Of Bubbles and Bergs: Underwater Acoustics at the Ice/Ocean Boundary

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Passive underwater acoustics have revolutionized many fields including marine biology and physical oceanography, but have only recently been applied to explore glacier ice/ocean interactions. Sources of sound near glacier and ice-sheet margins include calving events and ice shelf rifting events, iceberg motion and collision, glacier ice melting, ocean surface-ice-cover conditions, ocean wave action (including seiches), rain and snow, and subglacial discharge. We present preliminary results from a study of the frequency characteristics of sound within tidewater glacier fjords in Alaska and a discussion of the potential similarities and differences with West Antarctic ice/ocean boundaries.

We find that the ambient sound in the audible range (above 20Hz) a tidewater glacier fjord is dominated by sound produced by the formation of bubbles in the water from the melting of glacier ice (primarily ice bergs of all sizes) containing pressurized cavities within the ice (bubbles in the ice). The release of the pressurized air creates a bubble within the water with a surface that initially oscillates and transmits acoustic energy until the bubble surface reaches equilibrium with the surrounding water. The frequency of the sound produced depends on the diameter of the bubble, small bubbles oscillate at higher frequencies than large bubbles. We find that the bubbles produced from melting ice in the fjord of the Yahtse Glacier in Icy Bay, Alaska produces sound with a peak from 1-3kHz. The acoustic energy produced is a function of the percent of ice covering the water surface, with even a small percentage of ice cover producing an ambient noise environment that is significantly louder than most oceanic environments. In particular, it is significantly louder than environments with sea ice cover, which lack pressurized cavities within the ice.

Wave action due to the impact of an iceberg after calving and the resulting seiche also create bubble clusters with particular frequency content. We find that interaction of the seiche waves with the glacier terminus and with icebergs and shorelines creates generally higher frequency signals (5 to 30kHz) than stationary melting glacier ice. The magnitude and frequency content of the seiche acoustic energy varies through time with a pattern that can be related to models of seiche wave amplitude.

The ice/ocean boundaries in West Antarctica consist of both floating ice shelves (primarily) and grounded marine-terminating glaciers (primarily on the Antarctic Peninsula). Our results suggest that monitoring these environments for surface conditions (distinguishing among melting ice bergs, sea ice, wind, and rain, for example), waves impacting on ice shelves, calving events, and other processes at the ice/ocean boundary may be possible with a small array of moored hydrophones.

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