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POLAR RESEARCH IN TROMSØ

POLARMILJØSENTERET
NORSK POLARINSTITUTT
INSTITUTE OF MARINE RESEARCH
HAVFORSKNINGSINSTITUTTET
UNIVERSITETET I TROMSØ

Tiny Tromsø?

Let's face it: from an international perspective, Tromsø is a small, out-of-the-way town in a small, out-of-the-way country, incredibly remote, perched precariously at the edge of an icy sea. But from the perspective of polar research, Tromsø looms as a superpower bustling with activity. Not convinced? Read on!

Arctic Frontiers

Tromsø made its presence felt on this year's international polar scene starting in January, with a conference on the theme "Balancing human use and ecosystem protection". Five hundred people participated in Tromsø and another thousand followed the conference via a live internet broadcast. This was this first of what is to be an annual event: the Arctic Frontiers Conference.

World Environment Day

When the United Nations Environment Programme organised its World Environment Day around the theme "Melting Ice – A Hot Topic?" in June, Tromsø was host city. It began with a televised ecumenical ceremony in Tromsø's spectacular Arctic Cathedral, where Archbishop Desmond Tutu held the sermon. The next day a seminar entitled "Our Common Future – 20 Years On" marked the fact that twenty years have gone by since the presentation of the Brundtland Commission report on natural resources, the human environment and sustainable development. Gro Harlem Brundtland herself was one of the keynote speakers. Another was Rajendra K. Pachauri, currently chairman of the Intergovernmental Panel on Climate Change, which shares this year's Nobel Peace Prize with Al Gore. The seminar opened a two-day international climate conference where the speakers included top scientists, politicians, industry spokesmen and – not least – representatives from the indigenous peoples of the Arctic, who are perhaps those most closely affected by climate change. Simultaneously in other parts of Tromsø, World Environment Day was being celebrated with a youth conference, parades, a children's art exhibit and many other events.

International Polar Year

But what about research? Here again Tromsø and Norway belie their small size. The long-awaited International Polar Year (2007–09) officially started in March this year. Incredibly, little Norway is the country that is dedicating most money over the three-year period – and here we mean money in absolute terms, not per capita. Of the 31 IPY projects being organised from Norway, 25 have participants from research institutions in Tromsø. A complete list of these projects can be found on pages 18-19.

Even outside IPY, Tromsø is an important player in international polar research. See for example the articles on the Arctic Council Secretariat and the ARCTOS network, included in this issue of Polar Research in Tromsø.

So, yes, Tromsø is far from New York, Brussels, Tokyo and other centres of political and economic power, but where polar research in concerned, we are right in the thick of things.

Tromsø, December 2007
The Editors

Polar Research in Tromsø

Polar Research in Tromsø is published once a year by the Roald Amundsen Centre for Arctic Research at the University of Tromsø, the Norwegian Polar Institute, the Tromsø branch of the Institute of Marine Research and the Polar Environmental Centre, Tromsø, Norway. Its aim is to describe all manner of education and research in polar (chiefly Arctic) studies carried out during the past year at these institutions and at other research institutes and companies in the Tromsø area with which they have close ties.

It is sent on request and free of charge to all persons who are interested in polar studies.

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The Arctic foxes and sibling voles in Svalbard – predators and prey supporting a nasty parasite

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Grumant and the home of the sibling voles in Svalbard. Note the productive green grass slopes below the birdcliffs towards Bjørndalen. *Photo: Audun Stien*

In the first half of the twentieth century, sibling voles (*Microtus levis*) were introduced from Russia to the coal mining town Grumant on Spitsbergen, Svalbard. The very productive grass-covered slopes below the nearby birdcliffs allowed the voles to establish themselves in the wild and when the mine was closed in the 1960's, the voles remained. Today the eight kilometre stretch along the coast of Isfjorden from around Grumant to Bjørndalen is still the only area on the islands with a permanent vole population, and the sibling vole the only wild rodent species in Svalbard. In spite of their relatively minor importance in the Svalbard ecosystem, the sibling voles caused public concern in 1999 when a by-product of their presence was detected in the form of the parasitic tapeworm *Echinococcus multilocularis*.

Echinococcus multilocularis is found in most temperate and cold areas in the northern hemisphere with a notable exception being the Scandinavian Peninsula. The parasite develops to the adult stage in the intestines of dogs and foxes. Eggs produced by the adult parasites are distributed in the vegetation with the host's faeces. These eggs have to be eaten by a rodent (the intermediate host), in which the eggs develop into large cysts on the liver. Finally, the infected rodents must be eaten by a dog or fox for the parasite's life cycle to be completed. The main problem with *E. multilocularis* is that its eggs can also infect humans and cause serious disease. Until recently, such infections were often fatal due to the cyst's tumour-like, infiltrative and destructive growth in the human liver.

Over the last five years the Norwegian Research Council has supported our study of the interplay between Arctic foxes (*Vulpes lagopus*), sibling voles and *Echinococcus multilocularis* in Svalbard. One aspect of these studies has been to evaluate the risk for humans to become infected. For humans, the risk of infection is associated with contact with parasite eggs distributed by infected foxes. Since the intermediate host, the vole, has a restricted distribution, we expected infection levels in foxes also to show a strong spatial pattern. We therefore tested a large sample of fox faeces col-

lected on the ground and intestines from trapped Arctic foxes for evidence of *E. multilocularis*. The samples were collected from a large part of Spitsbergen. The results from the survey of fox faeces suggested that the density of infective eggs in the environment was high only in the Grumant area with its high density of voles. A large proportion of the fox faeces in this area were *E. multilocularis* positive and there was also a high density of fox faeces on ground because many foxes are attracted to the birdcliffs. As soon as we moved away from this core area for the sibling voles, the density of infective eggs in the environment dropped dramatically; levels were undetectable in the neighbouring valley Bjørndalen, just 2-6 km away. The investigation of the intestines of trapped foxes also showed high levels of infection around Grumant and a marked decrease in the proportion of foxes that were infected at increasing distances from Grumant. However, while only four out of 249 foxes trapped more than 20 km from the Grumant area were infected, three of them were trapped over 100 km away. This implies that some foxes may disperse the infection over great distances during the infectious period of approximately four months.

Together these studies show that the risk of humans acquiring *Echinococcus multilocularis* infection in Svalbard is high only in the area around the birdcliffs by Grumant with its combination of high vole and fox population densities. People should therefore be careful when they visit this part of Spitsbergen. Outside this area, human risk of infection is low. However, individual infected Arctic foxes may very well wander to the most distant parts of Spitsbergen in the course of their infectious period. The infection risk can therefore not be regarded as zero anywhere. In particular fox trappers should therefore be careful when handling their catch, even at the more remote trapping stations.

Sibling vole. The species was introduced from Russia, probably with hay for cows and horses. *Photo: Nigel G. Yoccoz*

Arctic fox in Grumant. Several dens are found around Grumant where the foxes primarily feed on the ample supply of eggs and birds in the birdcliffs. *Photo: Eva Fuglei*

Estimating pup production of hooded seals in the Greenland Sea pack ice

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The ice breeding Greenland Sea hooded seal (*Cystophora cristata*) is resident both in the Northwest Atlantic and in the Greenland Sea, where it has been of interest to hunters in Canada, Greenland, Norway, and Russia.

Our understanding of historical abundance of Greenland Sea hooded seals is limited. The Greenland Sea stock of hooded seals has been subject to commercial exploitation since the second half of the 1800s. After 1920, the Greenland Sea hooded seal hunt increased substantially, with average annual catches ranging between 40 000 and 50 000 individuals. After a five year pause in the sealing operations during World War II, total annual catches quickly rose to a post-war average of about 70 000 for the period 1954-1958. It was evident that these catch levels were higher than the stock could sustain, and some regulatory measures were taken in 1958. The total annual catches have subsequently followed a decreasing trend, primarily due to reduction in catch effort, and quotas were imposed in 1971. In the early 1980s the level of average annual catches had sunk to 8 000 seals. In the past 25 years, the average annual catch level has remained less than 5 000 animals (almost exclusively pups).

Current management of hooded seals is based on assessments performed by the International Council for the Exploration of the Sea (ICES). To provide advice, ICES requires that updated information about the status and development of the stock is available. To meet this request, the Institute of Marine Research (IMR) has implemented a long-term research plan which implies that necessary data for

Hooded seal pup on ice. The photograph shows why these pups are called "bluebacks". *Photo: Institute of Marine Research*

Hooded seal whelping concentrations visited in the Greenland Sea Pack ice (West Ice) by the Institute of Marine Research in 2005. This area was revisited in 2007.

