AUV-based acoustic observations of the distribution and patchiness of pelagic scattering layers during midnight sun

M. Geoffroy[1] (maxime.geoffroy@uit.no), F. R. Cottier[2], J. Berge[1], M. E. Inall[2]

[1]UiT The Arctic University of Norway, Tromsø, Norway

[2]Scottish Association for Marine Science, Oban, United Kingdom

Abstract

An Autonomous Underwater Vehicle (AUV) carrying 600 kHz RDI Acoustic Doppler Current Profilers (ADCPs) was deployed at four locations over the West Spitsbergen outer shelf in July 2010. The backscatter signal recorded by the ADCPs was extracted and analysed to document the vertical distribution and patchiness of the pelagic scattering layer during midnight sun. At the northernmost locations (Norskebanken and Woodfjorden), fresher and colder water than at the southernmost locations (Kongsfjordbanken and Isfjordbanken) prevailed in the surface layer (0-20 m) and scatterers (interpreted as zooplankton) were distributed over the entire sampling depth (0-150 m). In contrast, more saline and warmer Atlantic Water dominated the surface layer at Kongsfjordbanken and Isfjordbanken and scatterers were concentrated in the top 20 m, above the pycnocline. Scatterers formed patchy aggregations at all locations, but patchiness generally increased with the density of organisms and decreased at depths >80 m. This study contributes to our understanding of the vertical distribution of pelagic organisms in the Arctic and the spatial coverage of the AUV has extended early acoustic studies from 1-dimensional observations limited to Arctic fjords to a broader, more general offshore coverage. No synchronised or unsynchronized vertical migrations were detected, but the short time scale associated with AUV deployments resulted in high variance and autonomous vehicles are therefore not as effective as long-term mooring deployments to study vertical migrations. AUV-based acoustic surveys of the pelagic communities are nonetheless highly complementary to Eulerian studies, for instance by providing spatial measurements of patchiness.

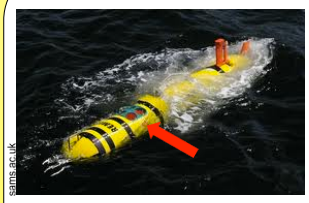
Background

- Previous studies demonstrated that zooplankton scatterers:
  (1) are associated with the pycnocline (Berge *et al.* 2014);
  (2) perform unsynchronised vertical migrations, but no diel vertical migrations (DVM) during midnight sun (Cottier *et al.* 2006).
- These studies, conducted in fjords, are based on Eulerian sampling and lack spatial resolution.

Objectives

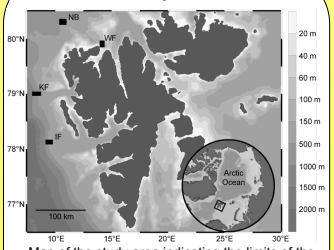
- Document the vertical distribution and patchiness of pelagic scatterers over a larger spatial scale than previous studies.
- Document the pros and cons of using AUV-mounted ADCPs for biological studies.

AUV-mounted ADCPs



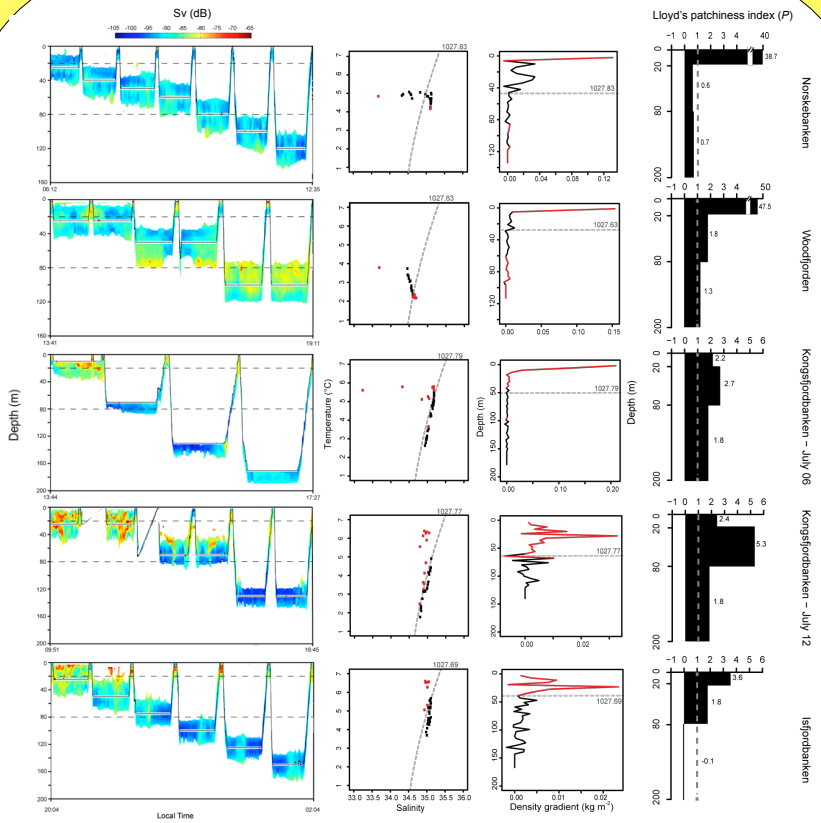
- Kongsberg Hydroid REMUS AUV
- Upward and downward looking 614 kHz ADCPs

Study area



Map of the study area indicating the limits of the AUV deployments (black boxes) at Norskebanken (NB), Woodfjorden (WF), Kongfjordbanken (KF), and Isfjordbanken (IF).

Results



Continuous volume backscattering strength (S_v in dB re 1 m^{-1})

Left column: Temperature-salinity diagrams with a 4m vertical resolution. Isopycnal lines (in kg·m^{-3}) demarcate bins with backscatter values higher (red dots) and lower (black dots) than average. Right column: Vertical profiles of density gradient. Red lines indicate sections of the profiles with backscatter values higher than average.

Lloyd's patchiness index (P) for each layer. The dashed grey lines indicate the limit between a uniform (P<1) and a patchy distribution (P>1).

Conclusions

- The pycnocline plays an important role in regulating the vertical distribution of pelagic scatterers on a regional scale by retaining organisms either in the surface layer (southern locations) or below the strongest density gradient (northern locations).
- Zooplankton consistently formed patchy aggregations in the top 20 m, which stresses both the ecological importance of this layer for predators and the need for prudent interpretations when calculating zooplankton abundances from stationary net deployments.
- No vertical migrations were detected, but AUVs are likely less useful than moorings to document these migrations because they are usually deployed for shorter periods of time.
- AUV mounted ADCPs can complement Eulerian studies, in particular by providing spatial measurements of patchiness.

References

- Berge, J., F. Cottier, Ø. Varpe, and others. 2014. Arctic complexity: a case study on diel vertical migration of zooplankton. J. Plankton Res. 36: 1279-1297.
- Cottier, F. R., G. A. Tarling, A. Wold, and S. Falk-Petersen. 2006. Unsynchronized and synchronised vertical migration of zooplankton in a high Arctic fjord. Limnol. Oceanogr. 51: 2586-2599.

ICES/PICES 6TH ZOOPLANKTON PRODUCTION SYMPOSIUM