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HIGH FREQUENCY ACOUSTIC OBSERVATIONS OF EPISODIC MIXING EVENTS IN LUNENBURG BAY

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1. INTRODUCTION

High frequency (0.6-5 MHz) acoustic backscatter data has been collected during the past four years (2002-2006) at Dalhousie's coastal ocean observing system at Lunenburg Bay (www.cmep.ca). Severe storm events, including hurricanes, produce high wave (Hs > 2m) and wind (U10 > 10 m/s) conditions in the area for sustained periods (T > 1 day) during late summer and autumn. Coincident with periods of high waves or high winds or both, enhanced acoustic backscatter is observed to occur throughout the water column.

The acoustical backscatter observations recorded via acoustic current profilers and velocimeters at three locations within the bay are shown in Figure 1. The subplots labeled BN1-3 correspond to locations around the bay (buoy node 1 is at the head of the bay while BN2 and 3 are at the south and north shores of the mouth of the bay). Six periods of enhanced surface-intensified backscatter (at days 267, 272, 277, 280, 287, 289) and 3 periods of enhanced scattering near the bottom (days 267, 272 and 289) occur between yearday 260 to 290 (September 17 to October 17). To varying degrees, local sheltering of wind and waves resulted in distinct data sets from each location for any given period of enhanced scattering.

2. SAMPLING PROTOCOL

During 2003 the acoustic profiler located at BN3 was an internally recording ADCP which was set to measure the velocity at 1Hz for two minutes and record the averaged ensemble. The real-time ADPs at BN1, 2 sampled at 1 Hz and recorded the ensemble average every 10 s, while the ADVs sampled and recorded at 4Hz with no averaging. The real-time instruments collected data for 10 minutes every half-hour. Wave height estimates were made using the data from the internally recording ADCP which was equipped with a waves measurement package, and calculated a spectrum every half hour using 20 minutes of data sampled at 2 Hz. Wind speed measurements were made using a shore based anemometer mounted on a 10m tower and were reported every hour. Additional wind speed estimates were made by buoy mounted anemometers (at 3m height above the sea-surface) at 1 minute intervals.

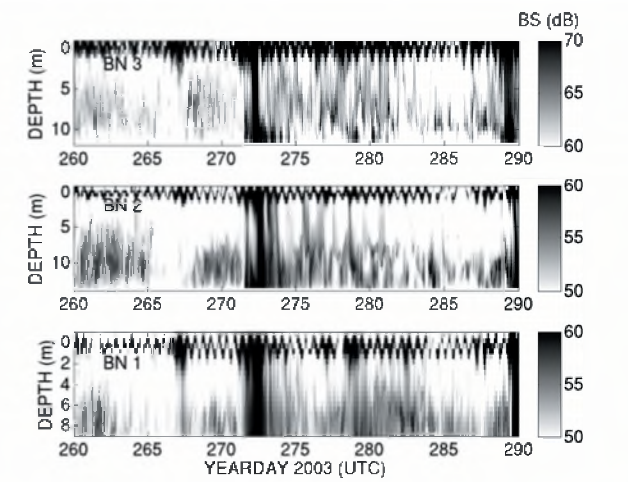

Fig. 1. Acoustic backscatter intensity (high backscatter in black) recorded at each of the three buoys during 2003.

3. RESULTS

The event at day 272 corresponds to the arrival of Hurricane Juan at Halifax NS. With Hs reaching 9 m outside Lunenburg Bay, and measuring 4 m at the mouth of the bay this event has been the focus of the preliminary investigation of these episodic events.

Figure 2 shows the acoustic backscatter intensity differences from BN2 recorded during Juan. The black dashed line is the depth at which the difference in measured backscatter at one vertical cell with the cell directly above is less than or equal to zero (positive number means that the cell above has a larger BS intensity). The black solid line is the depth to the bottom of the transition layer predicted by Terray et al. The depth to this layer is related to wind speed and significant wave height and directly related to the dissipation of kinetic energy from the surface to water column. The depth at which the backscatter intensity becomes uniform is related to the predicted depth of the transition layer.

