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Observing the mesopelagic zone of the Arctic

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The mesopelagic zone (200 – 1,000m depth) is one of the most understudied regions of the global ocean. This zone is characterized by pelagic communities that aggregate into acoustic sound-scattering layers. The fish and plankton community inhabiting the mesopelagic potentially represents the world's last unexploited resource of animal protein (St. John et al., 2016). As a result, it has become a point of interest for resource strategists and commercial fisheries as the potential next target of exploitation. However, we still know relatively little about this region because it is hard to sample due to its depth. Global mesopelagic fish biomass estimates range over an order of magnitude, partly due to the uncertainties in the population characteristics of siphonophores (Proud et al., 2019). Siphonophores are a group of colonial gelatinous zooplankton, some of which contain gas bladders that result in high acoustic backscatter. The aim of my PhD is to gain an understanding of how siphonophores influence acoustic estimates of mesopelagic fish biomass using a variety of different sampling methods.

During the recent MR23-06C research cruise aboard the research vessel *Mirai*, I collected acoustic data using an Acoustic Doppler Current Profiler (ADCP) and a Multibeam echosounder, and biological data in the form of environmental-DNA (eDNA) and zooplankton samples. Figure 1 shows an echogram (echo intensity values gridded by depth and time) displaying acoustic data collected in the Canadian basin. Acoustic scattering layers resided at c. 250 m depth during the day and migrated vertically at night to the surface. This movement of scattering layers is indicative of diel vertical migration (DVM), a behavior commonly observed at these depths, where organisms vertically migrate between the surface and the deep ocean in order to evade visual predation (or track their prey). The signal-to-noise ratio of the data (which decreases with depth) limited the useful range of the acoustic observations, but the migration observed in this part of the Arctic was found to be relatively shallow (c. 250m) when compared to the global mean of c. 525 m (Proud et al., 2017). This and other data collected by myself and other working groups during the cruise can give us an indication of the organisms performing DVM, as well as their contribution to various biogeochemical processes.

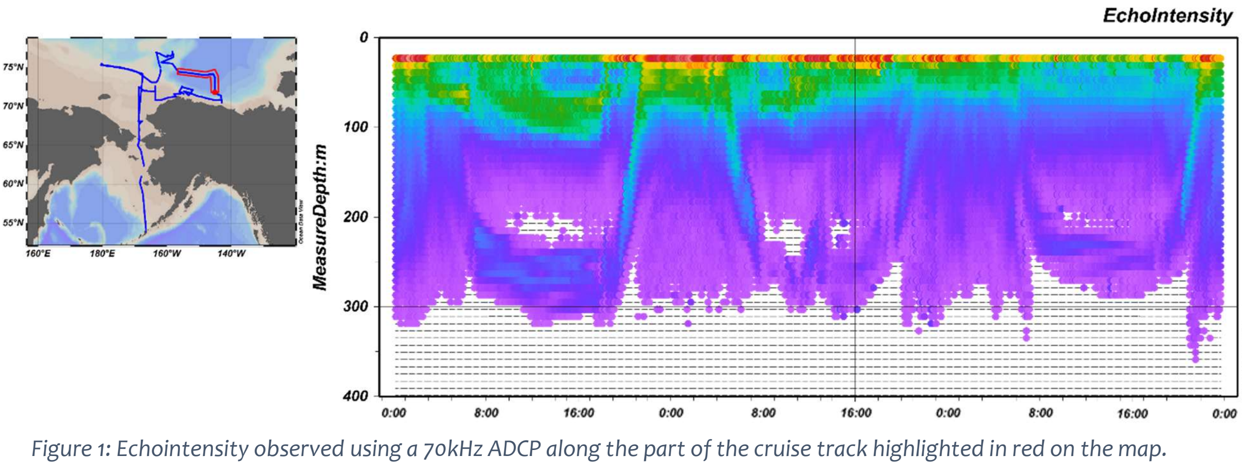

Figure 1: Echointensity observed using a 70kHz ADCP along the part of the cruise track highlighted in red on the map.

Based on my experience, I would recommend that the new research icebreakers (designed to go into the polar regions) are equipped with multi-frequency (especially 38, 70, 120 and 200 kHz) scientific echosounders. Scientific echosounders provide a cost-effective and non-invasive means of collecting a large volume of underway data with little effort. The collected data would be a tremendous asset to any sampling campaign as it can provide high resolution information on the distribution of prey (e.g. fish schools and scattering layers), as well as providing information on behaviour (e.g. DVM). Through DVM, mesopelagic organisms are key players in the biogeochemical cycling of the ocean (Robinson et al., 2010), and as such acoustic observations of this migration may also be of use in carbon or nutrient cycling studies. Multi-frequency acoustic data can also provide information on species ID. For example, the combined use of 38 and 120 kHz data has been used for decades to identify krill and estimate their biomass (Brierley et al., 1998), whilst lower frequencies, such as 18 and 38 kHz, can be used to estimate fish biomass (Irigoien et al., 2014). I would also recommend using ROVs or AUVs that have acoustic sampling capabilities as well as camera and lights to explore the areas below the ice, that cannot be reached by ship. The use of multiple different sampling techniques will improve the quality of the data, as each sampling method has different biases (e.g., net or light avoidance, bias towards swimbladdered organisms in acoustics).

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