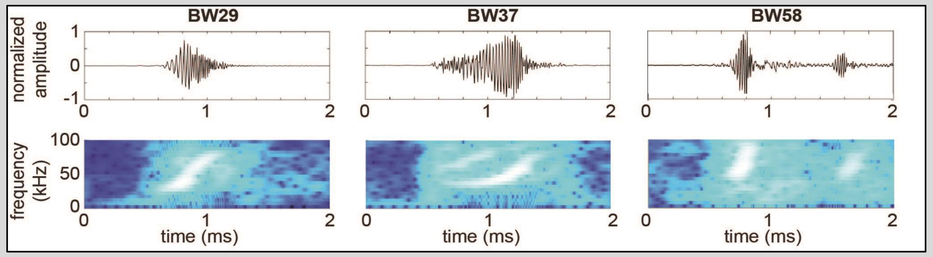


Figure 2: Example FM pulses of the three Antarctic beaked whale signal types, named after their peak frequencies, are shown as time series (top) and spectrograms (bottom).

- Three FM pulse types were detected in the recordings (Figure 2). Their spectral and temporal properties are distinctly different from the echolocation signal of Cuvier's beaked whales (*Ziphius cavirostris*), and are also unlikely to belong to Arnoux's beaked whales *(Berardius arnuxii).*
- The BW29 and BW37 signals occurred throughout the HARP recording period with seemingly alternating presence (Figure 3). A single encounter of the BW58 signal occurred in March 2014.
- The dominant signal, BW29, showed a possible preference for nocturnal foraging.

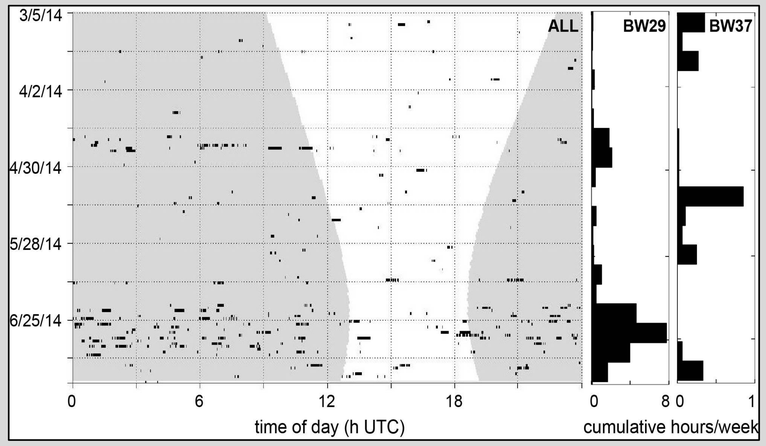
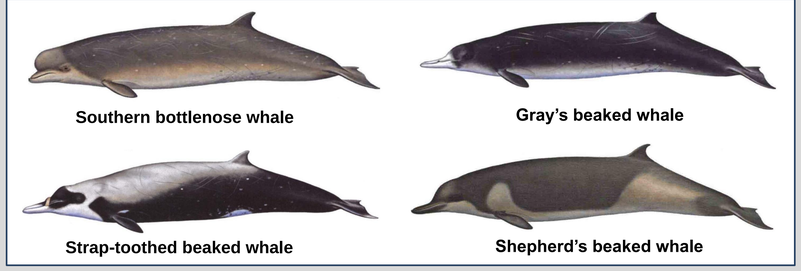


Figure 3: On the left, daily and hourly occurrence of all beaked whale signal types in the HARP data is shown as black marks, with gray shading representing nighttime. On the right, the weekly breakdown of occurrence of the two dominant signal types is shown (note the differing y-axis maximum values).

Discussion

Possible species candidates



- The most common signal type, BW29, showed particularly strong occurrence towards the start of the austral winter. It is likely produced by the southern bottlenose whale *(Hyperoodon planifrons*), one of the most abundant cetaceans in the Antarctic, which has been regularly observed in the Elephant Island region during shipboard visual surveys.
- Signal type BW37 was detected less frequently, and possibly belongs to Gray's beaked whales *(Mesoplodon grayi*), as this species is likely the second-most abundant beaked whale species in the area that the recordings were collected.
- Signal type BW58 was only detected once, and thus the low abundance source of this rare signal is possibly either the strap-toothed beaked whale *(Mesoplodon layardii)* or Shepherd's beaked whale *(Tasmacetus shepherdi*).
- HARP acoustic recording effort is ongoing, and thus the continued collection of these long-term data will provide insight into the occurrence, diversity, and relative abundance of these signals, as well as knowledge on seasonal and diel trends.

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Beaked whale illustrations: Brett Jarrett