

CLIMATE CHANGE AND CARBON FLUX IN THE BARENTS SEA AND THE POLAR OCEAN

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The Barents Sea is an arctic marginal shelf sea of the eastern North Atlantic, which supports one of the richest fisheries of the World Ocean. It is the western-most part of the extensive, wide and permanently or seasonally ice-covered shelf surrounding the Arctic Ocean on the Eurasian side. The two main water masses, Arctic water entering the Barents Sea from northeast and Atlantic water entering from southwest, are separated by the Polar Front. Modulated Atlantic water leaves the Barents Sea through the St. Anna Trough and continues in concert with a branch of subducted Atlantic water circumnavigating Svalbard, as a boundary current along the Siberian shelf break to the east.

The Arctic water is periodically ice-covered and the maximum extension of ice is close to the Polar Front in the western and central part of the Barents Sea while ice-cover in the eastern part is more extensive. The ice melts during spring and summer, giving rise to a stratified and nutrient rich euphotic zone that supports a distinct phytoplankton bloom in the marginal ice zone. In the areas dominated by Atlantic water stratification develops slowly by solar radiation solely during spring and summer and the resulting phytoplankton bloom is less distinct, but high in new production. The ice-coverage varies greatly from year to year, reflecting the interannual dynamics of inflowing Atlantic water, wind conditions and the ice cover in the previous year. The Atlantic water is warm, nutrient-rich and capable of introducing extensive, but variable amounts of zooplankton into the southern and central Barents Sea as well as around Spitsbergen. The dynamics of sea ice in the Barents Sea and its regulation of primary production during the short productive period at latitudes north of 70° N are, therefore, capable of influencing the carbon flux dynamics of the area, seasonally, inter-annually and on a global change scale.

The annual production of phytoplankton is in particular dependent on the ice distribution during spring and in an inverse manner. When the ice melts, strong vertical stability is created which reduces the vertical transport of nutrients compared to conditions where thermal heating alone creates stability. A maximal extent of ice-distribution gives thus rise to a maximum area of strong stratification after the ice-melt. Thus new production in the MIZ is a complicated function of nutrient availability (far smaller compared to non-stratified waters) and incident light. Comparing cold and warm years, primary production and vertical export was up to 400% higher in the ice-free area during the warm year. The total annual primary production for the whole Barents Sea increases about 30% during a warm year. Even greater variations are discovered for the vertical flux of carbon.

The time development of the vernal bloom in the marginal ice zone and the central Barents Sea in May can vary greatly. At a certain station the timing of the bloom maximum can vary between 2-3 weeks. A complicated zonal structure develops, and the spring bloom development is not from south to north, but it starts in the MIZ and intermittently it is from north to south. Later during the year the general development of the vernal bloom is, as expected, from south to north. The spring bloom spreads in a wave-like manner both south and north from its start in the MIZ. South-north gradients in the Barents Sea suggest a sandwich-type structure with regard to water masses, nutrient consumption, phytoplankton biomass and timing of plankton development.

Accumulation of suspended Chl a $> 100 \text{ mg m}^{-2}$ were only observed in the Barents Sea marginal ice zone and at a distance from the shelf break. Suspended POC concentrations were less variable. Similar results were found for the vertical export of Chl a and POC from the upper layers. It is suggested that the high retention rates of suspended biogenic matter along the shelf break of the Norwegian Sea and the Arctic Ocean north of Spitsbergen, sites influenced by branches of the North Atlantic Current, are caused by top-down regulation of phytoplankton biomass by overwintered and advected zooplankton. They share similarities with HNLC systems. Thus a tight coupling appears to exist between primary and secondary production on the shelf areas off northern Norway and Spitsbergen. Classical vernal blooms are not the rule in the area and can only be observed when the distance to the shelf break is significant, advection of zooplankton occasionally is restricted and stratification supports rapid accumulation of phytoplankton. As Barents Sea water has been observed as a boundary current along the Siberian shelf break as far east as Alaska and the supply of Atlantic water to the Polar Ocean is greater than that of the Pacific Ocean, more emphasis has to be given to the role of the Barents Sea. It is a modulating shelf for Atlantic water inflow and determines probably also for some of the nutrient and plankton composition of the water advected into the Eurasian shelf region of the Polar Ocean. The time variation of this inflow is unknown and its influence on the biota along the Siberian shelf speculative. However, it is well known that the benthos there is of Atlantic origin. Its diversity decreases from west to east and pacific species become more prominent first in the East-Siberian Sea.

Reduction of ice in recent decades in the Polar Ocean may have been influenced by variable inflow of Atlantic water through and around the Barents Sea. If the recent observations reflect global warming or reverberate natural cycling, should be addressed. The expected greater extent of the MIZ and the decrease in ice thickness induces complex, so far inadequately understood scenarios with regard to primary production. Along with the variable inflow of Atlantic water the role of advected plankton, in particular that of long-lived zooplankton, should be analyzed. These expatriates are allochthonous to the system and they may impose a significant impact on plankton development of the Eurasian shelf, implementing HNLC conditions induced by mesozooplankton grazing.