

# Echolocation signals of an Antarctic beaked whale

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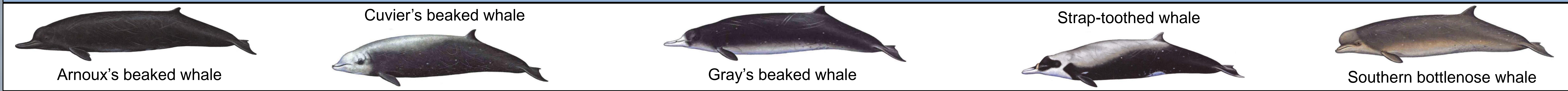
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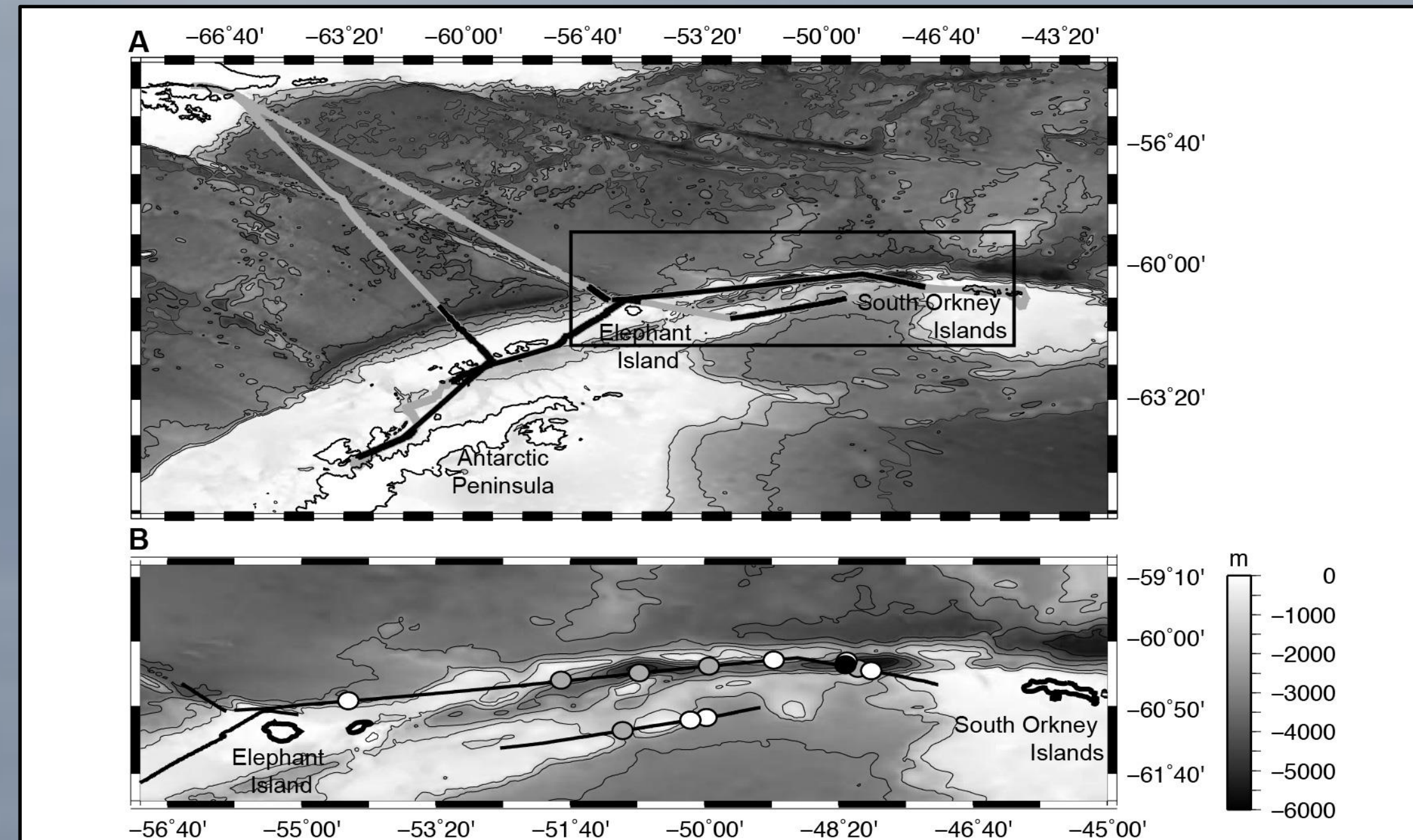
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## Beaked whale species of the Southern Ocean



