Acoustic Detection of Zooplankton in the Chukchi Sea

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Abstract

The Chukchi Sea is located within the U.S. Exclusive Economic Zone, and is covered with sea ice for approximately 7 months of the year making it inaccessible to ships. Thus it is difficult to conduct research to determine how the ecosystem responds to environmental and anthropogenic forcing. As part of the BOEM-sponsored multidisciplinary program CHAOZ (CHukchi Acoustics, Oceanography, and Zooplankton) we are studying this high latitude ecosystem to understand how it may respond to changes in climate, and how the response affects prey availability for bowhead whales transiting through the area. In August-September 2010, we conducted shipboard measurements of hydrography and lower trophic levels (chlorophyll, net and acoustic samples for zooplankton) along multiple, cross-shelf transects. In addition, an upward looking, 8-frequency acoustic instrument (TAPS-8; Tracor Acoustic Profiling System) was attached to a mooring deployed for year-round measurements. In August 2011 we returned to the study site, repeated our cross-shelf transects, and successfully recovered the moored TAPS-8. The instrument took measurements until at least the end of May 2011 and we will present the initial processed data. Our transect results show the sound scattering was highest at the surface and at depth with a minimum in the middle of the water column during both cruises. In 2011 we observed diel vertical migration of zooplankton at the mooring site. Two instruments, a TAPS-8 and a new TAPS-6 NG (Next Generation), were deployed in close proximity to each other in 2011 and will sample under the ice during the coming year.

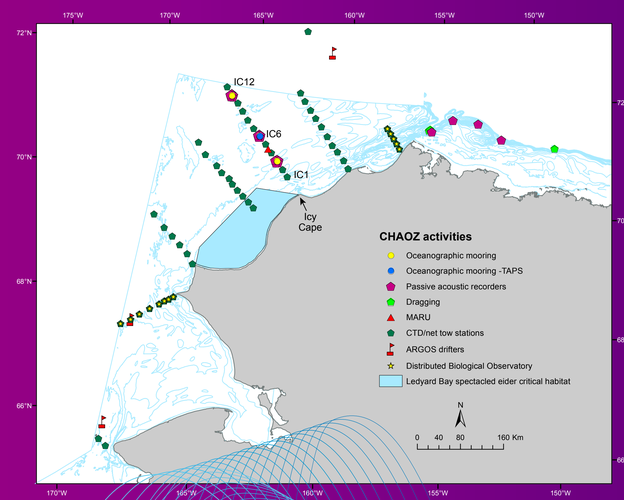

Figure 1. CHAOZ 2011 Operations Area. Geographic area where CHAOZ made shipboard measurements and deployed biophysical moorings. The TAPS-6 instrument was deployed on the transect line off of Icy Cape (●) in the middle of a cluster of passive acoustic recorders for marine mammal vocalizations (Station IC6). Figure courtesy of Jessica Crance.

Figure 2. TAPS6-NG. This is a picture of our newest acoustic instrument, the TAPS-6NG (Next Generation) during deployment. The data in this poster are from an older version of the same instrument (TAPS-8). The older model consists of an underwater pressure case containing both the electronics and the eight transducers (104, 165, 265, 420, 700, 1100, 1850, 3000 kHz). The instrument was programmed to collect measurements every 30 minutes and the transducers were pointing vertically towards the sea surface. The acoustic returns are recorded two different ways: the echoes from all eight frequencies in a small volume of water 1.5 m from the transducer faces (small volume) and the echoes from the four lowest frequencies at distances ranging from 1.5 to 13.5 m from the transducer faces (large volume). The new instrument will obtain data from 1 to 40 m away from the transducers.

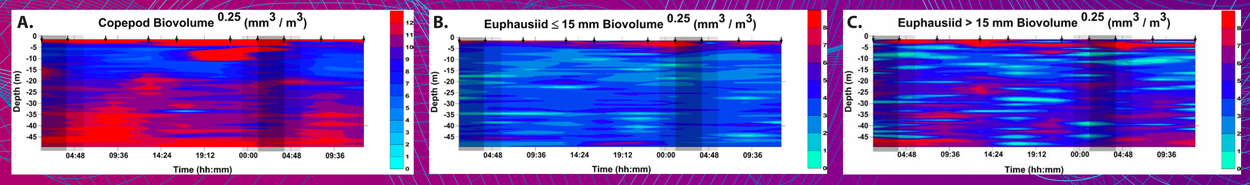

Figure 3. Acoustic Estimates of Zooplankton Biovolume at the Mooring Site. Arrows at top of each panel indicate time of sampling and shaded areas indicates twilight and dark periods, respectively. Acoustic measurements were made with a TAPS-6 mounted on a Tucker sled. Casts were accomplished every couple of hours to determine whether or not Diel Vertical Migration was occurred during our cruise. The TAPS-6 data have been processed using inverse methods to determine the biovolume of sound scatterers using two different scattering models: the truncated fluid sphere model (approximates copepod-like scatterers, 3a) and the Distorted Wave Bjorn Approximation model (approximates elongate scatterers such as euphausiids, 3b & c).

