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Use of a high resolution multi-frequency acoustic instrument for estimation of zooplankton biomass and characterization of vertical ecosystem structure in the N Bering and Chukchi seas.

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Overview:

There is a need to develop new techniques for the monitoring and study of zooplankton. One promising approach is the use of high resolution multifrequency acoustics to understand vertical structure, abundance and species composition. We undertook such studies at stations of the Distributed Biological Observatory (DBO) in the North Bering and Chukchi seas in the summer of 2013 (Fig. 1) . Our approach combined an Acoustic Zooplankton and Fish profiler (AZFP) in an instrument package with an Acoustic Doppler Current Profiler (ADCP) (see Fig. 2) which was deployed over the along with zooplankton net tows and a range of other data were collected regarding watermass properties. Our ultimate goal is to expand on and refine net-based biomass estimates.

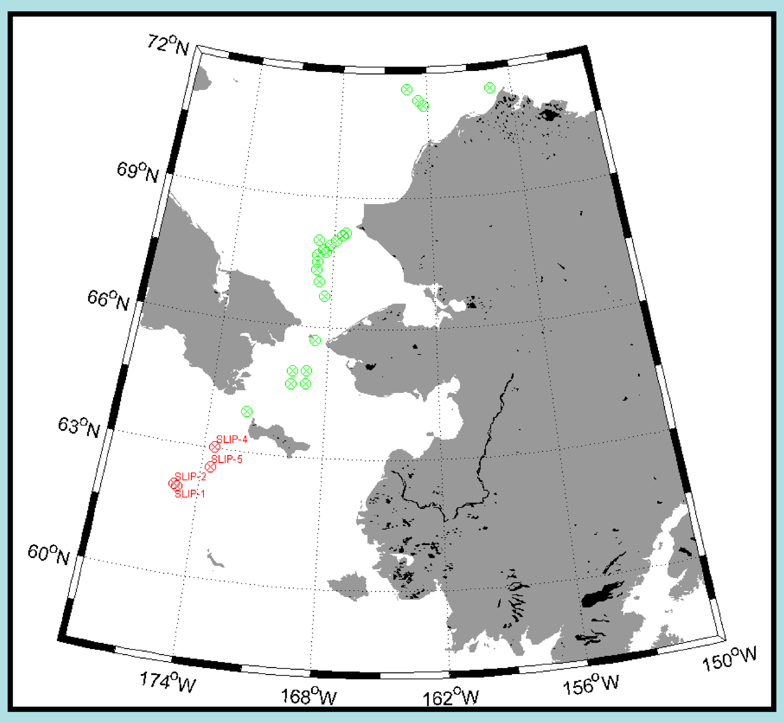

Figure 1. Sampling stations occupied by the Canadian Coastguard icebreaker CCGS Sir Wilfrid Laurier in July 2013. (Red stations are discussed here.)

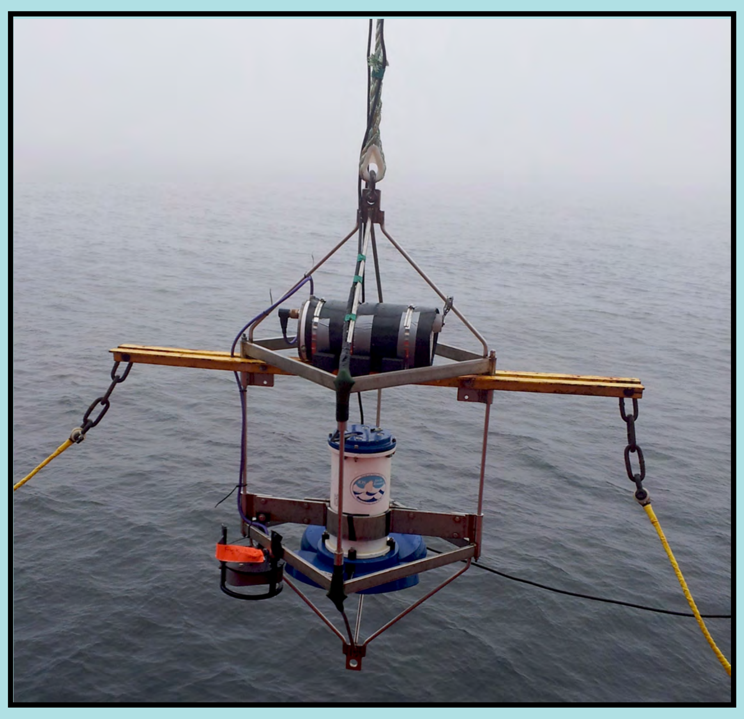

Figure 2. AZFP-ADCP instrument package as lowered over the port side of the ship while on station. Guide lines make sure the instrument package is aligned with the ship.

Approach:

The 4-channel AZFP operated at 125, 200, 455 and 769 kHz. The channels are pinged sequentially, starting with the highest frequency and transmitting at the end of the receiving period for the preceding channel. The transmission sequence was repeated once a second. The frequency dependent source level ranged between 201 and 204 dB. The receiver dynamic ranges were 88 dB for the 125 & 200 kHz channels and 80 dB for the 455 & 769 kHz channels. Due to the large dynamic range no time-varying gains were used or needed.