## Background

- Beaked whales are among the most poorly known groups of all large mammals and are difficult to survey visually due to their offshore habitat, elusive behavior, and prolonged, deep foraging dives.
- Beaked whale echolocation signals are typically frequency modulated (FM) upsweep pulses that are species-specific in their spectral and temporal characteristics.
- At least five species of beaked whales are known to occur in the Southern Ocean waters below South America, and little information exists on their relative abundance, distribution, and natural history. Of these five species, an acoustic description has only been made for Cuvier's beaked whale (*Ziphius cavirostris*).



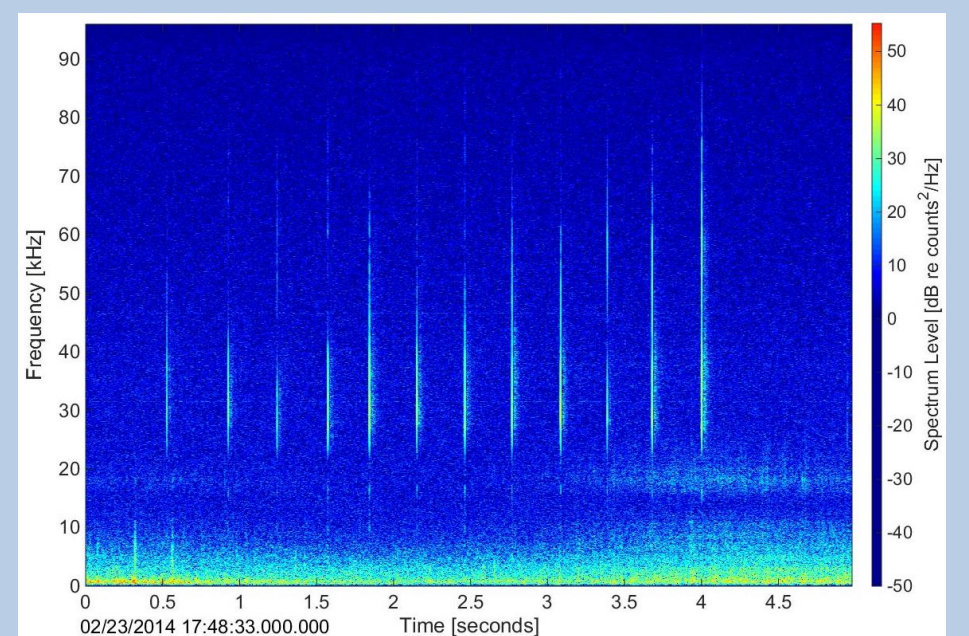
**Figure 1:** Bathymetric map of the survey area. (A) Vessel tracklines with acoustic effort indicated in black. (B) White circles: sequences used in BW29 analysis; gray circles: sequences containing  $\le 10$  pulses excluded from analysis.

