Supply of sympagic organic material to the Barents Sea benthos strongly linked to sea ice seasonality

Ivan J. Cautain[1*], Kim S. Last[1], David McKee[2,3], Bodil A. Bluhm[3], Paul E. Renaud[4,5], Amanda F. Ziegler[3,6], Bhavani E. Narayanaswamy[1]

[1] Scottish Association for Marine Science, Oban, Scotland
[2] Physics Department, University of Strathclyde, Glasgow, Scotland
[3] Department of Arctic and Marine Biology UiT - The Arctic University of Norway, Tromsø, Norway
[4] Akvaplan-niva, Tromsø, Norway
[5] Arctic Biology Department, University Centre in Svalbard, Longyearbyen, Norway
[6] Institute of Marine Research, Tromsø, Norway
**Corresponding author: Ivan.Cautain@sams.ac.uk*

The benthos plays a key role in carbon flow through Arctic ecosystems, being both an endpoint for much of the overlying production and an important food source for higher trophic levels. On Arctic shelves, primary production occurs in both pelagic and sympagic (ice-associated) habitats, by phytoplankton and ice algae respectively. Organic matter (OM) from both sources has been traced through benthic food webs using biomarkers, highlighting regional variability in the quantity of sympagic and pelagic OM utilised by benthos.

In an increasingly ice-free Arctic, it is important to understand the potential change in contribution of sympagic OM to benthos caused by primary production regimes shifting due to reduced ice cover. As the Barents Sea – located in the Atlantic Arctic, north of Norway – is the region with the most rapidly retreating sea ice of the whole Arctic Ocean, but also a site of important fisheries and industrial activities, it is a vital area to understand for better future management. We therefore aimed to quantify the relative contributions of sympagic *vs* pelagic OM in the Barents Sea shelf (200 - 400 metres deep) megabenthos across different seasons and durations of seasonal ice cover.

Megabenthos were collected with trawls in the summer and winter of 2018 and 2019 from 10 stations in the Barents Sea seasonal ice zone, where ice duration ranged from 0 to 245 days per year. The organisms were categorised into feeding guilds: surface deposit feeders, subsurface deposit feeders, suspension feeders, carnivores/scavengers, and facultative suspension/surface deposit feeders. We used highly branched isoprenoids – lipid biomarkers produced with distinct structures in sea ice and the water column – to estimate ratios of sympagic-to-pelagic OM in megabenthos. These biomarkers are particularly useful as they are source-specific, resistant to degradation, and produced by diatoms found in pan-Arctic algal communities.

Of 110 samples analysed, we found that the proportion of sympagic OM assimilated ranged from 0.4% to 96% and correlated strongly (r^2=0.59) with the duration of ice cover. This trend was observed for all feeding guilds other than suspension feeders. A longer period of ice cover provides a longer period for sympagic production, which is reflected in the OM utilised by the benthos. There was an estimated 9% decrease in the proportion of sympagic OM assimilated from summer to winter. This is likely due to the lower availability of sympagic OM in the winter as most ice algal production takes place in spring. Our data show that sympagic production can be an important source of OM for benthos in the Barents Sea, even though it only accounts for around 25% of annual primary production in the northern seasonal ice zone. These results are comparable to similar studies conducted on benthos in the Pacific Arctic, suggesting that the role of sympagic OM in benthic food webs is similar in both systems. Both of these are Arctic inflow shelves, which are most at risk of all Arctic seas of losing ice cover due to inflowing boreal water masses. However, the high variability of sympagic OM within benthos, and high proportion of pelagic OM at lower latitudes, suggests that in a future, ice-free scenario, the benthos could be adaptable and feed on pelagic OM.

Acknowledgements:
This work was possible thanks to funds and samples provided by the Arctic PRIZE project (NERC grant NE/P006302/1) and the Nansen Legacy programme (RCN#276730). Thank you to all the captains and crews of ships, as well as collaborators who helped with sample collection.

Oceanographic conditions and variability in Loch Ewe based on sustained observations at different spatial and temporal scales

Jennifer Scott[1], Alejandro Gallego[1], Bee Berx[1], Berit Rabe[1] and Helen Smith[1]

[1] *Marine Scotland Science – jennifer.scott@gov.scot , MSS.Oceanography@gov.scot*

Abstract

High-resolution in-situ measurements and multi-decadal time series of data, in the context of wider scale observations, are required to detect any long term changes in coastal ecosystems above the pattern of short term variability which characterises such systems. Marine Scotland Science has been conducting environmental monitoring in Loch Ewe, a sea loch on the west coast of Scotland, since 1999. A range of oceanographic, atmospheric and biological parameters are measured as part of the Scottish Coastal Observatory monitoring programme and INTERREG VA COMPASS project, including physical water properties (temperature, salinity, current speed and direction, and wave characteristics), meteorological conditions, carbonate chemistry, nutrient concentrations and the phyto- and zooplankton community. The temporal resolution of measurements ranges from every 10 minutes to weekly.

This study characterises the oceanographic conditions of Loch Ewe, investigating how they vary spatially and temporally across the available time series and determining the forcing mechanisms behind this variability. We describe tides, residual currents, freshwater input and salinity variability within the loch system. We also investigate the meteorological drivers of temperature change within the water column and to which extent wider scale phenomena such as the reported recent freshening of the subpolar North Atlantic (Holliday et al., 2020; Wells et al., 2022) are observed in our data.