This instrument was combined with an independently operating 150 kHz ADCP for depth dependent current measurements. The package was the first to be lowered over the side of the ship when the ship stopped on station and the last to be recovered. Water property data were collected using a Rosette/CTD system at each station. Zooplankton were collected for species composition and abundance estimates using vertical Bongo net tows.

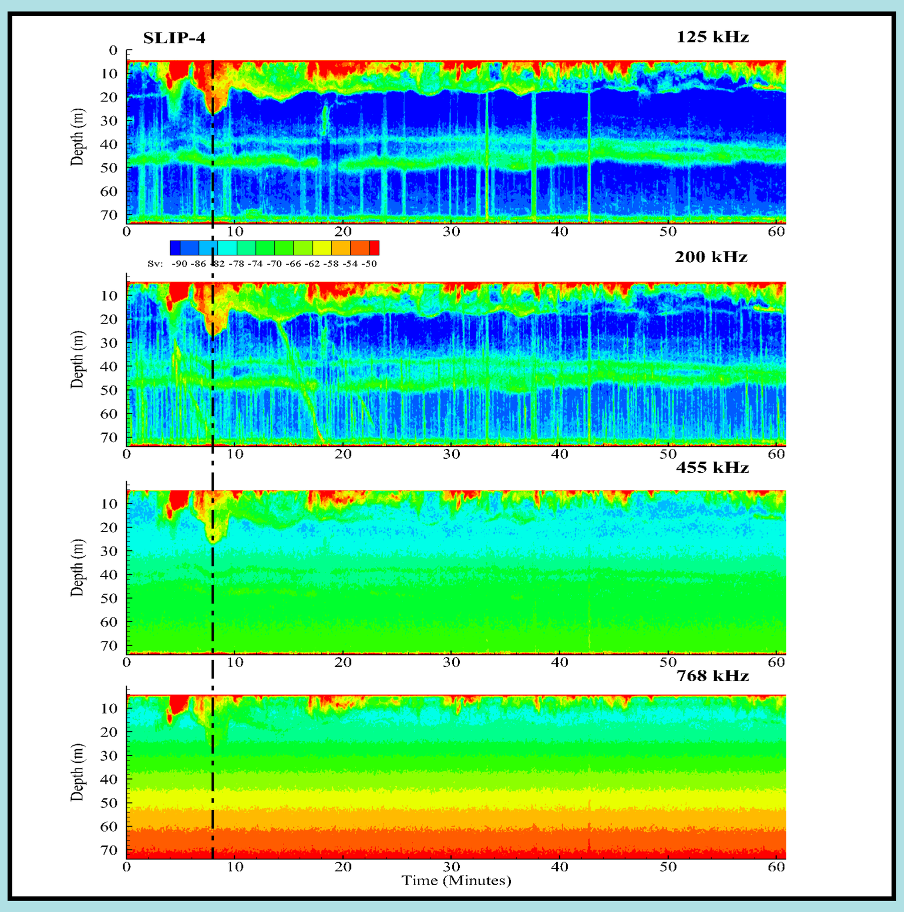

Figure 3. Backscatter data at each of the four AZFP channels from the SLIP-4 station (Fig. 1) over a 60 min. period. Broken line indicates time of data shown as line in Fig 4 and in detail in Fig. 5.