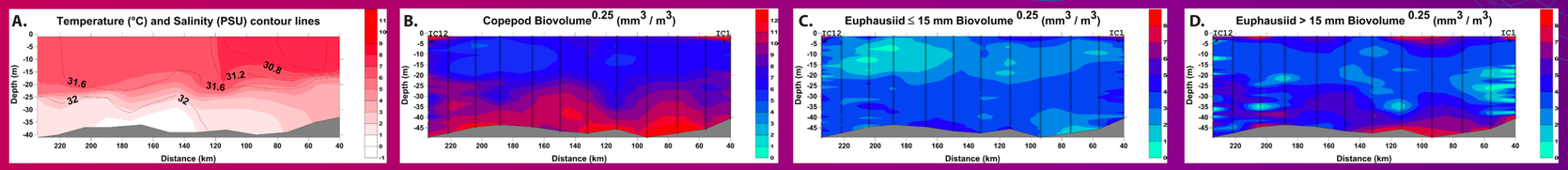

Figure 4. Hydrography and Zooplankton Biovolume Across the Icy Cape Transect Line. A) Temperature and salinity measurements made with an SBE 911plus. Acoustic measurements were made with a TAPS-6 mounted on a Tucker sled and processed in exactly the same way as in Figure 3. B) Copepod-like scatterers, C) Small euphausiid-like scatterers, and D) Large euphausiid-like scatterers. Vertical black line across the panels indicate where the measurements were taken along the transect.

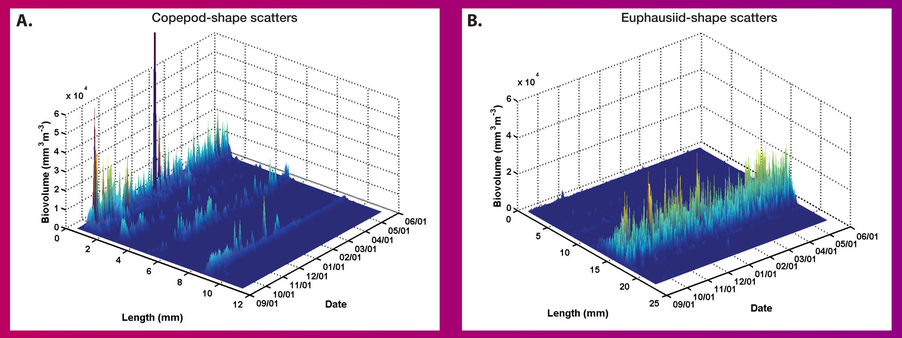

Figure 5. Small Volume Overwinter Time Series at IC6. We successfully recorded volume backscatter measurements under the ice at station IC6 with our older TAPS-8. The instrument collected data every 30 minutes from early September to mid to late May when the instrument memory became full. We used the inverse methods described above to partition the volume backscatter from the small volume into copepod-like (A) and euphausiid-like components (B) for the entire time series.

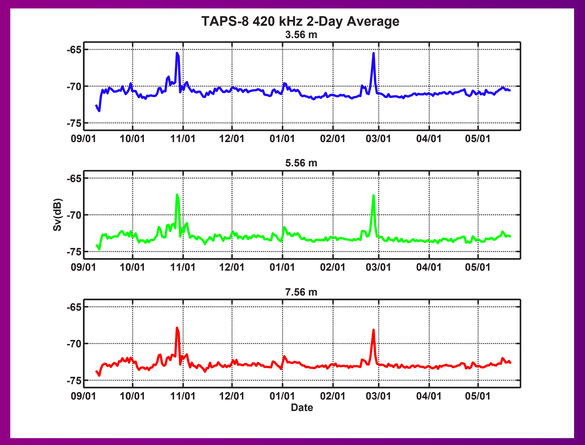

Figure 6. Large Volume Overwinter Time Series at IC6. We also examined the large volume backscatter for the 4 lowest frequencies. Shown here is the volume backscatter for 420 kHz at three distances from the transducer face. The time series at distances 3.56 to 13.56 m were all very similar in shape.

Conclusions

- We successfully measured acoustic volume backscatter of zooplankton in the study area from August to May using a TAPS-8. We captured the temporal trends in biovolume from the ice-free fall period to the beginning of the ice breakup/spring transition.
- We successfully resolved both spatial and temporal variability in zooplankton biovolume at the study site during our 2011 cruise.
- Two older TAPS-8[1] and one new TAPS-6 NG were deployed in 2011 at the mooring site. Changes in sample collection were made to obtain data for a much longer time period.
- There was a lens of relatively warm, fresh water near the coast during our 2011 cruise. The mooring site was just inshore of a layer of very cold, salty water at the bottom. Biovolume of small euphausiids (≤15 mm) was low throughout the transect. The biovolume of larger euphausiids (> 15 mm) was relatively higher than the biovolume of small euphausiids with "hot spots" at the surface and bottom. The increased values at the bottom began inshore and extended to stations IC7.
- The data suggest that some of the copepod-like and large euphausiid biovolume leave the near bottom waters for the surface during the twilight period, although the pattern is complicated and there is also a significant fraction of the copepod-like biovolume in the surface waters during the day.
- Work is ongoing to estimate and interpret the time series of volume backscatter collected from September 2010 to May 2011.

Acknowledgements

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The recommendations and general content presented in this poster do not necessarily represent the views or position of the Department of Commerce, the National Oceanic and Atmospheric Administration, or the National Marine Fisheries Service.

[1] Many thanks to Carin Ashjian, Steve Okkonen, David Leach and the crew of the USCG Icebreaker Healey for successfully deploying the second TAPS-8 in November 2011.