2010

POLAR RESEARCH IN TROMSØ

Fram Centre

NORSK POLARINSTITUTT

INSTITUTE OF MARINE RESEARCH
HAVFORSKNINGSINSTITUTTET

UNIVERSITETET I TROMSØ

Agreement in the High North

When Norway and Russia signed a Joint Statement on maritime delimitation and cooperation in the Barents Sea and the Arctic Ocean, it made headlines all over the world. The agreement ended a 40-year dispute over a region where both countries had commercial interests at stake. As a result, the area will now be opened up for extraction of oil and gas resources. Only time will tell if the seabed holds anything worth exploiting, but marine and oceanographic researchers now have access to an area that until now has essentially been off limits.

Some people frowned skeptically at the two nations' promise to "maintain and enhance cooperation with regard to fisheries and management of hydrocarbon resources". Some thought of Russia's environmental track record and shuddered apprehensively at the potential havoc that increased economic activity might wreak on this sensitive region. But others saw hopeful signs. Over a year ago, President Putin signed a decree to establish a "Russian Arctic" national park. After a personal visit to Franz Josef Land, Putin spoke of the environmental destruction he had seen, and vowed that Russia would clean up after herself. And indeed, just a few days later it emerged that Russian agencies had allocated 150 million NOK for clean-up efforts in Franz Josef Land in 2012. Norway and Russia already have bilateral cooperation on environmental issues and the Ministry of Natural Resources of the Russian Federation has expressed interest in implementing an ecosystem-based management plan for the Barents Sea similar to the Norwegian one (see page 8).

In a chronicle published in North Norway's leading paper *Nordlys*, Bjørn Fossli Johansen and Jan-Gunnar Winther of the Norwegian Polar Institute wrote: "With this year's delimitation treaty between Norway and Russia, and based on maritime law, our two countries have clarified the rights to the resources in the seabed of what was previously a disputed area in the Barents Sea and Arctic Ocean. [...] This unity is the embodiment of Norwegian–Russian cooperation in the High North. But it is also founded on a long history of cooperation with our neighbour in the east. We believe that the recent progression towards environmental awareness and protective measures in Russia vouches for a continued close and fruitful partnership, not least in environmental management issues. The delimitation agreement should not be the stopping point, but rather the springboard for Norwegian–Russian cooperation in the North."

Moving forward – the Fram Centre

In late September the Fram Centre, the High North Research Centre for Climate and the Environment, was officially opened by a delegation led by Prime Minister Jens Stoltenberg (see the article on page 13). The Fram Centre includes the entities that made up the Polar Environmental Centre but also incorporates several other leading research institutes situated in Tromsø and elsewhere. By gathering a wide range of knowledge-intense organisations under a single banner and providing ample funding, the government hopes to facilitate the interdisciplinary approach required to meet modern research challenges. Although climate change is mentioned as a particular focus, the Fram Centre will also be extremely well placed to innovate, develop and test new techniques for environmental monitoring and protection. Perhaps some of these initiatives will be taken in collaboration with our Russian neighbours.

Last issue

Polar Research in Tromsø was originally produced jointly by several independent research organisations. Some of them no longer exist and the rest are all linked directly or indirectly to the Fram Centre. As a consequence these changes, this will be the last issue of *Polar Research in Tromsø*. From next year onwards, you will find an account of the year's most exciting research results – and more – in a new publication called *Frammagasinet*. We hope to meet you there!

Polar Research in Tromsø

Polar Research in Tromsø is published once a year by the University of Tromsø (UiT), the Norwegian Polar Institute (NPI), the Tromsø branch of the Institute of Marine Research and the Polar Environmental Centre (now incorporated into the Fram 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.

This is the last issue of *Polar Research in Tromsø.*

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Tracking the migration of Arctic skuas