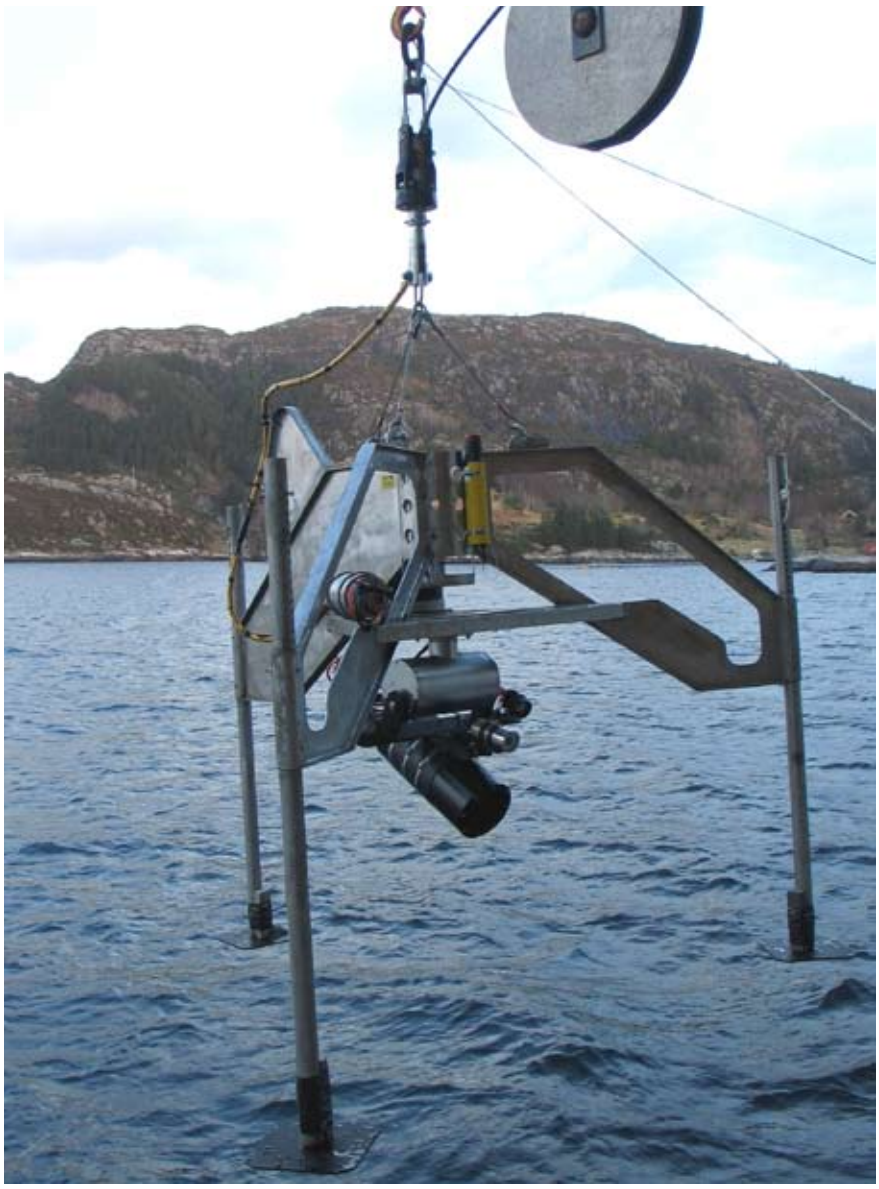
abundance estimation are collected approximately every 5-8 years.

Hooded seals whelp in March. This is an important time for IMR scientists as well, since the estimation of the population size is based on measurements of pup production. Due to the remoteness and inaccessibility of the areas with whelping concentrations, several logistic challenges have to be overcome. An ice-strengthened vessel is used to transport researchers and equipment to the Greenland Sea pack-ice (the West Ice) to areas historically used by hooded seals for breeding purposes (see map). The vessel carries a helicopter that is used for reconnaissance surveys and constant monitoring of pupping intensity throughout the whelping season. In addition, airplanes are used to locate whelping concentrations and take aerial photos. At the peak of the whelping season, strip-transect lines are flown over the whelping concentrations. Along these lines, pups are either counted visually from the helicopter or photographed from airplanes for later abundance estimation. Upon return to civilization, each photo is explored for numbers of pups, and the entire photo material serves as a basis for estimating the total number of pups born that year.

To correct the abundance estimates for pups that had left the ice or had not yet been born at the time of the survey, it is necessary to estimate the distribution of births over the pupping season. This is done by using information on the proportion of pups in distinct morphological stages, which vary in an age-dependent manner. These arbitrary but easily recognizable age categories are based on the pup's pelage colour and condition, overall appearance, and muscular coordination.

The total hooded seal pup production in the Greenland Sea was estimated to be 24 000 in 1997. The estimate obtained in 2005 was only 15 250, i.e., considerably lower than in 1997. When available pup production estimates are incorporated into a population model, it appears that the Greenland Sea hooded seals may have undergone a substantial decrease in population abundance from the late 1940s and up to the early 1980s. In the most recent two decades, the stock appears to have stabilised at a low level, just a little over 70 000 animals, which may be only 10-15% of the level observed 60 years ago. For this reason the hooded seal hunt in the West Ice region was stopped in 2007. In addition, the area shown in the map was revisited in 2007 in order to either confirm or reject the estimate obtained in 2005.

There is good evidence that previous ice conditions in the central Greenland Sea were significantly different from those witnessed in recent decades. Hooded seals prefer the large, heavy floes of Arctic ice for pupping rather than the thinner sheets of winter ice, and it is likely that the observed reductions in suitable ice have changed the hooded seal breeding habitat in the Greenland Sea. It is not known, however, how this may have affected the status and development of the hooded seal population in the area. Assessing possible mechanisms and factors contributing to the apparent problems now seen in the population of Greenland Sea hooded seals is a challenge for the IMR. Current and future research on Greenland Sea hooded seals focus on several of these factors, such as reduced fertility, predation, food shortage, disease and reductions in ice cover. These research projects are part of the Institute's efforts during the ongoing International Polar Year.



Observation platform, Campod, with high resolution video camera and sensors enabling quantitative estimates of seabed substrates and abundance of bottom-dwelling organisms.
Photo: MAREANO, Institute of Marine Research

The MAREANO exploration of the seabed

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Norwegian waters cover a total of over 2 million km^2. As of today, knowledge about the seabed in these waters is limited. In fact, we know far more about the surface of the planet Mars than about the seabed right outside our coastline! In 2007 the Norwegian Government allocated 33 million NOK for the interdisciplinary programme MAREANO, which aims to map and study the seabed in Norwegian waters. The programme will initially (2006-2010) focus on environmentally sensitive areas of the Barents Sea: Tromsøflaket, Troms II, NordlandVI and Eggakanten. The plan is to continue mapping in other areas after 2010.

The programme will be carried out from 2006 until 2010. The importance of MAREANO is specifically stressed in the Integrated Management Plan for the Barents Sea presented by the Norwegian Government. Extensive plans are being made for exploitation of oil and gas reserves in Lofoten and the Barents Sea, and sustainable management of the area is highly dependent on improved knowledge of the Arctic ecosystems.

What does the seabed consist of? What is the relationship between the physical environment, species diversity and biological resources? To which degree and where are contaminants stored in seabed sediments? Where are the coral reefs located? These are questions that will be addressed by MAREANO (Marine Area Database for Norwegian Coasts and Sea Areas).

In order to provide answers to these questions, the MAREANO programme has been divided into three main components: mapping, research and dissemination.

Mapping Surveys and basic studies of the physical, biological and chemical environment of the seabed will initially prioritise a number of environmentally sensitive areas of the Barents Sea and the Lofoten area in which offshore petroleum activities are being planned. Future areas to be surveyed will be selected on an annual basis in agreement with the government and relevant user groups.

Research The research will focus on corals, biotopes, the effect of oil and gas spills on biotopes, and relationships between biotopes and sediments. By following up seabed mapping with sampling and video recordings of the benthic fauna, one result of the MAREANO research will be increased precision in prediction of bottom habitat occurrences based on information from detailed seabed maps.

Public databases As the name of the programme indicates, the information gathered through surveys and research will be systematised in a database on Norway's coastal and marine regions. This database will also be open to contributions from external sources of knowledge in the public and private sectors, such as local and regional government bodies and the offshore industry. The online MAREANO database currently contains information on selected topics and a limited interactive map service for parts of the Barents Sea (see www.mareano.no). The service will be devel-

