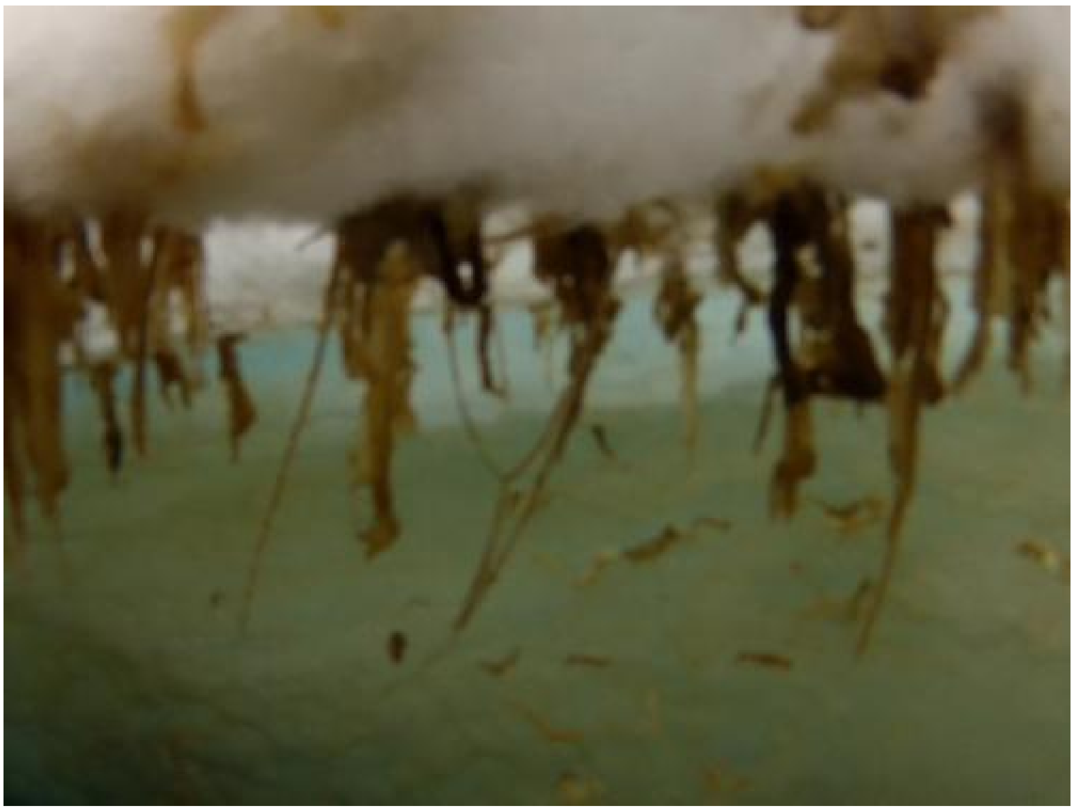
Rapid changes in the Arctic ecosystem

February 19 2013



Melosira arctica grows on the bottom side of ice floes. Credit: Mar Fernandez-Mendez

(Phys.org)—Huge quantities of algae are growing on the underside of sea ice in the Central Arctic: in 2012 the ice algae Melosira arctica was responsible for almost half the primary production in this area. When the ice melts, as was the case during the ice minimum in 2012, these algae sink rapidly to the bottom of the sea at a depth of several thousands of metres. Deep sea animals such as sea cucumbers and brittle stars feed on the algae, and bacteria metabolise what's left, consuming the oxygen in the sea bed. This short-term reaction of the deep sea ecosystem to changes in sea ice cover and ocean productivity has now been published in the scientific journal *Science* by a multidisciplinary team of researchers around Antje Boetius from the Alfred Wegener Institute the Max Planck Institute for Marine Microbiology in Bremen.

Scientists and technicians from twelve nations travelled the Central Arctic on the research icebreaker Polarstern in the late summer of 2012. In and under the ice they used a large number of ultra-modern research devices and methods such as camera-guided sampling devices and an under-ice remotely operating vehicle (ROV). Prof. Antje Boetius, who leads the Helmholtz-Max Planck Research Group on Deep-Sea Ecology and Technology has a first answer to the all-important question of how the Arctic is changing due to warming: "Far quicker than has so far been expected! The seabed at a depth of more than 400 metres was littered with clumps of ice algae which had attracted lots of sea cucumbers and brittle stars", explains the microbiologist.