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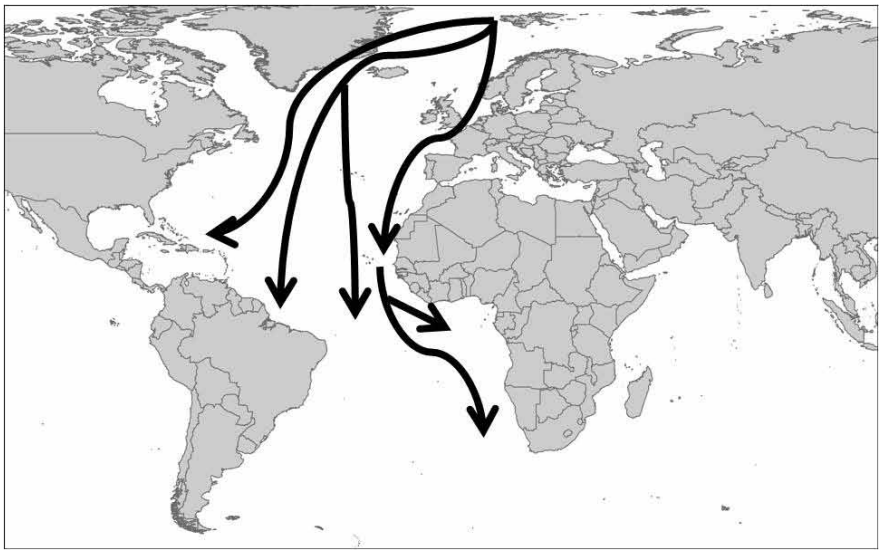
Migration enables animals to choose the optimal habitat for different parts of the year. In the summer, many animals are attracted to Arctic and temperate areas, which offer favourable environmental conditions that help ensure successful reproduction. However, winters at these latitudes can be challenging and many animals migrate long distances to seek better conditions elsewhere. This is especially true of birds because of their ability to fly. Birds undertake the longest annual migrations known on earth.

Studying migration is important for understanding the factors that affect animal survival and for identifying the habitats they depend on throughout the year. Traditional methods, like bird ringing, have been insufficient to track the migration of many bird species. We are now using new logger technology to meet this challenge. Light-level geolocators are miniaturised electronic loggers that can be attached to a bird ring; they are so small (weighing only 1.5-2.5 g) that the bird can easily carry them. These geolocators record light intensity to identify timing of sunrise and sunset, which in turn are used to calculate latitude and longitude.

Arctic skua flying over the breeding territory in Kongsfjorden in Svalbard. Photo: E. Biersma

The Arctic skua (*Stercorarius parasiticus*) is one of the species we have studied with this method. This species is famous for its kleptoparasitic behaviour. They steal food from other seabirds, such as gulls and terns. In Svalbard they mainly kleptoparasitise kittiwakes. A skua pesters its victims until they drop their food. This aerial pursuit is an impressive spectacle, as skuas are consummate fliers. Information about skua migration, however, has been very scarce, with very few ring recoveries. To fill this knowledge gap we deployed Arctic skuas with light-level geolocator loggers in 2009. The birds were captured and equipped in their breeding territories in Kongsfjorden in Svalbard. We went back for recaptures in the same territories in 2010 and retrieved eleven loggers.



The main flyways and wintering areas of Arctic skuas breeding in Svalbard. Illustration: B. Moe

In this, the first study to track the migration of Arctic skuas, we identified two main flyways and three main wintering areas. During autumn migration, ten of our eleven skuas flew west towards Greenland and one skua flew south towards the North Sea. They all spent the winter in tropical or sub-tropical waters: off West Africa, in

the Gulf of Guinea or off South America. The Arctic skuas utilised large oceanic areas both during migration and during winter. The distances covered were among the longest animal migrations ever recorded.

The annual migration of Arctic skuas integrates arctic, temperate and tropical waters, and demonstrates impressive adaptations to cope with contrasting environmental and climatic conditions. It is not known whether the identified flyways and wintering areas are fixed individual preferences or whether individuals can choose different flyways and wintering areas in different years. Nevertheless, the species does not seem to depend entirely on a few well defined and restricted habitats, so-called hotspots. The viability of Arctic skua populations is probably affected by the health of the entire North Atlantic Ocean. As this ocean basin is subject to intense human exploitation, including oil industry and fishing, this study highlights the need for environmental conservation and management on a transatlantic scale.

Seasonal emaciation potentiates the toxicity of persistent organic contaminants in arctic animals

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Even though the Arctic is regarded as a pristine environment far away from point sources of heavy pollution, persistent organic contaminants enter the Arctic through long-range atmospheric transport and ocean currents. The animals living in arctic areas are exposed to persistent organic contaminants through their diet, and species at the top of the food web accumulate these contaminants to a greater extent than animals feeding on a lower trophic level. Hence, the highest levels of persistent organic contaminants in arctic animals are found in arctic top predators such as polar bear (*Ursus maritimus*), glaucous gull (*Larus hyperboreus*) and arctic fox (*Vulpes lagopus*). Arctic animals have large seasonal variations in their body fat stores, which reflect variations in food availability, cost of reproduction and migration. For example, the body fat stores of arctic fox are reduced from 25 to 5 percent when the fat is mobilised to meet energy demands during the reproduction period. Arctic seabirds can lose 10-20% of their body mass during the egg laying, brooding and chick rearing period due to deposition of fat in the egg and fat mobilisation to meet energy demands during nest attendance.

