Possible effects of retreating sea-ice cover on sub-Arctic and Arctic ecosystems

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The Arctic sea-ice cover has been shrinking over the past decades but the unexpected, drastic decline of ice volume during 2007 has brought the spectre of a totally ice-free Arctic summer forward by several decades. The accompanying loss of albedo during the summer months will lead to warming of the surface ocean and further acceleration of the rate of melting of the Greenland ice cap. Sea level is currently projected to rise by 1 m by the end of this century which will have a devastating effect on coastal ecosystems worldwide, particularly coral reefs and mangrove forests, apart from the human dimension. The direct effects of sea-ice retreat on local ecosystems will be manifold because sea ice has a number of contrasting effects on the ecology of the seas impacted by it. The shading effect of its snow cover on primary production in the underlying water is the most conspicuous but its role as a habitat for micro-organisms, their metazoan grazers and predators as well as its function as a platform for breeding and hunting by seals and polar bears respectively, are also well known. Clearly, the ongoing retreat of sea ice will enhance productivity of the exposed Arctic Ocean but it will have catastrophic effects on the populations of ice-dependent species. The collapse of the food chain leading from polar cod, via seals, to polar bears has been highlighted in the media and the effect on walrus populations and the benthic communities on which they used to feed is now coming into focus.

Less-well appreciated is the role of sea ice as a transport medium, from the coast to the open sea, for the trace nutrient iron. Most of the sea ice in the Arctic is formed over the broad, shallow shelf regions under turbulent conditions which results in substantial amounts of resuspended sediment being incorporated into the ice matrix. Offshore transport by winds enables more ice to be formed and results in large-scale export of sediment-rich ice to the open ocean. Subsequent melting of this ice releases iron to potentially iron-limited phytoplankton thereby inducing massive spring blooms terminated by mass sinking of biomass out of the surface layer which fuels benthic production early in the year. Unfortunately, confirmation of this scenario by measurements of iron concentration are lacking. Nevertheless, in sub-arctic seas, retreat of the winter extent of sea ice over the past decades has drastically changed the seasonal cycles of productivity and vertical flux with far-reaching consequences for the structure of pelagic and benthic food webs. This regime shift can be explained by iron limitation and tested with simple, *in situ* iron fertilization experiments carried out in spring in the open Barents Sea and along the shelf slope of the eastern Bering Sea.

Similarly, shrinking of the area subject to iron input from seasonal ice melt, will lead to iron limitation of the high Arctic ocean and result in eventual establishment of the high-nutrient, low-chlorophyll (HNLC) condition currently known from the sub-Arctic Pacific. However, because of the low macronutrient concentrations in inflowing Atlantic water, aggravated by

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stabilization of the surface layer by freshwater input from Greenland which will reduce winter convective mixing, the overall productivity increase in the Arctic Ocean will be modest, apart from the region influenced by Bering Strait inflow. Thus, the higher productivity of an ice-free Arctic Ocean will have only a negligible effect on the ecosystem but also on atmospheric CO_2 levels.

Biography

Victor Smetacek was born in 1946 and grew up in the foothills of the Indian Himalayas. After acquiring his B.Sc. in biology from Agra University, India, he received a scholarship to study marine biology at Kiel University, Germany. His early research was carried out in the framework of an interdisciplinary team studying interaction between the water column and sediments, at first in shallow Kiel Bight and later in the Norwegian Sea. He acquired his PhD in 1975 and was appointed Professor for Biological Oceanography at the University of Bremen and Head of a Biology Section at the Alfred-Wegener-Institute in Bremerhaven in 1986. Since then he has worked in the Southern Ocean, at first in the vicinity of the continent and in sea ice and later in the Antarctic Circumpolar Current. He was Chief Scientist on two successful *in situ* iron fertilization experiments (EisenEx and EIFEX) in 2000 and 2004 respectively. His research interests comprise pelagic ecosystems, including sea-ice ecology, and their relationship to biogeochemical processes and vertical particle flux in the context of past and ongoing climate change. He has served on the scientific steering committees of JGOFS and GLOBEC and has been awarded several medals including the Huntsman award of the Bedford Institute of Oceanography.