

pattern results in index values for all grids where high values indicate high numbers and high abundance of plants requiring relatively high temp-

eratures within an Arctic context.

To verify if these index values really reflect temperature conditions, temperature sums during the growth

period were measured at different sites during a cold and a relatively warm year, in addition to using data

Atmosphere–Ice–Ocean Interaction Studies on Svalbard fjords

Sebastian Gerland

(gerland@npolar.no)
Norwegian Polar Institute, Polar
Environmental Centre, Tromsø

Jan-Gunnar Winther

(winther@npolar.no)
Norwegian Polar Institute, Polar
Environmental Centre, Tromsø

Kåre Edvardsen

(ked@nilu.no)
Norwegian Institute for Air Research, Polar
Environmental Centre, Tromsø

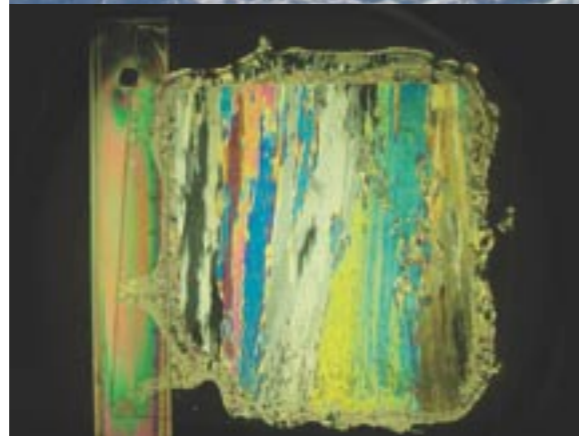
The inner parts of fjords at the western coast of Spitsbergen are covered by land-fast sea ice in winter and spring. Due to the influence of warm Atlantic water – transported to the archipelago by the West Spitsbergen Current – the timing of ice formation in these fjords is delayed compared with locations in Arctic Canada, and the ice is less thick. Ice formation in West Spitsbergen fjords also depends on their orientation, shape and size. One example of this is the largest fjord, Isfjorden, which usually develops fast ice only in its inner part and in smaller connected fjords, such as Billefjorden. Another is Kongsfjorden, located north of Isfjorden. Kongsfjorden regularly has a fast ice cover in its inner part, where a group of islands and shallow water ease ice formation (Gerland et al. 1999; Svendsen et al. 2002). The warm water influence allows ice formation usually not before mid-winter or later, and the ice's thickness is only around 70 cm. In contrast, in Van Mijenfjorden, ice formation starts earlier because the fjord is well protected by an island, Akseløya, and water exchange is limited to two narrow straits north and south of that island. Here, the fast ice usually becomes thicker than 1 m. After the onset of melt in late spring, the reflectance of snow and ice surfaces drops drastically, contributing to the melting of the ice (e.g. Winther et al. 2001).



The AIO research site on the fast ice of inner Kongsfjorden, Svalbard. Foreground: electromagnetic ice thickness profiling. Background: tent for under-ice turbulence monitoring equipment and snow machines for travel between Ny-Ålesund and the research site.



The setup for surface reflectance measurements in the field (here in April 2003 on Kongsfjorden). The downlooking optical sensor on the tripod is connected with an optical fibre to the spectroradiometer.



A vertical thin section of fast ice, seen between crossed polarizers. The different crystals appear in different colours. That section with columnar ice is from the bottom part of a core, obtained in April 2003 in Kongsfjorden. The shape and size of the crystals give information about the freezing conditions during ice formation.

In the project Atmosphere–Ice–Ocean Interaction Studies (AIO), funded by the Research Council of Norway, groups from the University of Bergen (UiB), the Norwegian Polar Institute (NPI), the University Centre in Svalbard (UNIS), the Norwegian

Institute for Air Research (NILU), the University of Washington and the McPhee Research Company, the complex natural processes controlling ice formation, freezing, melting, and break up are investigated in detail. The fieldwork for these studies runs

in Kongsfjorden, Van Mijenfjorden and Storfjorden. UiB, UNIS and the American project partners focus especially on the hydrographic conditions during ice formation and melting, by applying high resolution turbulence measurements in the upper layers of sea water. At the same locations, NPI and NILU investigate ice thickness development and the role of the ice and upper water layers in reflecting, scattering and attenuating solar radiation. Those processes are crucial for the energy balance at the atmosphere–ice–ocean interfaces.

In April and June 2003, detailed optical measurements were performed on fast ice in the inner part of Kongsfjorden. By using advanced spectroradiometers (measuring solar radiation from 350 nm to 2500 nm wavelength), surface reflectance and transmittance of ice and upper water layers were recorded under different ice conditions. Further, ultraviolet radiation was measured above and below the ice. Physical properties of the ice and its texture were also recorded.