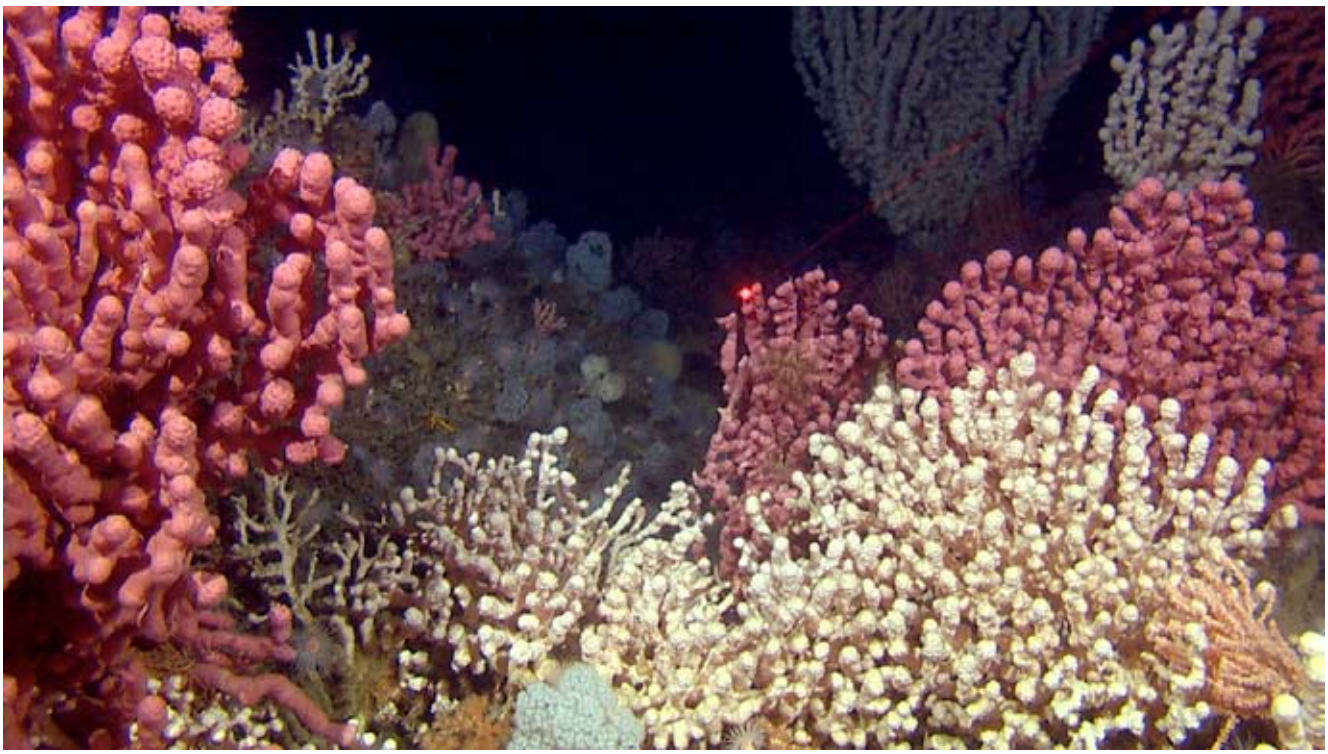

Image captured by the observation platform, Campod, from Malangsrevet. This reef was discovered and mapped during the second MAREANO cruise conducted in the Spring of 2007. The large red and pink coral "trees" are the coral *Paragorgia arborea*.
Photo: MAREANO, Institute of Marine Research

oped to cover the totality of Norway's coastal and marine regions.

The ultimate aim of MAREANO is to provide a tool that will give users from the industry, authorities, research and the general public direct access to neutral and reliable knowledge. An example of such knowledge will be maps that combine different types of data to display potential conflicts between vulnerable spawning grounds and planned offshore activities in the Barents Sea. Another is the possibility of combining data on types of seabed, currents and depth in order to identify optimal sites for fish farms in the coastal zone.

The seabed off the Norwegian coast is characterised by deep fjords and shelf areas and the habitats are complex and not easily documented using only standard sampling gear. That is why an observation platform has been built, with a high-resolution video camera and sensors enabling quantitative estimates of epibenthic megafauna.

In the deeper parts of the Norwegian coast and shelf, coral and sponge communities are locally abundant. The distribution of these and other habitats, and observed effects of fisheries are examples of valuable information this new equipment can provide.

MAREANO is a multi-disciplinary programme, bringing together biologists from the Institute of Marine Research and geologists from the Geological Survey of Norway, and the Hydrographic Service. A number of other partners will also participate in the field work and contribute to the MAREANO database.

Financing is provided by the ministries of the Environment, Fisheries and Coastal Affairs, Trade and Industry and by the Research Council of Norway through the new Marine and Coastal Programme.

Declining contaminant levels, biomarker responses and lipid cycles in ringed seals from Svalbard

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Ringed seals can be considered model candidates for monitoring contaminant accumulation and contaminant-induced biological effects: they are highly abundant, have a central place in the Arctic food web, and have a circumpolar distribution. They are dominant species in the diet of polar bears throughout the Arctic, and constitute an important part of Inuit diets in many coastal communities, linking them directly to human health issues.

A recent study in male ringed seals from Svalbard has shown that levels of contaminants are declining. A pre-

Male ringed seal on ice. *Photos: Hans Wolkers*

vious study on polar bears suggested that PCBs were declining through the 1990s, but stabilised after 1998. However, the results from ringed seals clearly show that the decline continues and levels in 2004 are often less than a third of those in 1995 (Fig. 1).

The results also indicated that the levels of polybrominated diphenyl ethers (PBDEs) are declining (Fig. 1). From 1998 to 2004 PBDE levels declined by about two thirds. This decline, the first reported PBDE decrease in marine mammals, is most likely due to stricter regulations concerning PBDE production and use in Europe. Europe has taken initiatives to phase out the use of all PBDEs; in August 2004 two commercial PBDE mixtures, penta- and octa-BDE were banned, while a ban of deca-BDE from 2008 is being considered. The decline of these compounds in ringed seals from Svalbard, before the official ban in 2004, but might be explained by chemical industries voluntarily phasing them out in anticipation of the official ban. These results clearly show the effectiveness of applying strict regulations on the production and use of chemicals.

Activity of the enzyme cytochrome P450 1A (CYP) has been widely used a marker of contaminant exposure. However, differences in contaminant bioavailability due to physiological factors, such as changes in lipid cycles, can complicate interpretation of relationships between contaminants and biomarkers such as CYP. When body lipids are used to cover energy demands during periods of reduced food intake, accumulated contaminants are also released and become bioavailable. Hence, biomarker responses as well as contaminant-induced biological effects may vary owing not only to changes in environmental levels of contaminants, but also to changes in contaminant bioavailability related to lipid dynamics.

Ringed seals breed and moult from approximately April to June. Food intake is dramatically reduced, particularly in males, and blubber is mobilised and metabolised to cover energy demands. During this period, animals will exhibit varying degrees of lipid mobilisation, resulting in varying degrees of increase in contaminant concentrations in their tissues as well as increased contaminant bioavailability. This might be expected to result

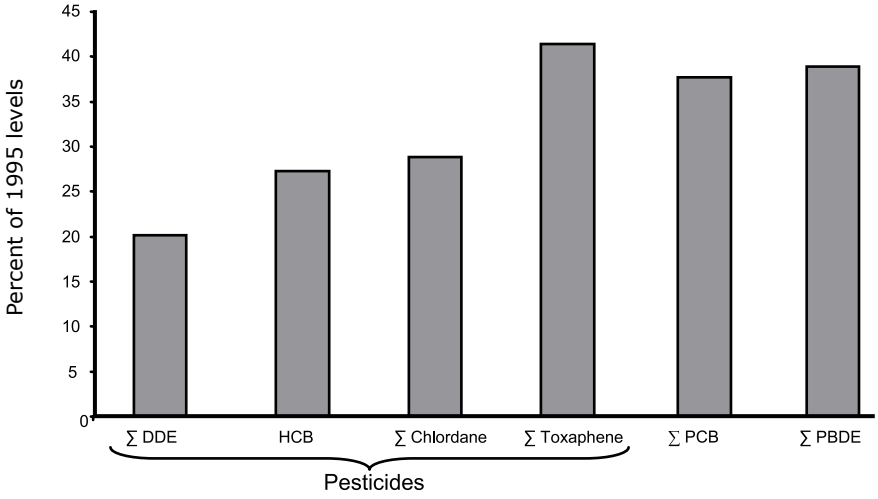

Figure 1. Contaminant levels in ringed seal blubber sampled in Svalbard in 2004, expressed as percent of levels found in 1995.

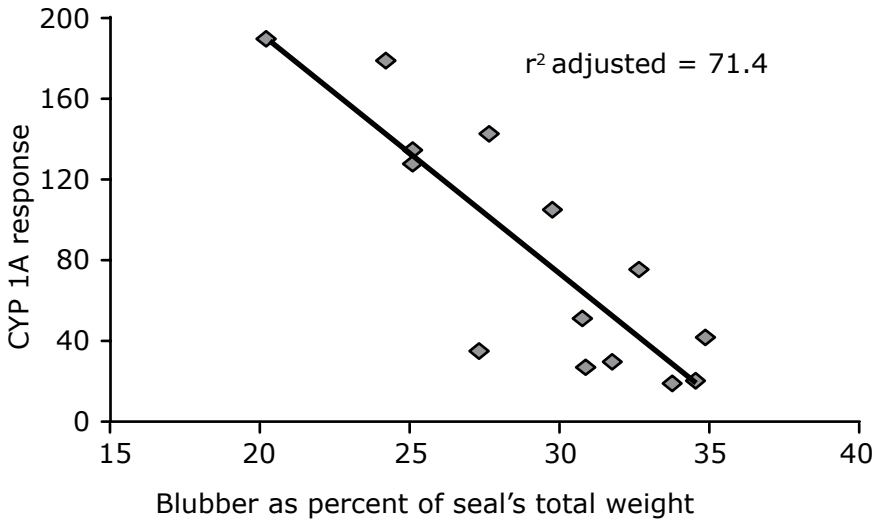

Figure 2. The cytochrome P 450 response in male ringed seals mobilising their blubber.

in CYP responses of varying degrees. The male ringed seals examined in this study were in a state of negative energy balance due to breeding and moulting. Surprisingly, there was no direct relationship between contaminants and CYP. Although pollutants in blubber are assumed to reflect the overall exposure over time, the circulating contaminant levels in seals may simply have been too low to elicit a CYP response. In addition, some key compounds might not have been included in the chemical analyses. The close association between CYP and the percentage of the seal's total body weight that is blubber (Fig. 2), supports this possibility: the observed CYP induction may be related to mobilisation and increased bioavailability of the accumulated contaminant mixture, including compounds that were not measured in the chemical analyses.