Caged arctic fox. Photo: Norwegian Polar Institute

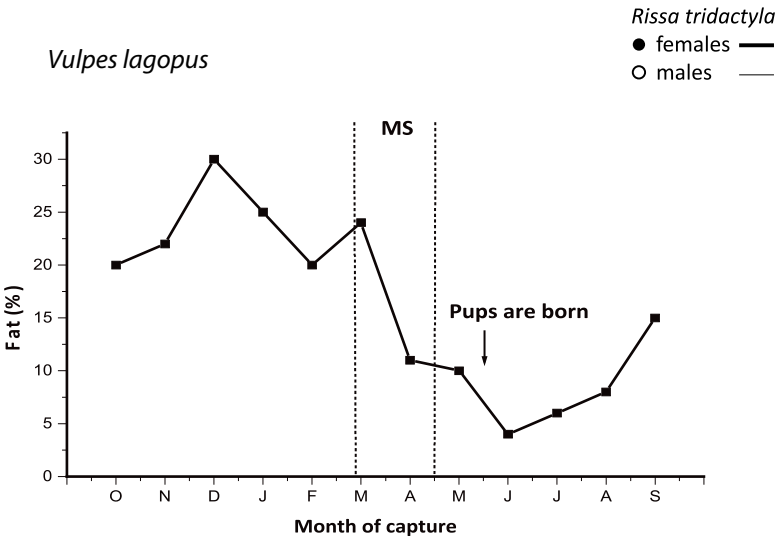
Most persistent organic contaminants are fat-soluble and adipose tissue is therefore the major storage site for these lipophilic contaminants. Storage of organic contaminants in adipose tissue is actually an advantage for the animal as concentrations of contaminants in vital organs such as the brain and the liver remain relatively low. However, when body fat is mobilised during periods of high energy demands, the organic contaminants that are stored in the body fat are released into the blood and re-

distributed to these vital organs. This means that fat mobilisation may lead to an increased bioavailability of accumulated organic contaminants at "target" sites. This may further lead to biotransformation of contaminants, which increases their toxic potential. In arctic fish, for example, the activity of biotransformation enzymes increased by a factor of 12 when fat was mobilised. Increased biotransformation enzyme activity may in turn influence contaminant levels and patterns, and enhance the risk of adverse biological effects.

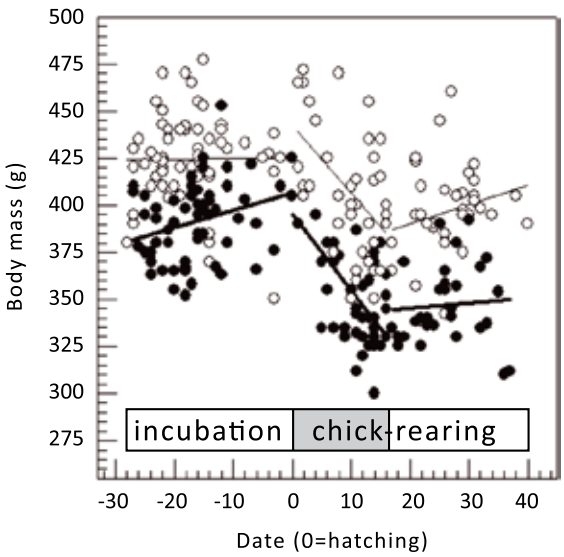
In two recent studies, we investigated the effect of seasonal emaciation on contaminant redistribution and the activity and/or mRNA expression of biotransformation enzymes in herring gull chicks and farmed arctic foxes exposed to persistent organic contaminants. The studies demonstrated that fasting strongly increased the concentrations of these contaminants in vital organs. In herring gull chicks, also the concentrations of hydroxylated metabolites of polychlorinated biphenyls (OH-PCBs) increased during fasting periods. In addition, some biotransformation enzymes were induced in lean herring gull chicks and lean farmed arctic foxes, but not in well-fed, fat specimens. Moreover, fasting and fat mobilisation have physiological effects in themselves, independent of the concentration of contaminants. Interestingly, the result of these physiological effects was down-regulation of biotransformation enzymes in farmed arctic foxes, but up-regulation in herring gull chicks. This illustrates that birds and mammals may respond differently to seasonal emaciation.