Sea anemones are animals which feed in the deep sea from material which algae form on the water's surface and which then sinks down several thousands of metres. Credit: OFOS, Alfred Wegener Institute

The algal deposits with diameters of up to 50 centimetres covered up to ten per cent of the seabed. The researchers were able to count them using an Ocean Floor Observation System (OFOS). Also for the first time in the ice-covered Arctic, the Helmholtz-Max Planck researcher Dr. Frank Wenzhöfer was able to measure the bacterial and faunal oxygen consumption directly in the deep sea using micro-sensors. And life was thriving under the algae cover: bacteria had started to decompose the algae as evident from a greatly reduced oxygen content in the sediment. By contrast, the sea bed in the adjacent algae-free areas was aerated down to a depth of 80 centimetres and had virtually no algal residues.

But where do the large quantities of algae on the deep-sea floor come from? Plants cannot grow in 4000 m water depth because there is no light. Using an ROV, the researchers found lots of remains of ice algae everywhere under the sea ice. "It has been known for some time that diatoms of the type Melosira arctica can form long chains under the ice. However, such a massive occurrence has so far only been described for coastal regions and old, thick sea ice ", explains Boetius. When planning the expedition three years ago the researchers proposed the hypothesis that ice algae could grow faster under the thinning sea ice of the Central Arctic. And the observations now published in the scientific journal Science support their hypothesis: at 45 per cent, the ice algae were responsible for almost half of the primary production in the Central Arctic Basin. The remaining primary production was attributable to other diatoms and nanoplankton, which live in the upper layers of the water column.

Normally, the small phytoplankton cell sinks only very slowly through the water column and is largely consumed already within the ocean surface layer. By contrast, the long chains of algae formed by Melosira arctica are heavy and can quickly sink to the bottom of the sea. In this way they exported more than 85 per cent of the carbon fixed by primary production from the water surface to the deep sea in summer 2012, just before the expedition. The researchers suppose that the algae had actually grown recently because they found only one-year old ice in the Central Arctic, and because the algae extracted from the guts of sea cucumbers were still able to photosynthesise upon return to the ship's laboratory. The good nutritional state of the sea cucumbers was also evidence of the massive food supply: the zoologist Dr. Antonina Rogacheva of the P.P. Shirshov Institute of Oceanology found that the animals were larger than normal and with highly developed reproductive organs – an indication that they had been eating abundantly for some two months.

The sea ice physicists on board investigated why ice algae are able to thrive beneath the thinning Arctic sea ice, and how they may also lose their habitat quickly due to the increasing ice melt. They determined the ice thickness with an electromagnetic probe dragged by a helicopter and by ice drillings. They also used an underwater robot (ROV) to view the ice from below and to measure how much light penetrates through the ice. Dr. Marcel Nicolaus from the Alfred Wegener Institute explains: "At the end of the summer we still found a lot of ice algae remains, and could quantify them by using an under-ice ROV. The increasing cover by melt ponds permits more light to permeate the ice, and makes the algae grow faster." However, since the ice has become so much thinner in recent years, and the Arctic so much warmer, the ice algae will melt out more quickly from the ice and sink.

"We were able to demonstrate for the first time that the warming and the associated physical changes in the Central Arctic cause fast reactions in the entire ecosystem down to the deep sea", summarizes lead author Boetius. The deep sea has so far been seen as a relatively inert system affected by global warming only with a considerable temporal delay. The fact that microbial decomposition processes fueled by the algal deposits can generate anoxic spots in the deep sea floor within one season alarms the researcher: "We do not know yet whether we have observed a one-time phenomenon or whether this high algal export will continue in the coming years." Current predictions by climate models assume that an ice-free summer could occur in the Arctic in the next decades. Boetius and her team warn: "We still understand far too little about the function of the Arctic ecosystem and its biodiversity and productivity, to be able to estimate the consequences of the rapid sea-ice decline."

More information: Boetius, A. et al. Export of algal biomass from the melting Antarctic sea ice. *Science*. DOI: 10.1126/science.1231346