Safeguarding the environment for oil and gas development in the Barents Sea

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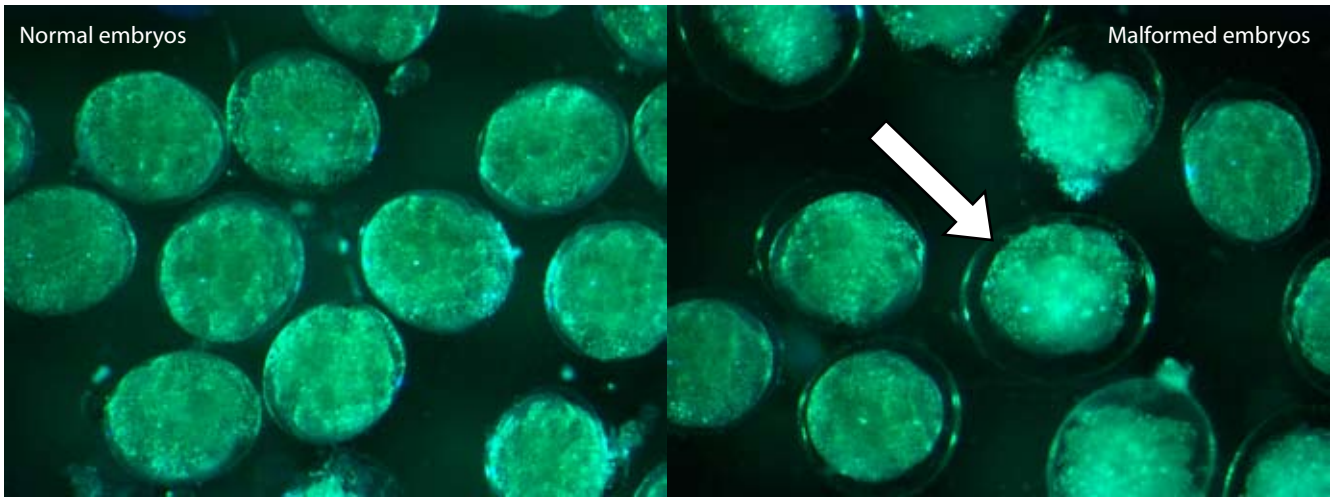
The Barents Sea is the largest among the pan-Arctic shelf seas, and accounts for 49% of the total primary production on the pan-Arctic shelf. This productivity has sustained one of the world's largest fisheries for more than fifty years and supports some of the world's most numerous colonies of seabirds, such as little auk, puffin and guillemot. The region also supports diverse seafloor communities with kelp forests as well as a variety of marine mammals including walrus, seals, whales and polar bears. In response to a rise in world energy demand, petroleum industry activities have expanded northward into the Barents Sea, with further expansion projected for the foreseeable future. This has raised the issue of the potential anthropogenic



Comparison of normal and malformed embryos of *Gammarus wilkitzkii*. The most frequently observed malformation is a gap between the outer cell membrane and embryo.

Jasmine Nahrgang
Polar cod: a key species for environmental risk assessment and monitoring.
ConocoPhillips

Louise Kiel Jensen
Long-term effects of oil pollutants on the Arctic *Calanus* complex.
ARCTOS-StatoilHydro

Gro Harlaug Olsen
Environmental effects of offshore oil activities on benthic ecosystems.
Norwegian Research Council

Ph.D. students working with petroleum ecotoxicology and Arctic organisms. *Photos: Merete Stefanussen*

impact of oil-related compounds on the unique polar marine ecosystem.

In an effort to obtain answers, the Norwegian Research Council and petroleum industry operators are sponsoring a variety of research projects aiming to increase understanding of the biological effects of petroleum on Arctic marine life. This is critical because the bio-monitoring tools and risk assessment methodologies currently used to safeguard the environment from harmful impacts were developed for use in the North Sea. Given the differences in ecosystem characteristics in the North Sea and Barents Sea, these tools and methodologies are likely to require modification prior to application in the Arctic.

To this end, ecotoxicological experiments are being performed at the Polar Environmental Centre in Tromsø and the Ny-Ålesund Marine Laboratory. Projects on Arctic benthic (bottom-dwelling), pelagic (free-swimming) and sympagic (ice-associated) species are beginning to yield valuable results. Different responses to oil exposure have been documented for Arctic and temperate benthic bivalve species exposed to high concentrations of petroleum compounds. Oil exposure studies of pelagic organisms are also underway with a comparative study of differences among species of the cold-water Arctic *Calanus* complex (*C. finmarchicus, C. glacialis* and *C. hyperboreus*). These tiny crustaceans are ecologically important in the Barents Sea as they form the keystone link between primary producers and fish stocks. Differences in size, lipid contents and life span among the three *Calanus* species will likely influence their responses to oil exposure.

Sympagic species, i.e., organisms associated with the Barents ice-edge, are a particularly important focus of the ongoing research. The sea ice ecosystem is a highly specialised community, consisting of ice algae, small crustaceans, fish and other organisms. The currently available information on petroleum ecotoxicology is inadequate to evaluate potential impacts on the organisms and sea ice ecosystem as a whole. However, experiments are now underway on the sea-ice associated polar cod (*Boreogadus saida*) and the shrimp-like ice amphipod *Gammarus wilkitzkii*. The findings show that female *G. wilkitzkii* exposed to high levels of the water soluble fraction of oil have a higher frequency of embryo malformations than unexposed females. In addition, sub-lethal effects related to growth and reproduction have been documented for adult amphipods.

Genomics is a potentially powerful new approach for quickly recognising biological impacts after a petroleum accident. Through studies on the polar cod, several new gene sequences have been identified and used to document a genetic response less than half a day after exposure to an oil compound.

The ongoing complementary ecotoxicology research activities are yielding essential knowledge on effects of oil exposure for key compartments of the Arctic ecosystem. With linkages to the ARCTOS network and Ph.D. School of the University of Tromsø, these projects also offer an exciting collaborative environment where talented students are on their way to becoming a new generation of specialists in ecotoxicology and cold-water environments. Through several Norwegian Research Council Bilateral projects with the United States, Canada and Russia, this new knowledge on the Norwegian Arctic is being synthesised within a pan-Arctic perspective. Due to the shared marine border in the Barents Sea between Norway and Russia, particular emphasis is being given to enhancing collaboration with Russian scientists. For example, several new biomarkers have been identified through a collaboration with Professor Nina Nemova of the Karelian Research Center, Russian Academy of Sciences, and are under development for future incorporation into a common biomonitoring toolbox for the Barents Sea.

Glacier mass loss in Kongsfjord, northwestern Svalbard

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Glacier mass balance is the amount of snow and ice lost or gained on a particular glacier during a certain time period. Mass balance is a lumped climate signal influenced primarily by precipitation and temperature. Glaciers lose ice through ablation (evaporation, melting, calving) and gain ice through accumulation (snowfall). Typically, balance is reported as a single number, which reflects the loss or gain for the glacier as a whole.

The Norwegian Polar Institute measures mass balance on three glaciers, all in the Kongsfjord area of northwestern Spitsbergen, Svalbard (Fig. 1):

- Austre Brøggerbreen (BRG), with measurements from 1967
- Midtre Lovénbreen (MLB), with measurements from 1968
- Kongsvegen (KNG), with measurements from 1987.

The first two records are among the longest continuous Arctic glacier mass balance time-series. The record from Kongsvegen, though shorter, is equally important, as it is more representative for Svalbard glaciers by virtue of its size and larger range of elevations. Kongsvegen is also a surge-type glacier: that is, it alternates between long periods of relatively little movement and short "surges" lasting 1-3 years, when the glacier's speed increases dramatically and the glacier front can advance kilometres or more. The last surge on Kongsvegen occurred sometime just before 1948. Surge frequency for Svalbard glaciers is on the order of decades to centuries.

Glacier mass balance is measured mainly by measuring the exposed height of an array of stakes planted along the glacier's centerline. The annual net balance is the sum of winter balance and summer balance. Winter balance is obtained by sounding the snow depth over the glacier at the end of the accumulation season, in May, as well as measuring snow density and the exposed height of stakes. Summer balance is obtained at the end of the

Fig. 1. The three Norwegian Polar Institute study glaciers in the Ny-Ålesund area.