Dead glaucous gull on a nest with three live chicks. Photo: Norwegian Polar Institute

The results of these studies illustrate that arctic animals may have higher contaminant load in sensitive organs during periods of mobilisation of body reserves and emaciation. This may potentiate the induction of biotransformation enzymes. Hence it is suggested that arctic animals are particularly sensitive to organic contaminants when they are fasting, not only because of the release from fat tissue, but also because the physiological effect of fasting in itself affects (up- or down-regulates) the biotransformation enzymes. Increased enzyme activity could lead to a greater production of bioactive metabolites; decreased enzyme activity could result in less efficient elimination of organic contaminants. The findings of these studies suggest that two different "time-windows" are of particular relevance when ecotoxicological studies are carried out on arctic animals, i.e., when they are at their fattest and when they are at their leanest. It is important to have detailed knowledge about what happens during these time-windows, and to take this into consideration when conducting time-trend analyses, monitoring, risk assessments and effect studies in arctic animals.



Seasonal changes in fat content (% of skinned carcass mass) of arctic foxes (modified from Prestrud and Nilssen 1992. *J. Wild. Manage.* 56: 221-233). MS = mating season.



Seasonal changes in body mass (g) of black-legged kittiwakes (Moe et al. 2002. *J. Avian Biol.* 33: 225-234).

Influence of climate on accumulation of contaminants in the arctic marine food web

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The Arctic is one of the regions that the Intergovernmental Panel on Climate Change (IPCC) believe will be most affected by climate change. Some of the expected alterations have already been reported: thinning of the ice sheet, less multiyear ice, increased river discharge into the Arctic Basin, increased melting of glaciers, warmer surface temperatures and greater inflow of Atlantic water masses. These changes may potentially alter species distributions, food web structures, carbon cycling, and subsequently tropho-dynamics and transport and uptake of persistent organic pollutants (POPs) into and within the Arctic. Additionally, the arctic environment is characterised by high seasonality in light intensity, primary production, food availability, lipid concentration in organisms, migration of organisms, and ice cover. These "naturally occurring" factors also influence availability and uptake of POPs in the organisms and in food webs irrespectively of climate change.

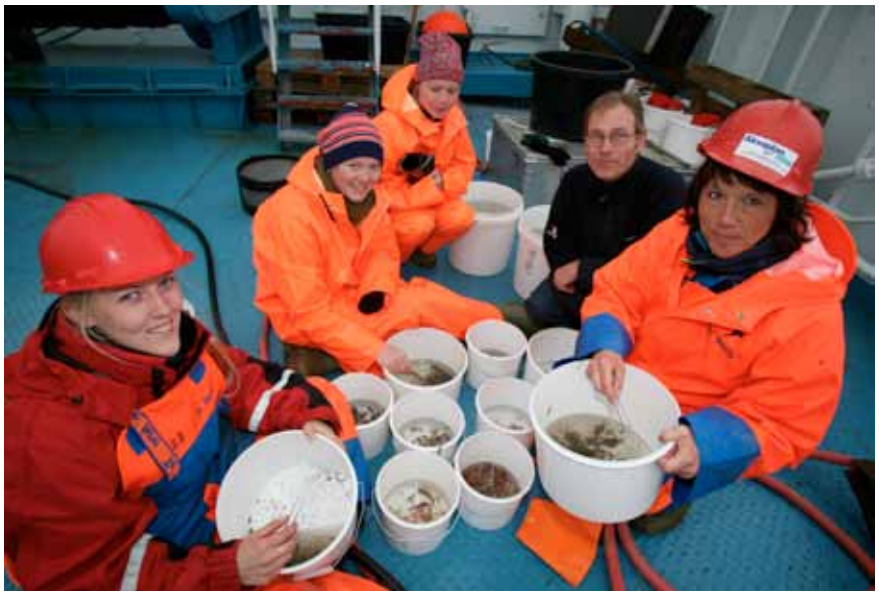
It is not yet clear how climate change might affect accumulation of POPs in marine food webs. Modelling and sensitivity analyses have identified sea ice cover, temperature, precipitation rates, and altered primary production as having the largest impact on POP transportation and accumulation in the arctic environment. Large uncertainties remain, however, regarding prospective changes in relevant input parameters for the models. Increased empirical knowledge is needed on how alterations in variables that act both regionally and globally, such as climate, might influence the disposition of contaminants in ecosystems.

The International Polar Year project "Contaminants in Polar Regions (COPOL)" was designed to provide more of the empirical knowledge required, and as a part of COPOL the project "Influence of climate on accumulation of contaminants in arctic marine pelagic food web" was conducted (PhD thesis, Ingeborg G. Hallanger). The thesis work was funded by ConocoPhillips. The goals were to investigate how seasonal variation and climate change can affect uptake and accumulation of organic contaminants in arctic ecosystems.