## Methods



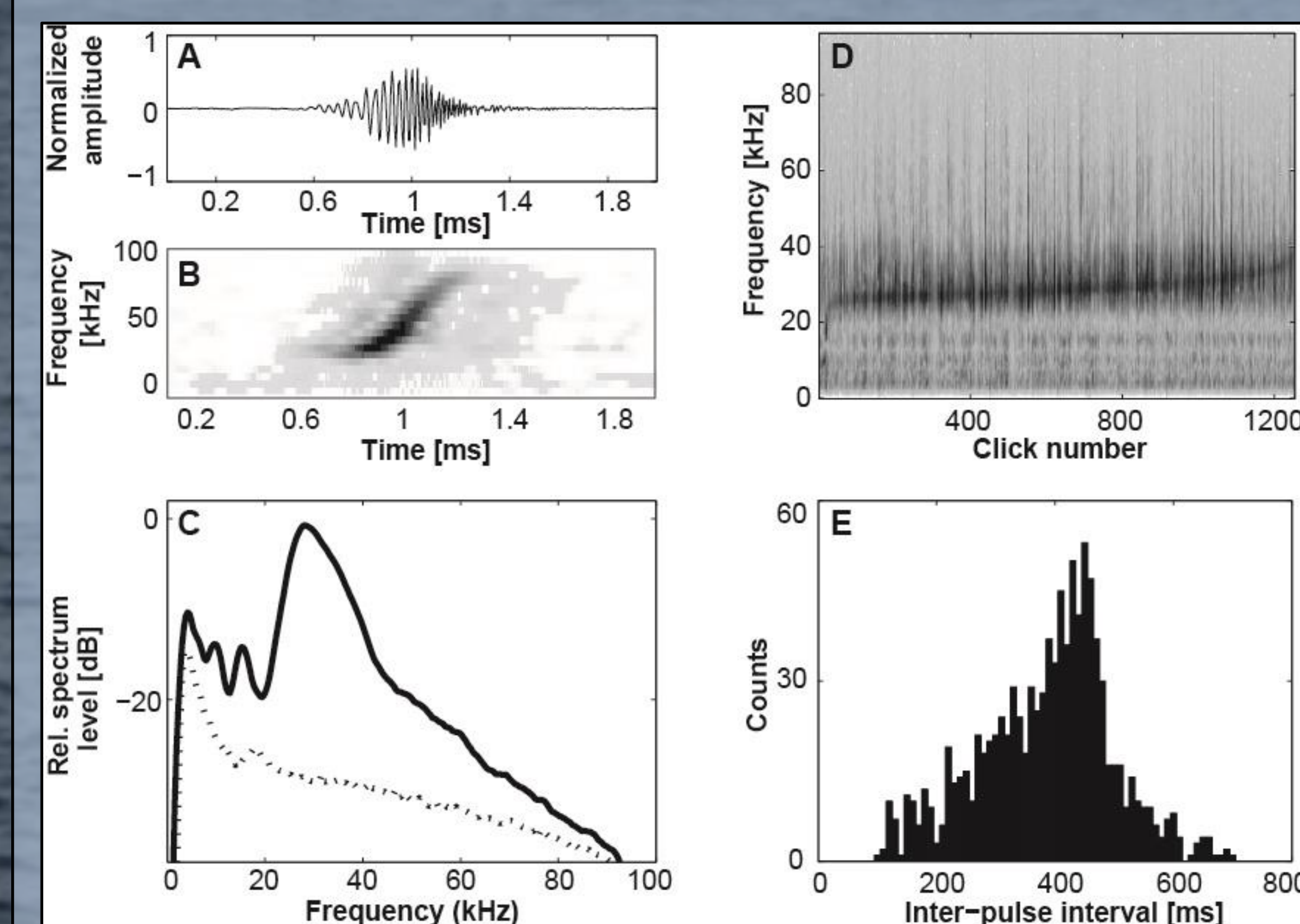
- A shipboard cetacean survey was conducted in Antarctic waters in February 2014 (Figure 1). Acoustic recordings were collected with a four-element towed hydrophone array.

- Manual inspection of the towed array data was performed using the MATLAB-based software program *Triton* and revealed FM upsweep pulses of unknown origin (Figure 2), but likely produced by beaked whales. Individual FM pulses were extracted using automatic routines, and a variety of signal parameters were then calculated.