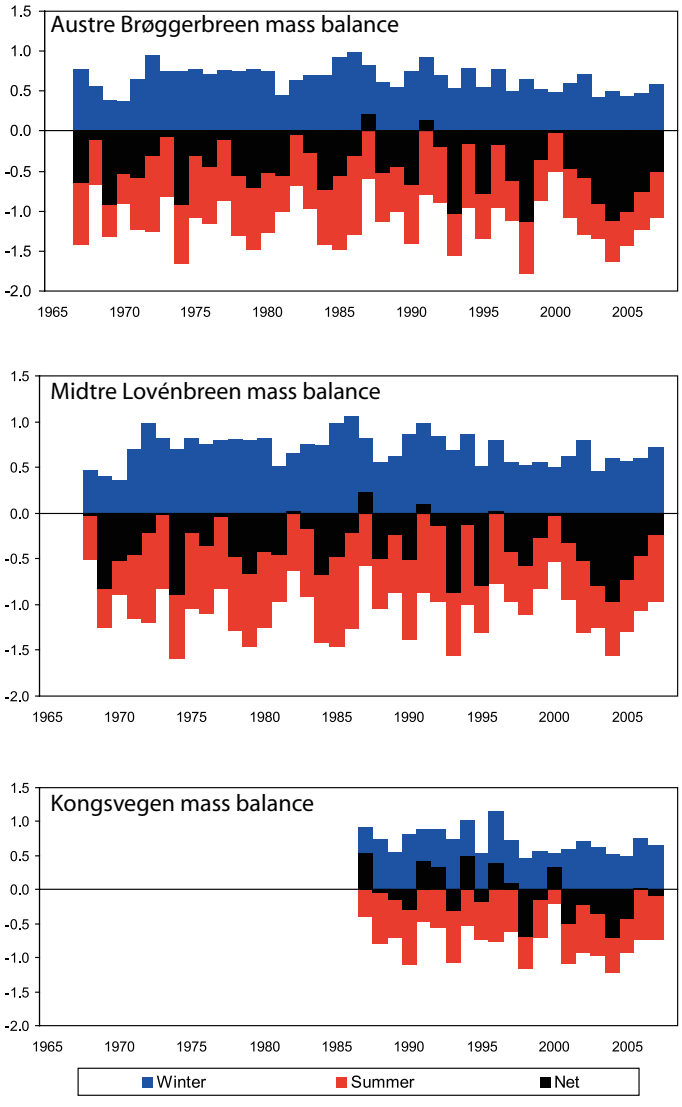

Fig. 2. Winter, summer and net balance record from Brøggerbreen, Midtre Lovénbreen and Kongsvegen. Balances at Kongsvegen are more positive than those for the smaller glaciers during the whole measurement period. This is because the upper part of Kongsvegen lies at a higher altitude than either Brøggerbreen or Midtre Lovénbreen.

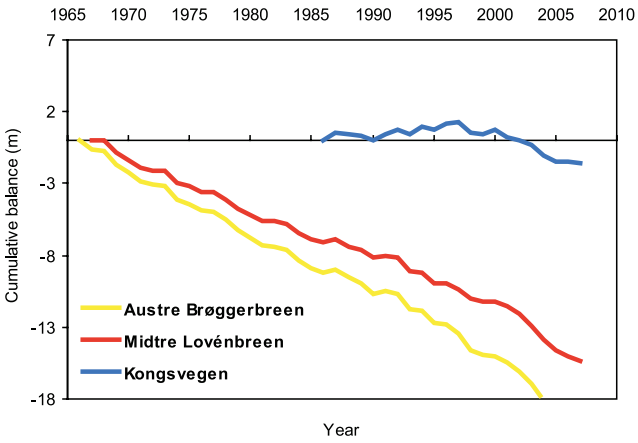

Fig. 3. Cumulative net balance is a proxy for glacier volume, and shows a negative trend for Brøggerbreen and Midtre Lovénbreen, in concordance with the observed glacier retreat. The recent years indicate an increase in the rate of retreat. Kongsvegen was actually increasing in volume until about 2000, when balances became increasingly negative.

ablation season, in September, by determining the change in the exposed height of the stakes.

Austre Brøggerbreen is a north-facing valley glacier extending from 50 to 600 m a.s.l. and with a total surface area of 6.1 km^2. Midtre Lovénbreen, just to the east of Brøggerbreen, extends from 50 to 650 m a.s.l. and has a surface area of 5.2 km^2. Kongsvegen, a much larger glacier located to the southeast of Ny-Ålesund, extends from sea level to over 850 m a.s.l. It is 25 km long, with an area of about 100 km^2. Austre Brøggerbreen and Midtre Lovénbreen have both had consistently negative mass balances since the beginning of the records (Fig. 2). The mass balance on Kongsvegen is more positive, since the glacier's accumulation area is larger and reaches higher elevations.

For all the glaciers, the winter balance is relatively stable and the summer ablation shows more variability, meaning that summer melting provides the strongest influence on the net balance. While the trends for both winter and summer balances are not statistically significant, there is an overall tendency over the measurement period for decreased winter accumulation and increased summer melting.

The last seven years have seen more strongly negative net balances on all glaciers. This is true also on Kongsvegen: whereas the net balance in the first fifteen years of monitoring shifted between positive and negative, only one the past seven years shows a positive net balance. This has caused the long-term summed net mass balance on Kongsvegen to reverse sign, such that it is actually losing mass on the long term, compared to when the measurements started (Fig. 3).

Finally, geodetic measurements show that the rate at which glaciers in western Svalbard are losing mass appears to have accelerated in the most recent years. Photogrammetric analysis and airborne laser altimetric data indicate that a number of glaciers, ranging in size from 5 to 1000 km^2, are losing mass at an accelerating rate. The average thinning rate for Midtre Lovénbreen, the glacier with the best data coverage, has increased steadily since 1936 (Fig. 4). Thinning rates for 2003-2005 are more than four times the average for the first measurement period 1936-1962. On Slakbreen, a glacier near the Svea mine in southern Svalbard, thinning rates for the latest measurement period 1990-2003 are more than four times that of the period 1961-1977. Thinning of several glaciers in Wedel Jarlsberg Land has also increased, doubling between the period 1990-1996 and 1996-2002. These results imply that western Svalbard glaciers are contributing more to sea level rise than previously supposed.

For further reading: Kohler J, James TD, Murray T, Nuth C, Brandt O, Barrand NE, Aas HF, Luckman A. 2007. Acceleration in thinning rate on western Svalbard glaciers, *Geophys. Res. Lett.*, 34, L18502, doi:10.1029/2007GL030681.

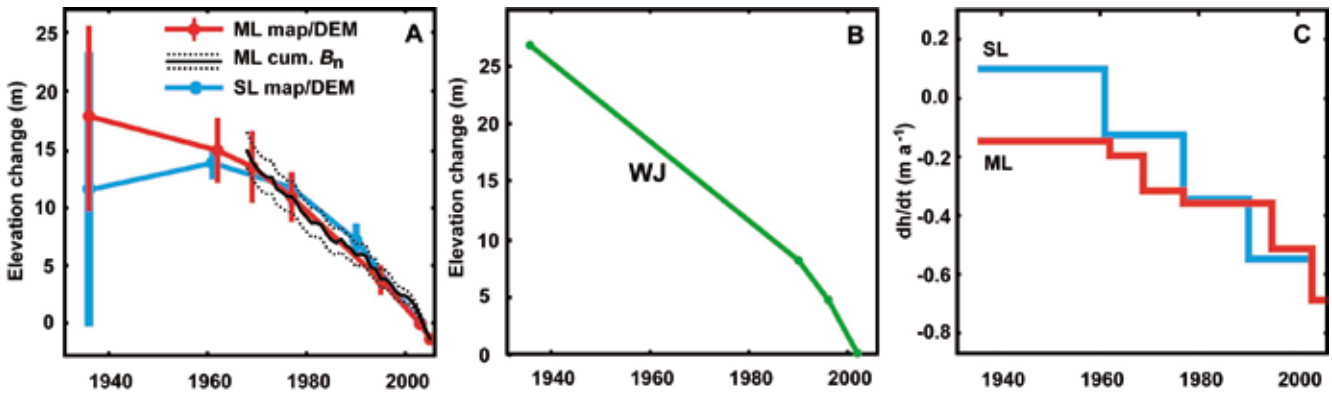

Fig. 4. (A) Average elevation change over time for Midtre Lovénbreen (ML) and Slakbreen (SL), and (B) for Wedel Jarlsberg Land (WJ). The black line (A) shows cumulatively summed net mass balance on ML from field measurements, converted to units of ice thickness, with accumulated annual error ± 25 cm (dashed lines). (C) Average thinning rate on ML and SL for each period. From: *Geophys. Res. Lett.* American Geophysical Union

Monumental portrayal of Carl Weyprecht encouraging his crew to resume efforts to reach the open sea, with Franz Josef Land in the background. The artist, expedition co-leader Julius von Payer, went on to study painting. Heeresgeschichtliches Museum, Vienna