Acknowledgements

The authors would like to acknowledge and thank Jane and Willie Grant for the work they do in Loch Ewe to support this science, and all Marine Scotland Science staff working on COMPASS and the Loch Ewe Scottish Coastal Observatory. This project is supported by the European Union's INTERREG VA Programme, managed by the Special EU Programmes Body (SEUPB). The views and opinions expressed in this abstract do not necessarily reflect those of the European Commission or the Special EU programmes Body (SEUPB).

References

Holliday, N.P., Bersch, M., Berx, B., Chafik, L., Cunningham, S., Florindo-López, C., Hátún, H., Johns, W., Josey, S.A., Larsen, K.M.H. and Mulet, S., (2020). Ocean circulation causes the largest freshening event for 120 years in eastern subpolar North Atlantic. Nature communications, 11(1), pp.1-15.

Wells, S.R., Bresnan, E., Cook, K., Eerkes-Medrano, D., Machairopoulou, M., Mayor, D.J., Rabe, B. and Wright, P.J., (2022). Environmental drivers of a decline in a coastal zooplankton community. ICES Journal of Marine Science, 79(3), pp.844-854.

Hydrological requirements for salt marsh habitat in Scotland

Thorsten Balke[1], Cai Ladd[1]

[1] *School of Geographical and Earth Sciences, University of Glasgow – thorsten.balke@glasgow.ac.uk*

https://www.imarest.org/membership/membership-registration/upgrade-your-membership/student-member-simarest

Salt marsh habitats require tidal inundation but are generally limited at the seaward edge to elevations above the Mean High Water of Neap Tide (MHWN) mark. Prolonged or too frequent tidal inundation will lead to salt marsh being replaced by unvegetated intertidal flats or seagrass habitats. With the potential threat to salt marshes

due to sea-level rise and an increasing interest in restoring and creating salt marsh for their societal benefits it is crucial to be able to accurately assess the hydrological conditions that allow salt marsh to form and persist. Using a combination of water level sensors and novel Mini Buoy sensors, we present a summary of monitored hydrological conditions at a number of Scottish salt marsh – tidal flat transitions. The data reveal that only very few of the monitored Scottish marshes are able to tolerate inundation that is characteristic of MHWN elevations. Moreover, tidal inundation at the mean high water mark is markedly seasonal in Scotland. We will further demonstrate how the Mini Buoy can be used to assess tidal exchange, for example at a managed realignment site post breach, to inform future adaptive management. We will discuss how low-cost hydrologic and hydrodynamic monitoring approaches with the Mini Buoy can help to improve intertidal habitat restoration success.

Acknowledgements

We would like acknowledge funding from MASTS: EFLSG2. We would like to thank all students, volunteers, collaborators and technical staff who supported the various fieldwork efforts.

Greenhouse gases in the urban Clyde estuary: Physical estuarine processes and nutrient loading impact greenhouse gas generation

Alison M. Brown [1], Adrian M. Bass[2], Ute M. Skiba[1], John Macdonald[2], Amy E. Pickard [1]
1 Centre for Ecology and Hydrology (albrown52@ceh.ac.uk)
2 University of Glasgow - College of Science and Engineering - School of Geographical and Earth Sciences

Biologically productive regions such as estuaries, even though they only cover a small percentage of the world's oceans, contribute significantly to methane and nitrous oxide emissions. This paper synthesises greenhouse gas (GHG) and nutrient data measured in the Clyde estuary to determine the main physical and biogeochemical mechanisms that influence GHG sources and sinks, and ultimately lead to high GHG evasion.

The Clyde estuary, a temperate, urban mesotidal system, is often highly stratified with reduced mixing with a high loading of nutrients. The physical processes within the estuary are strongly influenced by river flow and tide. Nitrous oxide (N_2O) concentrations can be predicted in both the upper fresh and lower saline layers primarily by consideration of: the total dissolved nitrogen concentration, dissolved oxygen saturation and conductivity, with denitrification triggered by the lower oxygen conditions, which occur frequently in the lower saline layer. The apparent rapid response of N_2O production to increases in dissolved nitrogen concentration implies that most nitrogen processing is occurring in the water column despite the low turbidity within this estuary. Methane (CH_4) concentrations are more variable and show clear differences between the upper fresh and lower saline layers. The initial significant increase in methane concentration in the surface layer, after the transition from river to estuary, confirms that CH_4 generation occurs within the estuary rather than being passed from the river. Methane concentrations within the lower saline layer are significantly higher than in the surface layer suggesting generation within the bed with the peak CH_4 generation occurring where salinities are consistently below 10psu. The prolonged low river levels that occurred between June and September 2021, with the resulting saline intrusion into the inner estuary, caused a significant suppression of this CH_4 generation.

Understanding these dynamics helps to improve our knowledge of estuarine environments and their potential for GHG release to atmosphere.

Acknowledgements

This works was funded by a Natural Environment Research Council (NERC) studentship through the IAPETUS Doctoral Training Partnership Grant No.: NE/S007431/1.