Life at the edge

Benthic Fauna at the Barents Sea Ice Edge in a Changing Climate (BASICC)

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Sea ice is a major factor influencing the ecology of the Barents Sea. Ice conditions range from quasi-permanent ice cover in the northern areas to mostly ice-free areas in the south. In the intermediate zone, there is seasonal ice cover, with maximal ice cover around March-April and minimum cover in August-September. In addition to seasonal variations in ice cover, there are large inter-annual variations in the southern extent of sea ice, as well as in ice structure and thickness. In warm years, with a greater intrusion of warm Atlantic water, the summer ice-free area may extend far north of Svalbard. In colder years, the northeast coast of Svalbard may remain ice-covered year-round. Conversely, the winter sea-ice edge may reach Bjørnøya and even farther south towards the Kola coast during colder years, whereas during warmer years, large parts of the Barents Sea may remain ice-free all year. Reductions in ice cover and thickness in the Arctic in response to climate change have been taking place for several decades and are projected to continue (e.g. Comiso 2006). So, how will changes in ice conditions affect the Arctic ecosystem in general and the Barents Sea in particular?

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The common sun star *Crossaster papposus* on soft glacial sediment with dead corals. Note the drop stone released from melting ice (right).

In the Barents Sea, the annual spring phytoplankton bloom, and the resulting pulse of organic material to the ecosystem, is restricted to a short window between the start of ice-melt around April-May and the formation of new ice around September. The duration of ice cover influences the timing of the spring bloom and therefore also the dynamics of food supply to the benthos at the sea floor. Recent studies in the Barents Sea have indicated that the intense pulse of food material that becomes available upon ice-melt is rapidly and directly transferred to the benthos. See Wassmann *et al.* (2006) and Carmack & Wassmann (in press), and references therein, for an overview of physical and biological processes on pan-Arctic shelves.

International research project

For the past three years, we have been investigating the relationship between the abundance, richness and biomass of benthic organisms and sea-ice cover. We have further examined the possible cascade effects that may be expected in the future. The project, financed through the Eastern European programme of the Research Council of Norway, with additional support from Hydro Norway, has involved scientists from Norway (Akvaplan-niva, University of Tromsø and NIVA), Russia (Zoological Institute, Murmansk Marine Biological Institute), USA (University of South Carolina, Bates College, Maine). Further, the project is integral to the MarBEF responsive mode project ArctEco.

We sampled 47 stations within an area of around 400,000km^2 covering areas influenced by both Atlantic and Arctic water-masses, with various mixing zones in between. Further, there is a range of water depths and sediment types across the area, so a wide range of benthic organisms might therefore be expected. We recorded around 663 taxa, represented by just under 60,000 individuals.

Benthic fauna and climatic implications

All the main taxonomic groups were well represented at most stations. However, general faunal abundance and biomass reached their highest levels in the area of intermittent ice cover (the middle zone of our station network), with an average of more than 130 taxa per station represented by 1,760 individuals (maximum around 180 and 2,600 respectively). Faunal abundance was lowest in the predominantly ice-covered area, with an average of 90 taxa per station represented by less than 600 individuals. The total biomass varied greatly among stations, depending on the animals present, but values ranged from less than 10g per m^2 in the predominantly ice-covered area up to 780g in the area of intermittent ice cover. Also, organic carbon flux to the sediments (mg/cm^2 yr), calculated by ^{210}Pb, was greatest in this area.

The representation of various feeding and behavioural attributes within the faunal assemblages was analysed, in terms of both biomass and abundance. In general, there was a good representation of all the main faunal functions at almost all stations. However, some trends were evident. In terms of biomass, preliminary calculations show a distinct decrease in sessile taxa in predominantly ice-covered areas relative to open areas, and