The Arctic as part of central European culture

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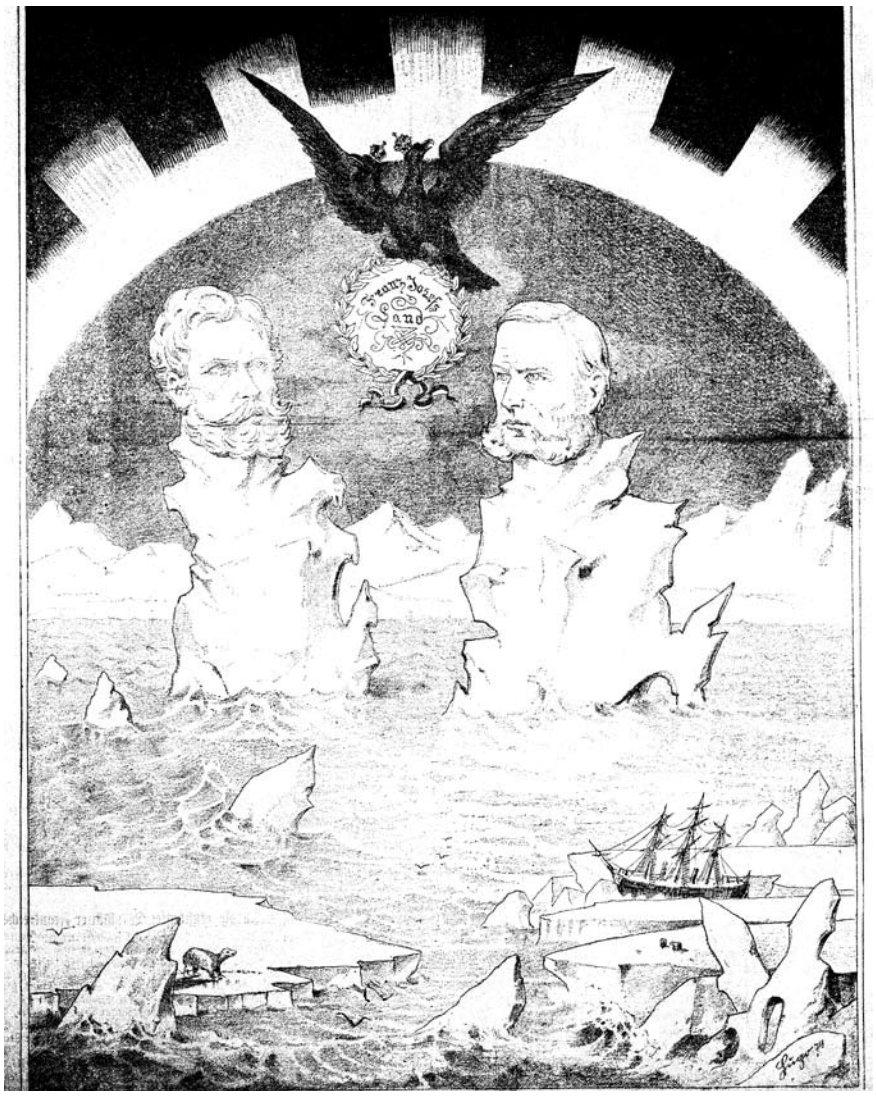
On his return from the Austro-Hungarian Arctic Expedition in 1874, Carl Weyprecht realised the need for more international coordination in Arctic research. The next year he addressed a scientific conference in Graz, suggesting the establishment of observation stations in different parts of the Arctic. It was these suggestions which led to the first International Polar Year (1882-1883), and the current IPY is an active reminder of Weyprecht's role in instigating international Arctic research efforts.

The 1872-1874 expedition, co-led by Julius Payer, is thus an important link in the chain of events leading to the state of polar science today. At the same time, however, it also set in motion a chain of textual and cultural expressions which went far beyond the publication of scientific reports and expedition accounts, including festive occasions, musical pieces, caricatures, television programmes, board games, paintings and literary works. These expressions have become part of a wider cultural response to Arctic exploration, formed mostly outside the Arctic. This has had wide-reaching consequences for public perceptions of and motivations for Arctic research.

Cultural representations of the Arctic are the products of both historical contexts and the continually changing formal constraints of different kinds of discourse. Investigation of the material shows how what can be labelled *Arctic* or *polar discourse* overlaps with many other forms of discourse. For example, when approaching the unfamiliar environment of the Arctic, representations tend to evoke both very old conceptions of the Arctic (such as the idea of an open polar sea) and analogies with conceptions formed only decades earlier in alpine discourse.

Often Arctic discourses are as connected to their political contexts as with the Arctic itself. The return of the Payer-Weyprecht expedition was a European media event; in Austria-Hungary, journalists struggled to evaluate its significance in the Central European context. Many of them placed great weight on its typically Austro-Hungarian cultural mix: in addition to the one Norwegian on board, expedition members came from what are today Hungary, the Czech Republic, Austria, Croatia and Italy. Liberal forces hoped that the expedition might become a model for a well-functioning, modern and multicultural empire. It may even be that Weyprecht was inspired by the



Detail of a contemporary caricature showing expedition leaders Julius Payer (left) and Carl Weyprecht as icebergs off Franz Josef Land, with the eagle of Austria-Hungary. *Die Bombe* 13.09.1874

Detail of a contemporary satirical drawing showing Arctic fashion as available from the firm of Polar Bear & Walrus, North Pole ("entrance also from Vardø"). *Der Floh* 12.09.1874

success of the expedition's cultural mixing in his later attempts to internationalise polar science.

The expedition is well known in literary studies as the subject of Christoph Ransmayr's 1984 novel *The Terrors of Ice and Darkness*. There are however many other novelisations and dramatisations of the expedition, including popular plays written on its homecoming and an 1875 scientific fantasy by the Hungarian novelist Mór Jókai. Narratological analyses also reveal the common use of novelistic strategies in expedition accounts and in popular retellings, suggesting a strong need for literary discourse within Arctic discourse in general.

This research is a sub-project within the Arctic Discourses project, funded by the Research Council of Norway and by the University of Tromsø, and involving a group of over 20 researchers at the Humanities Faculty and in Umeå, London, Vienna, Amsterdam and Copenhagen. The overall aim of the project is to investigate the overlapping of Arctic and literary discourses from the 1830s onwards. It is hosting a major international conference in Tromsø in February 2008.

The Arctic Discourses Project: http://uit.no/humfak/arkdisk/

ARCTOS network collaborative research: new information on climate–marine ecosystem interactions for the Barents Sea

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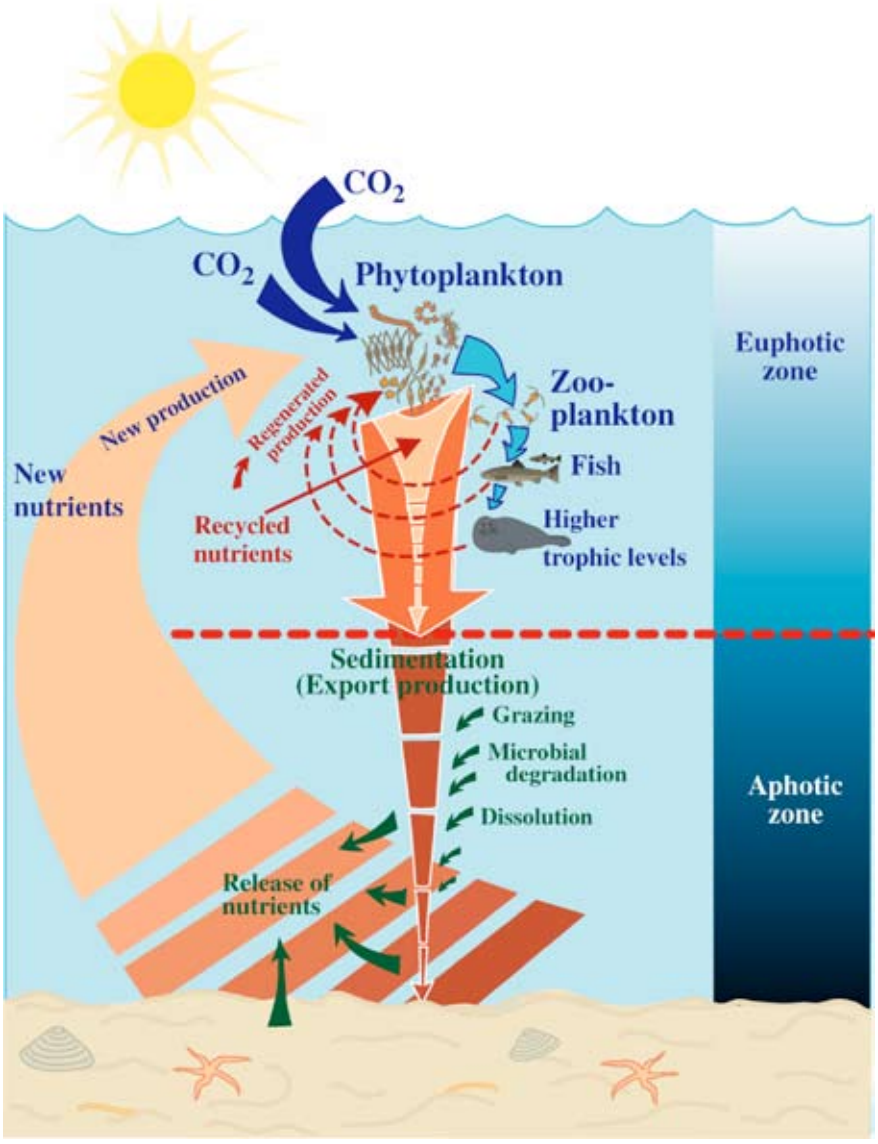
The earth is undergoing unprecedented changes in response to the build-up of global greenhouse gases in the atmosphere (IPCC, 2007). Already, changes in the physical and chemical environment of the Arctic are being detected, an indication that major changes are on the horizon for marine ecosystems. Yet today, we are far from a coherent picture of what and how these changes will occur, limiting society's ability to adequately plan for and respond to change. Scientific thinking has undergone a major shift in recent years from expectations of a gradual progression of environmental and ecological changes to expectations of potential rapid and abrupt changes.