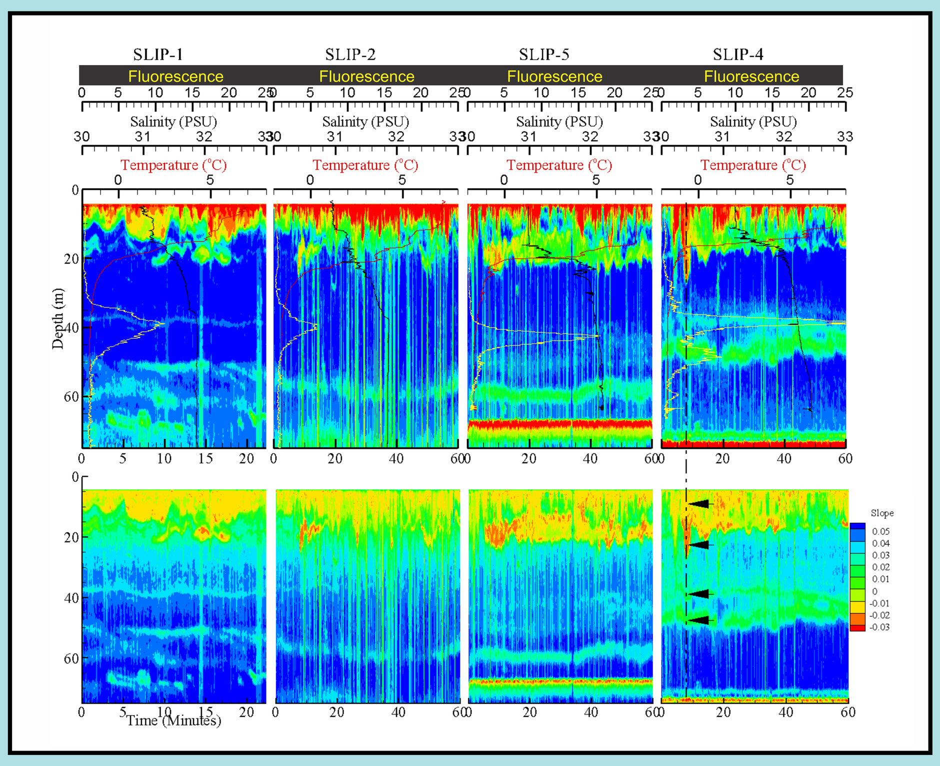

Figure 4. Backscatter (bs) data at 125 kHz from all 4 stations along the SLIP transect (Fig. 1) (Upper panels), and bs versus frequency slope in lower panels (see Fig. 5). Superimposed are T, S, and fluorescence profiles. Vertical broken line and black arrows show time and depth of profiles shown in Fig. 5. Solid horizontal lines near the bottom in right 2 panels are bottom bs.

Results:

Figure 3

Typical backscatter (bs) at each frequency. Strong near-surface bs is from bubble plumes. Horizontal layers in upper 2 images between 35 and 50 m are plankton (see Fig.5). Apparent strong bs below 40 m in lower 2 panels indicate range limitations at these higher frequencies due to sound attenuation.

Figure 4

Along-transect data show spatial variability in plankton distributions associated with different water mass characteristics. Identifiable plankton layers are sometimes associated with strong fluorescence peaks. Near surface bubble plumes due to rough seas will mask bs from plankton layers.

Figure 5

The multifrequency aspect of the observations can be used to identify the type of scatterers causing the observed bs. Identifiable layers are marked by coloured arrows (a). The corresponding bs versus frequency data at these locations are fitted using least squares. Negative spectral slopes are observed in bubble plumes, decreasing with depth. Probable zooplankton layer (green) also has negative, but significantly less steep slope. Probable phytoplankton layer (blue and identified by high fluorescence in Fig. 4) has increasing bs with increasing frequency.

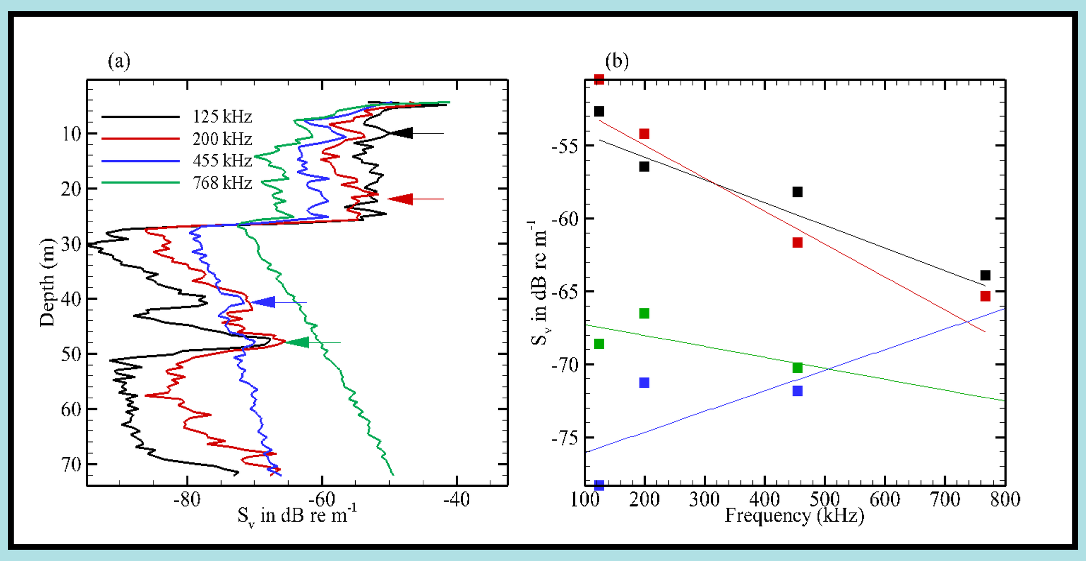

Figure 5. (a) Backscatter (bs) versus depth at 4 frequencies at time shown in Figs. 3 & 4. Identified layers marked by coloured arrows. (b) bs versus frequency at arrow depths. At depths greater than 25 m the data from the highest frequency channel is not used.

Summary:

Preliminary results using a multifrequency backscatter sonar to identify scatterers in the water column show that the frequency dependent characteristics obtained from the AZFP can be used to separate different types of scatterers. Work in progress is using zooplankton abundance and species composition data from vertical net-tows and laboratory defined species frequency dependent backscatter characteristics, to calibrate the sonar backscatter to obtain acoustic biomass estimates. Preliminary estimation of acoustic derived abundance as compared to those from net tows shows comparable results. Using information regarding currents obtained from the ADCP will allow for estimation of spatial abundance of major zooplankters to improve on the overall understanding of variability in zooplankton biomass.

Acknowledgements:

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