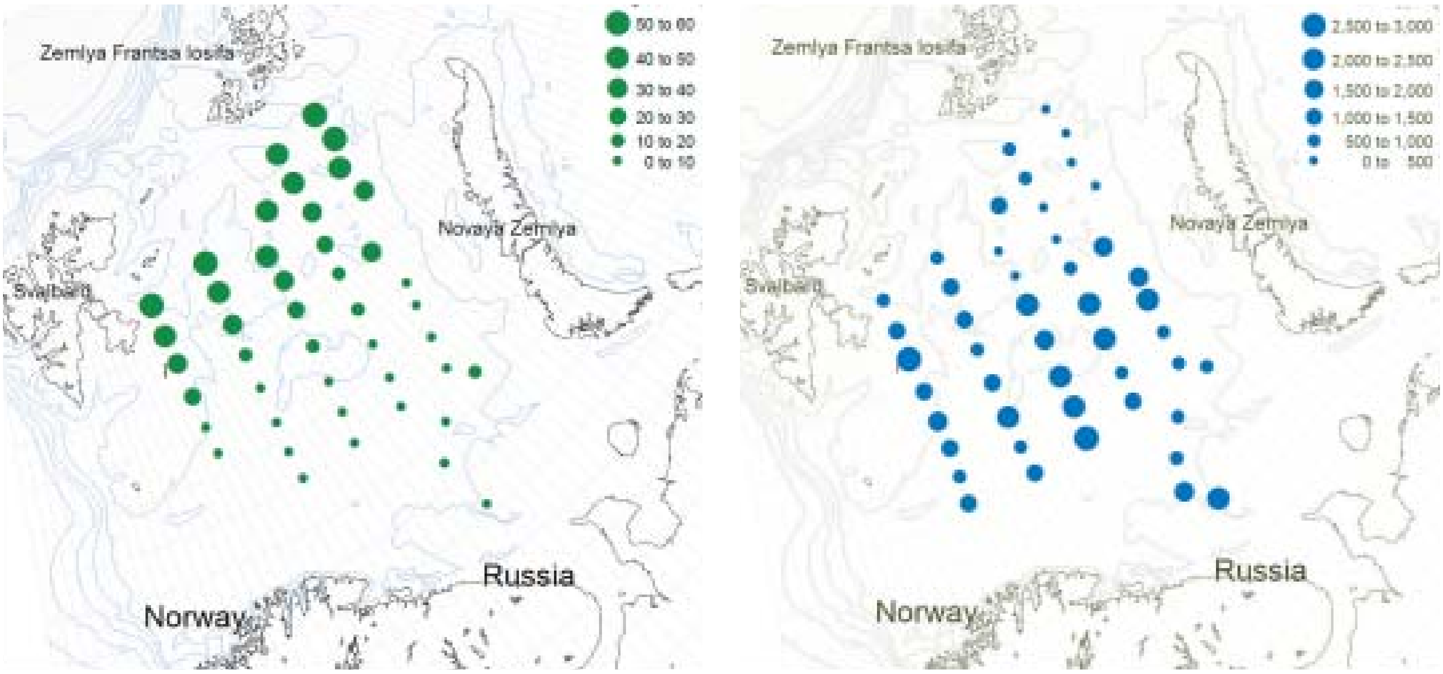

Figure 1. ***Left:*** percentage ice cover at the sampling stations, based on daily satellite records averaged for three years prior to sampling (data from NSIDC). ***Right:*** faunal abundance.

conversely, a higher representation of motile and semi-motile taxa. There also was a notable increase in carnivorous taxa at some of the heavily ice-influenced stations. However, no such trend was apparent when calculated in terms of numerical abundance, reflecting the fact that the carnivorous taxa tend to be large but not numerically abundant. This suggests that in predominantly ice-covered areas, where the production season is limited, there is an increased representation of a motile – and in some areas, carnivorous – "hunting" lifestyle among the benthic fauna.

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The basket star *Gorgonocephalus eucnemis*, which was found in the northern part of the study area.

At the heavily ice-influenced stations in the north, there also was a decrease in taxa that mix the sediment, relative to the more southern areas, in terms of both abundance and biomass. This was supported by sediment mixing analyses using ^{210}Pb as a tracer. Our results suggest that the faunal assemblages in heavily ice-influenced areas contain a high proportion of animals that feed and defecate at the sediment surface, contrary to areas of intermittent or minimal ice influence, where much of the fauna are active in mixing sediment. In this era, where there is increasing interest in petroleum exploitation in the Barents Sea and concerns about long-distance transportation of contaminants and threats to the food web, the implications of biological mixing are of prime concern. Greater sediment reworking may facilitate the rapid removal of contaminants from surface to deeper contaminant layers, making them less available to the food web.

Long-term changes in climate are expected to have far-reaching consequences for these ecosystems. Generalising our results, we could predict that during warm periods, when the ice edge moves farther north, the area of high benthic abundance will shift farther north. The area currently most 'rich' in fauna may become less so, and represent a more 'regular' Atlantic character.

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