Few ecological data sets for the Arctic coastal seas are available to search for the signs of either a gradual progression or rapid transitions and those that do exist have not been well integrated for the purpose of identifying changing spatial and temporal patterns in biological diversity. In addition, scientists have yet to achieve sufficient understanding of the functional aspects of Arctic ecosystems to allow us to extrapolate past and present trends into expectations for the future. Will Arctic warming result in an expansion of commercially valuable marine resources, or will it result in a variety of unexpected negative consequences that threaten the resource sustainability and general health of the entire Arctic marine ecosystem?

The carbon cycle is the base of the marine ecosystem and one important metric by which we measure climate change. Therefore, a critical element in the stewardship of our ecosystems is to establish rates and mechanisms of carbon cycling at the land–ocean boundary. Understanding the carbon cycle is a major focus of the ARCTOS network (www.nfh.uit.no/arctos/intro.html), a network of research scientists based in Northern Norway, dedicated to collaborative research on how climate change acts on ecosystems, biodiversity and the biological global flux in the Arctic. This network was established to give more thrust to marine ecological research, support international cooperation and integration, and to enhance the visibility of Norway's contribution to research in the Arctic. Major new advancements have recently been achieved through the now completed Norwegian Research Council NordKlima CABANERA project "Carbon flux and ecosystem feedback in the northern Barents Sea in an era of climate change" (www.nfh.uit.no/cabanera/index.html). The project, coordinated by Professor Paul Wassmann at the Norwegian College of Fisheries Sciences, University of Tromsø, involved more than 20 institutes from Norway and abroad. A series of 25 manuscripts on the ecosystem and carbon flux of the Northwest Barents Sea shelf will be published as a dedicated volume of Deep-Sea Research II in Spring 2008.



Generalised schematic of the marine carbon cycle

ARCTOS Network Elements

ARCTOS Network consists of a large active contact net of six Norwegian, six Nordic and twenty-two international institutions. Leading Norwegian institutes are: University of Tromsø (Norwegian College of Fisheries Science and Faculty of Science), Akvaplan-niva, the University Centre in Svalbard, the Norwegian Polar Institute and the Institute of Marine Research. The network increases cooperation on basic and applied research and education, supported by a world-class Arctic research infrastructure.

ARCTOS PhD-school, formally under the Department of Aquatic BioSciences, Norwegian College of Fisheries Science, University of Tromsø, provides contemporary education in new methods of Arctic marine science. Today more than thirty PhD, post doctoral and master's students are taking courses given by the PhD school.

ARCTOS ongoing projects consist of thirty-three international research, network and teaching projects headed by consortium members. These include some of the largest projects in marine ecology in Europe.

The CABANERA project provides new information on key ecosystem relationships in the northern Barents Sea, and in particular reveals the tight coupling between sympagic (ice-associated), pelagic and benthic ecosystem components. Sea ice algae are a critical food source to the bottom-dwellers (benthos) of the northern Barents Sea. Here, ice algae contribute 17-22% of primary production compared to only 6% for the Barents Sea as a whole. Scientists observe that the supply of pelagic primary productivity from both ice algae and phytoplankton is transferred in only a few days from the ocean surface to the seafloor. If projections on sea ice melting prove accurate, not only will there be a loss of habitat for the specialised community of ice-associated organisms (from small crustaceans and fish to marine mammals), but melting will likely lead to major changes on the seafloor for benthic communities dependent on ice algae as a food source. The risks and consequences of climate change for the Barents Sea ecosystem are significant. If society is to prevent unexpected environmental consequences, building up additional ecosystem understanding must remain a priority.

For further reading:

Intergovernmental Panel on Climate Change (IPCC) 2007. Climate Change, 2007. The Physical Science Basis. In: Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Eds. Solomon S, Quin D, Manning M, Chan X, Marquis MC, Averyt K, Tignor M, Miller HL), Cambridge and New York.

Progress in Oceanography Special Issue, Structure and Function of Contemporary Food Webs on Arctic Shelves: A Pan-Arctic Comparison. Volume 71, Nos 2-4, 2006. ISSN 0079-6611.

Arctic Council Secretariat

During the summer of 2007, Tromsø became the home of the Arctic Council Secretariat, adding to the long range of polar institutions in the "Paris of the North". The Secretariat is situated in the Polar Environmental Centre and has three employees. Their task is primarily to support the Arctic Council Chair, which rotates between member states. The Secretariat also helps coordinate the activities within the different working groups under the Arctic Council.

The Arctic Council is a high-level intergovernmental forum for cooperation, coordination and interaction between Arctic states, indigenous communities and other Arctic residents. The member states of the Arctic Council are Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden and the USA. In addition, indigenous Arctic peoples are represented through the organisations Aleut International Association, Arctic Athabaskan Council, Gwich'in Council International, Inuit Circumpolar Council, Saami Council, and Russian Association of Indigenous Peoples of the North.

Focus on climate change

Norway is the chair country during the period 2006-2009. Under the Norwegian chairmanship, the Council is focusing on some of the key challenges facing the Arctic region, such as the need for integrated resource management and the threat of climate change.

The three employees at the Arctic Council Secretariat. From left Tana Lowen Stratton, Maria-Victoria Gunnarsdottir and Jesper Hansen. *Photo: Tordis Villinger*

Permanent status

The new location of the Arctic Council Secretariat is based on an agreement between Norway, Denmark and Sweden which secures the Secretariat a permanent place in Tromsø until 2013. Earlier, the Secretariat has circulated between the member countries and has followed the chairmanship, which rotates every two years.

The establishment of a permanent Secretariat for the Arctic Council strengthens Tromsø's position as one of the leading cities in the Arctic world. The Secretariat also contributes to the city's international atmosphere, as the three employees come from such different places as Canada, USA/Iceland and Denmark/Greenland.

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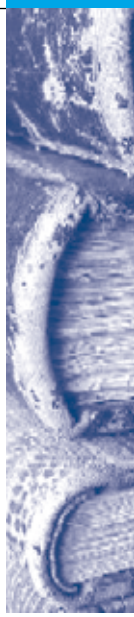

Arctic Council facts
The Arctic Council was founded in Ottawa, 19 September 1996.
From the Ottawa Declaration:

The Arctic Council is established as a high level forum to:
a. provide a means for promoting cooperation, coordination and interaction among the Arctic States, with the involvement of the Arctic indigenous communities and other Arctic inhabitants on common Arctic issues, in particular issues of sustainable development and environmental protection in the Arctic.
b. oversee and coordinate the programs established under the Arctic Environment Protection Strategy on the Arctic Monitoring and Assessment Program (AMAP); Conservation of Arctic Flora and Fauna (CAFF); Protection of the Arctic Marine Environment (PAME); and Emergency Preparedness and Response (EPPR)*.
c. adopt terms of reference for and oversee and coordinate a sustainable development program.
d. disseminate information, encourage education and promote interest in Arctic-related issues.

* *Today the Arctic Council is also involved in the Arctic Contaminants Action Program (ACAP) and the Sustainable Development Working Group (SDWG).*

Norway and the International Polar Year: some political aspects

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Science can be very political. The history of Norway and the International Polar Years shows that there has been a longstanding connection between the scientific and the political spheres. During the International Geophysical Year (1957–58), which occurred during the Cold War, the geophysicists played a significant political role in the struggle between East and West. But at the same time, they played this role with restraint. Although power politics was clearly part of the picture, scientists largely succeeded in keeping the IGY an international cooperative effort.

Today's historical research shows that international contacts between East and West during the Cold War, for instance as forged through the IGY, contributed to a lasting dialogue that ameliorated the antagonism. In 1959, the twelve nations that were doing research in Antarctica during the IGY became parties to the Antarctic Treaty. Ratified in 1961, the treaty dedicated Antarctica to the pursuit of peaceful activities. It established full freedom for all nations to conduct research there, under the supervision of the Scientific Committee on Antarctic Research (SCAR). Territorial claims were set aside, or put on ice, so to speak.

Today, an even more distanced relation to traditional power politics is within reach. The challenges are not the same now as they were some 50 years ago. One might argue that today's International Polar Year (IPY) is to a large extent intertwined with a broader environmental discourse – a "softer" kind of discourse.