**Figure 2:** Spectrogram of an example pulse train.

## Results and Discussion



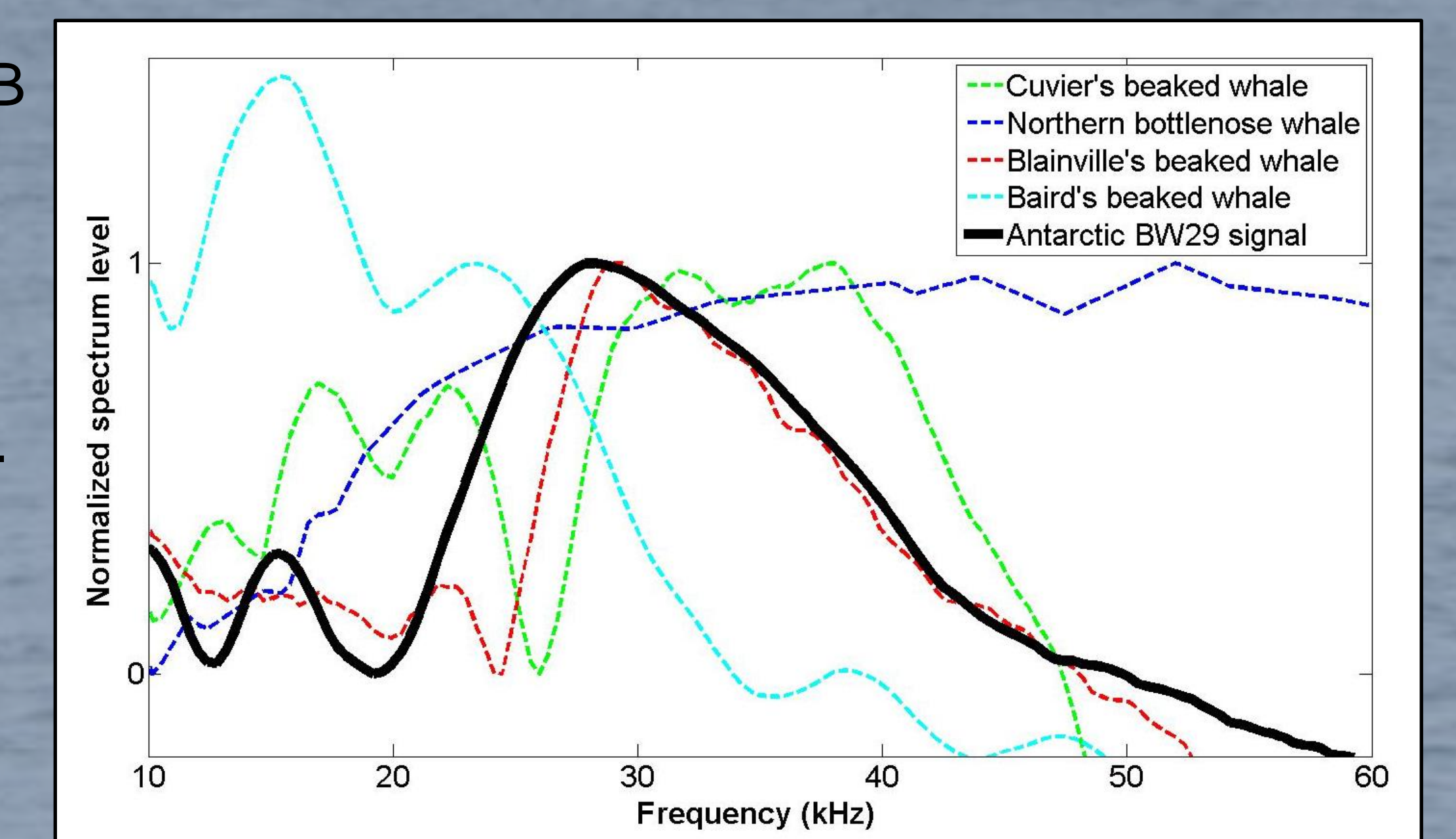
**Figure 3:** BW29 pulse type. (A) Timeseries and (B) spectrogram of an example pulse. (C) Mean spectra (solid) and mean noise (dotted). (D) Concatenated spectrogram. (E) Histogram of IPIs.

- 1,294 FM pulses were used for the signal characterization of the FM pulse type herein called Antarctic BW29 (named after its peak frequency). Median peak frequency was 28.7 kHz with a -10 dB bandwidth of 14.3 kHz. Median pulse duration was about 600  $\mu$ s and inter-pulse interval (IPI) was about 400 ms (Figure 3).

- The BW29 signal does not correspond to Cuvier's beaked whale (Figure 4), and is also unlikely to belong to Arnoux's beaked whale (*Berardius arnuxii*), which is closely related to Baird's beaked whale.

- Because its spectral shape is reminiscent of that of the mesoplodont Blainville's beaked whale (*Mesoplodon densirostris*), the BW29 signal is possibly produced by either Gray's beaked whales (*M. grayi*) or strap-toothed whales (*M. layardii*). Although the northern bottlenose whale appears very distinct from the BW29 pulse type, it is still possible that its sister species, the southern bottlenose whale (*Hyperoodon planifrons*), is the source, as it is one of the most abundant Antarctic cetaceans.

- Because beaked whale FM pulse types can be discriminated to species level, passive acoustics are a useful way to investigate beaked whale abundance, distribution, and diel and seasonal patterns. Future work in Antarctic waters could provide definitive species classifications of unknown signals and would subsequently allow us to explore the behavioral ecology of these cryptic cetaceans.



**Figure 4:** Mean spectra of Antarctic BW29 FM pulse type (bold black line). Mean spectra of Cuvier's beaked whale, northern bottlenose whale (*Hyperoodon ampullatus*; sister species of southern bottlenose whale), Blainville's beaked whale, and Baird's beaked whale (*Berardius bairdii*; sister species of Arnoux's beaked whale) are denoted as thin dashed lines.

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