Autonomous Underwater Vehicle Measurements Under Antarctic Sea Ice

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ABSTRACT
The March 2003 deployment of Autosub in the Antarctic was the first field study under the Autosub Under Ice programme of the UK Natural Environment Research Council. Several missions were run under sea ice in the western Bellingshausen Sea at depths ranging from 90 to 200 m. Data from the vehicle’s upward-looking ADCP indicate a strongly oscillating horizontal velocity at and near the ice underside due to ocean swell. Swell period, height, direction, and directional spread are computed every 800 m from the ice edge to 10 km inland. Period-dependent attenuation of swell by ice is observed. Directional spectra showed slow changes in swell properties during propagation through the ice pack.

BACKGROUND
From 22 to 25 March, 2003, Autosub (Figure 1) completed four missions under sea ice north of Thurston Island (Figure 2). Autosub is a 7.5 m long, 1 m diameter battery-powered vehicle which carries several instruments. Here, only the Acoustic Doppler Current Profiler (ADCP) data from mission 324 will be discussed. Other variables include conductivity, temperature and depth; vehicle pitch, yaw, and roll; and velocities from a downward-looking ADCP.

RESULTS
Horizontal surface track velocity generally shows periodicity in the range of 8–15 s, indicating the ice floes were surging and heaving with the swell. Floe diameters were less than 30 m, which is much less than the deep water swell wavelength (100–350 m). In this regime the floes very nearly follow the circular path of a point on the water surface. Figure 3 shows decreasing orbital velocity amplitude as the sub travelled further into the ice pack on 25 March, 2003. A similar decay was observed upon return. The mean ice drift was southeastward.

Unique to this study is the calculation of the directional spectrum at closely-spaced locations. By calculating the spectrum of velocity along the x-axis as that axis is rotated around the half circle, we can find how the spectral density varies with direction as well as frequency (Figure 7). Wave pressure or surface height is needed to resolve the “coming or going” ambiguity present in our definition. This sum of incident and backscatter spectral density is similar in form to model calculations.

CONCLUSIONS
To our knowledge, these are the first scalar and directional wave data collected by an AUV. We observe exponential attenuation of waves propagating through sea ice that depends on period. Mean period increases with distance from the ice edge. There appears to be refraction of the waves. Waves are more spread at higher frequencies, but for any one frequency, the spread does not seem to relate to distance from the edge. More under-ice runs and modelling are needed to confirm these observations, which are at odds with current scattering models. This observational technique may also be useful for open water studies (e.g., coastal zones).

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