The IPY, an international campaign on the largest scale, aims to improve our understanding of the polar regions and their role in the global system. This is "big science". The current IPY (2007–08) involves the participation of 63 nations and approximately 60 000 people in research and affiliated activities. More than 200 international research projects are being carried out, about half of them with Norwegian participation. The Norwegian parliament has allocated NOK 80 million per year from 2007 to 2010, a total of NOK 320, to this endeavour. Two-thirds of this money is going to projects concerning meteorology and climate research.

The IPY is of great significance for Norway, a polar nation with interests in both the north and the south. The Norwegian economy is largely dependent on natural resources, such as petroleum and fisheries. How will climate change affect the exploitation of these resources? What are the geopolitical consequences in the Far North of the Arctic Ocean's shrinking ice cover?

There are three main drivers attracting international attention to the Far North: global climate change, energy, and changing political relations, especially with Russia. Issues connected to energy and traditional geopolitics fall into the "harder" discourse.

The Norwegian authorities are keenly aware of the increasing international attention focussed on the polar regions. The government is in fact contributing to it, having launched its "High North Strategy" in 2006. The Norwegian government hopes the IPY will contribute to a permanent international scientific co-operation in the Far North, especially with Russia. The legacy of the IGY may have stimulated this thinking. But the political aims and scopes concerning the IPY go even further. There is a hope on the Norwegian side that the political leaders will manage to merge the two discourses mentioned above. As Foreign Minister Jonas Gahr Støre put it, "We are advocating ambitious environmental goals, and we are seeking to promote the establishment of high health, safety and environmental standards for petroleum activities in

the whole of the Barents Sea." According to Støre, Russia looks favourably on this goal.

Global climate change, and the international scientific efforts to understand these processes better, leave us with the clear impression that national security can no longer be regarded only in the "old-fashioned" way as power politics and military threats. For ordinary individuals as well as for nations, security challenges are also related to climate change, natural resources, economic relations and transportation. Merging the questions of energy and climate change, and trying to find solutions through international co-operation, is undoubtedly an ambitious vision, but it is a vision in line with the history of past IPYs.

Arctic Frontiers

More than 500 individuals from 21 nations attended the 1st Arctic Frontiers conference in January 2007, and over 1000 additional participants from 27 nations followed the conference through a live internet broadcast. Under the main topic "Balancing human use and ecosystem protection" the conference addressed responsibilities for sustainable development in the Arctic. In the policy section, the focus was on resources, environment and good governance. The scientific section dealt with food web dynamics and biogeochemical fluxes in the Arctic Ocean.

Arctic Frontiers (www.arcticfrontiers.com) is to be an annual event in Tromsø, Norway, for discussing the multiple perspectives of Arctic issues. The conference brings together stakeholders from the pan-Arctic nations and the European Union, including decision makers, industry representatives, regional interest groups, and top scientists. It is hosted by the University of Tromsø, and organised and financed by stakeholders from the private and public sector.

The 2nd annual Arctic Frontiers conference "Oil and Gas – Political, Social and Scientific Challenges in the Arctic" will take place in Tromsø, 20-25 January 2008, and feature cooperation with the Arctic Monitoring and Assessment Program (AMAP), a permanent working group of the Arctic Council.

Conference

On 19 and 20 November the University of California, Berkeley, the Fridtjof Nansen Institute, the Norwegian Ministry of Foreign Affairs (through the General Consulate in San Francisco) and the University of Tromsø jointly arranged the conference "Resource Exploitation and Environmental Challenges in a Changing Arctic" in Berkeley. In addition to presenting recent research results and background information relevant to policy making from both the USA, and from Norway, the conference provided an arena for key players in both these domains to discuss future collaboration between the two countries.

Report

Troms County Council and the University of Tromsø have published the report "Tromsø som polar kompetanseklynge" (Tromsø as a Polar Competence Cluster). The report gives an overview of the total Polar R & D activity in Tromsø, both in the public sector and in the business community. Particular emphasis has been put on existing clusters in the fields of marine biotechnology, space-related activity (e.g. remote sensing), and Arctic marine ecosystem R & D, and on discussing the possibility of developing new clusters.

Download the report from http://hdl.handle.net/10037/1221 (In Norwegian, but with an executive summary in English).

World Environment Day

UNEP's World Environment Day was hosted by Norway and Tromsø this year. (See also page 2.) The Norwegian Polar Institute, one of the organizers, initiated a conference around the theme "Melting Ice - A Hot Topic?", with the cooperation of the Ministry of the Environment, the Ministry of Foreign Affairs and the Nordic Council of Ministers. IPCC chairman Rajendra Pachauri delivered one of the keynote addresses at the conference, which gathered around 400 participants from 35 countries. A pleasant spin-off was a conference for schoolchildren which drew nearly 400 for the programme in Norwegian and 100 for the English programme. To access the webcast of the conference, see the NPI website at www.npolar.no .

The International Polar Year (IPY)

Tromsø-based institutions are participating in 25 of the 31 IPY projects with Norwegian financing.

Antarctic krill and ecosystem studies (AKES)
Institute of Marine Research

Arctic natural climate and environmental changes and human adaptation: from science to public awareness (SciencePub)
Geological Survey of Norway, Norwegian Polar Institute, University of Tromsø

Arctic predators as indicators of tundra ecosystem state (ArcticWOLVES)
University of Tromsø, Norwegian Polar Institute

Atmospheric research and monitoring at Troll; a long-term observational program (AtmoTroll)
Norwegian Institute for Air Research, Norwegian Polar Institute

Bipolar Atlantic thermohaline circulation (BIAC)
Norwegian Polar Institute, Institute of Marine Research

Climate effects on planktonic food quality and trophic transfer in Arctic marginal ice zones (MIZ) (CLEOPATRA)
Norwegian Polar Institute

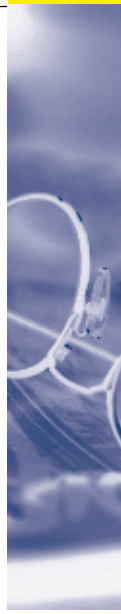
Contaminants in polar regions – dynamic range of contaminants in polar marine ecosystems (COPOL)
Norwegian Polar Institute, Akvaplan-niva, Norwegian Institute for Air Research, Norwegian Institute for Nature Research

Global POP – an investigation of environmental pollutants in fish worldwide
Norwegian Institute for Air Research

Improved forecasting of adverse weather in the Arctic region – present and future (IPY-Thorpex)
Norwegian Polar Institute

Integrated Arctic Ocean observing system: closing the loop (iAOOS-Norway)
Norwegian Polar Institute, Institute of Marine Research

Interhemispheric conjugacy effects in



solar-terrestrial and aeronomy research (IPY-ICESTAR)
Norwegian Institute for Air Research, University of Tromsø

Long-term sea level variability in the Nordic Seas (LEVANS)
Norwegian Polar Institute

Mapping threats to Arctic bird populations. The effect of infectious organisms and pollution on bird health (BIRD-HEALTH)
Norwegian Institute for Nature Research, Akvaplan-niva, Norwegian Polar Institute, University of Tromsø

Marine mammals exploring the oceans pole to pole (MEOP-Norway)
Norwegian Polar Institute, Institute of Marine Research

Monitoring of development in traditional indigenous lands of the Nenets Autonomous Okrug, northwestern Russia (MODIL-NAO)
Norwegian Polar Institute

Norwegian component of the ecosystem studies of subarctic and Arctic regions (NESSAR)
Institute of Marine Research, Akvaplan-niva, Norwegian Polar Institute, University of Tromsø

Norwegian-US Antarctic IPY traverse (TASTE-IDEA)
Norwegian Polar Institute

Permafrost observatory project: a contribution to the thermal state of permafrost in Norway and Svalbard (TSP Norway)
Geological Survey of Norway

Polar bear circumpolar health assessment in relation to toxicants and climate changing (BearHealth)
Norwegian Polar Institute

Polar study using aircraft, remote sensing, surface measurements and models, of climate, chemistry, aerosols, and transport - Norway (POLAR-CAT)
Norwegian Institute for Air Research

Present day processes, past changes, and spatiotemporal variability of biotic, abiotic and socio-environmental conditions and resource components along and across the Arctic delimitation zone (PPS Arctic Norway)
Norwegian Institute for Nature Research

Reindeer herders vulnerability network study: reindeer pastoralism in a changing climate (EALÀT)
University of Tromsø

The dynamic response of Arctic glaciers to global warming (GLACIODYN)
Norwegian Polar Institute, Norut Information Technology

The impacts of oil and gas activity on peoples in the Arctic using a multiple securities perspective (GAPS)
University of Tromsø, Norwegian Polar Institute

The linguistic and cultural heritage electronic network (LICHEN)
University of Tromsø

More information: www.polaryear.no

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Janne E. Søreide
Zooplankton communities, food web structures and sympagic-pelagic coupling in the Svalbard-Barents Sea marginal ice zone (Joint supervision with Akvaplan-niva and the Norwegian Polar Institute)
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Inger Lin Uttakleiv Ræder
Comparative functional and structural studies of proteins from the marine psychrophilic bacterium *Vibrio salmonicida*. Aspects of host adaptation and cold activity of proteins
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