The acoustic backscatter measured in the first bin (1.65m from the bottom) of the ADP and the acoustic backscatter measured by the ADV (25 cm from bottom) are well correlated over this event, as shown by the dashed and dash-dotted line in Figure 3. Both are related to the sum of the power spectral density of the vertical velocity over the frequency range $0.2 < f < 0.8$ (shown by the solid line).

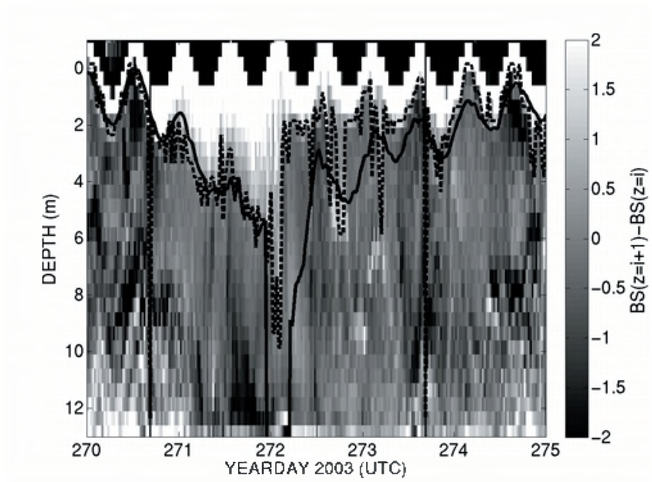

Fig. 2. The difference (BS(z(i+1))-BS(z(i))) in averaged backscatter ensembles averaged over the 10 minute sampling period, measured by the ADP at BN2. The dashed black line is the depth to a BS intensity difference of zero, while the solid black line is the depth to the transition layer predicted by Hs and wind speed. A white value indicates the backscatter in a bin above is greater than the backscatter in the adjacent bin below.

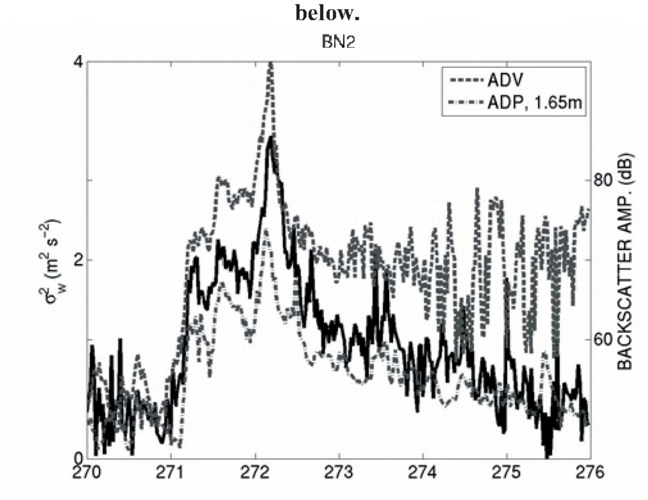

Fig. 3. Vertical velocity variance in the 0.2 < f < 0.8 band is shown by the solid line. The acoustic backscatter measured in the first bin (near-bottom) of the ADP (dash) and the backscatter measured by the ADV (dash-dot) are also shown.

4. DISCUSSION

There are several interesting features which are prominent in this data but not presented in this summary. These include:

- Near-surface backscatter intensity is directly related to wind speed at time scales of one minute
- Near-surface backscatter is dependent only on wind speed, with little or no dependence on fetch
- During periods of resuspension of bottom sediments, the power spectra of near-bed vertical velocity exhibit a slope of -5/3, indicating turbulence is responsible for the upward flux of sediment.
- The backscatter measured by the ADV (at 25-cm height) remains elevated much longer than that by the ADP (at 1.65-m height).

A supplemental experiment which included the deployment of in-situ laser measurements of sediment size has yet to be analyzed. In addition, sediment samples take from each of the site have been taken and measured but have not yet been incorporated into this discussion.

REFERENCES

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