First results reveal that the thickness of the snow layer which covers the fast ice and mild weather events in early spring before the onset of melt influence melting and ice break-up. Such mild events can lead to snow melt near the surface. Subsequent re-freezing of the resulting melt water, further downwards in the snow layer, creates another ice layer on top of the original sea ice. We compared the reflectance for solar radiation of the different surfaces and also compared our results with observations from previous years. Though there are few detailed comparable investigations from previous years, we see indications that the formation of these additional ice layers varies strongly interannually.

In 2004, the AIO field activities will consist of two larger campaigns on Van Mijenfjorden. First, during freezing in March, detailed studies of the ice and the hydrographic processes beneath the ice will be carried out and stand-alone automatic monitoring equipment will be installed. In June, the monitoring equipment will be re-

covered during a second campaign, supported by the Norwegian coast guard.

References

- Gerland, S., Winther, J.-G., Ørbæk, J.B. & Ivanov, B.V. 1999: Physical properties, spectral reflectance and thickness development of first year fast ice in Kongsfjorden, Svalbard. *Polar Research* 18 (2), 275–282.
- Svendsen, H., Beszczynska-Møller, A., Hagen, J.O., Lefauconnier, B., Tverberg, V., Gerland, S., Ørbæk, J.B., Bischof, K., Papucci, C., Zajaczkowski, M., Azzolini, R., Bruland, O., Wiencke, C., Winther, J.-G. & Dallmann, W. 2002: The physical environment of Kongsfjorden-Krossfjorden, an Arctic fjord system in Svalbard. *Polar Research* 21 (1), 133–166.
- Winther, J.-G., Gerland, S., Ørbæk, J.B., Ivanov, B., Zachek, A.S. & Bezgreshnov, A.M. 2001: Effects on spectral reflectance from snow ageing. *Memoirs of National Institute of Polar Research* 54, Japan.

The Influence of Ultraviolet Radiation and Climate Conditions on Fish Stocks: A Case Study of the Northeast Arctic Cod (UVAC project)

Georg Hansen

(georg.h.hansen@nilu.no),
Norwegian Institute for Air Research, Polar
Environmental Centre, Tromsø

The Northeast Arctic cod (*Gadus morhua*) stock in the Barents Sea is one of the world's commercially most important wild fish stocks. Effective management is indispensable to maintain this valuable natural resource at a viable level. Quota determinations are based on annual assessments of the year class sizes, mainly by empirical estimates derived from Barents Sea surveys. Although today's methods to measure and predict cod year classes are assumed to be quite advanced, recent experiences with relatively large discrepancies between predictions and actually measured stock highlight the importance of a deeper understanding of the factors

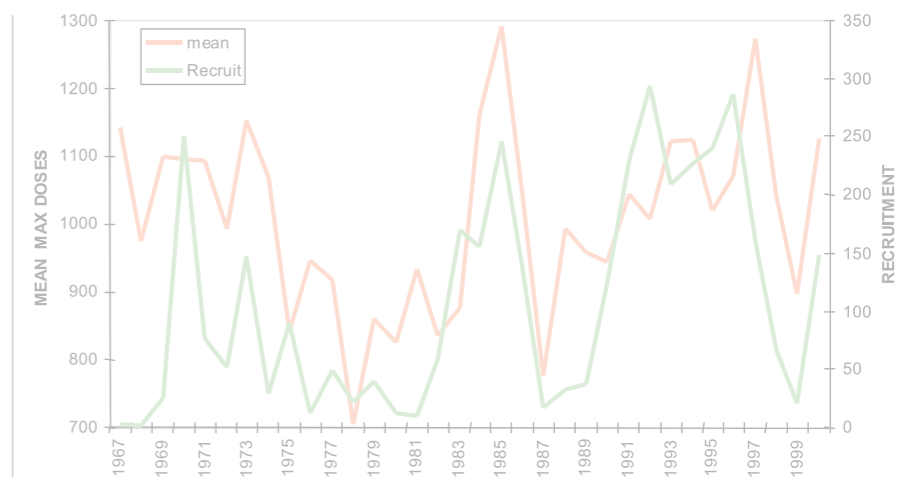


Figure 1. Comparison between the mean maximum doses of UVR (around 1 April and 1 May) in Tromsø from 1967 to 2000 (red), and cod recruitment (green). The data indicate a significant positive correlation between maximum UVR daily doses and cod recruitment.

and processes regulating the cod stocks. It is evident that if year class size is influenced by biological and physical–biological mechanisms active at an early development stage, studies of feeding conditions

(phytoplankton–zooplankton–cod interactions) and the impact of the geophysical environment (water temperature–solar ultraviolet radiation ([UVR]–climate), both on juvenile cod and its prey, should be included