Sampling of zooplankton using a MIK net. Photo: Ole Magnus Rapp, Aftenposten

Accumulation of POPs in organisms has been shown to vary with the season. This is true both for organisms at low trophic levels (zooplankton)

Sorting zooplankton requires knowledge, patience, and a steady hand. Five hours after sampling the zooplankton will have been sorted and safely stowed in the freezer.
Photo: Ida Beathe Øverjordet



Scientists at work on deck sorting organisms from bottom sediments for the benthic part of the COPOL project. The author is second from the left. Photo: Ole Magnus Rapp, Aftenposten

and for those at higher levels (fish and birds). However, the seasonal pattern in accumulation and magnification can differ depending on the chemical and group of organisms involved.

Zooplankton are regarded as well suited for assessments of how seasons (and climate change) can alter POP uptake and accumulation in the arctic ecosystem, since they reflect environmental changes in POP exposure more rapidly than longer lived organisms at higher trophic levels. Zooplankton also provide the link between primary production and fish, seabirds and marine mammals. In all species of zooplankton studied, the POP concentrations decrease from May to October. This coincides with decreasing POP concentrations in seawater and increasing lipid stores in the plankton during the same period. Investigation of the accumulation and magnification from zooplankton to fish and birds generally identified July as the month when magnification was greatest. This was because the fish species and (for some POP compounds) kittiwakes had highest POP concentrations in July. The decreasing POP concentration observed from May to October in the zooplankton species further emphasises the magnitude of this increase in accumulation through the food web. These results indicate that estimates of the uptake and accumulation of POPs are dependent on the time of sampling (i.e. season).

Knowledge about the influence of season is essential to be able to differentiate between seasonal variation in accumulation and magnification of POPs and alterations caused by climate change. Elucidating possible climate change-induced alterations in a seasonal environment is a complex and difficult task. Clearly climate change has potential to alter the POP concentrations in the Arctic. However, it is still uncertain to what degree they will be altered, and whether we can expect a net increase or decrease of POPs in the Arctic with a warmer climate.

Oceans Management 2.0

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Climate change, increasing economic activity, and a growing understanding of how oceans are to be managed, has brought the concept of Integrated Oceans Management to the fore. Essentially, this concept means that the cumulative effects of various pressures on marine ecosystems are to be taken into consideration when managing oceans.

Numerous international agreements advocate the introduction of Integrated Oceans Management. In particular, the 2002 World Summit on Sustainable Development (WSSD) stated that "Oceans, seas, islands and coastal areas form an integrated and essential component of the Earth's ecosystem and are critical for global food security and for sustaining economic prosperity …". Specifically, the WSSD "Encourage(d) the application by 2010 of the ecosystem approach…". Similar statements have been made in a number of international fora, including the United Nations General Assembly.

Many countries are now in the process of developing national ocean policies where "integrated oceans management" or a similar term ("ecosystem-based oceans management", "marine spatial planning") is central. All the Arctic nations are included in this group of countries.

In Norway, the growing interest in petroleum development in the North, together with the evolution in international standards for oceans management and concern for the valuable fisheries resources in the North, triggered work on Integrated Oceans Management. In 2001, the Norwegian Storting adopted a white paper setting out the broad principles. In 2008 a new Ocean Resources Act was adopted, transforming these principles into law.

The adoption of the white paper spurred a comprehensive process in developing what came to be called the Management Plan for the Barents Sea, which also concerns parts of the Norwegian Sea and the coast of Northern Norway southwards to the Lofoten Islands. The work was overseen by an inter-ministerial committee with representatives from the relevant ministries, and the final plan was adopted by the Storting in 2006. Since then a second management plan has been adopted for the Norwegian Sea, and a third plan for the North Sea is in the works.

The key feature of the Barents Sea Plan is that it identifies areas of particular biological significance ("vulnerable and valuable areas"), assesses the total impact of various activities and pressures on the marine ecosystems, and on this basis decides where and when petroleum activities can take place. The map shows the areas where petroleum activity is regulated.

The plan will be revised in 2011 based on the original knowledge foundation complemented with new information obtained from monitoring of important parameters and a comprehensive assessment of how various pressures might potentially affect the marine environment. The key issue is whether new areas are to be opened for petroleum-related activities.

What, then, are the lessons of the Norwegian experience for the wider Arctic when it comes to Integrated Oceans Management?

The Barents Sea is one of the areas in the Arctic that has been most widely researched. The work on the plan therefore benefitted from the existence of a major body of science, although it was also evident that new data were needed for the integrated assessments of impact. The central role of science in the plan is obviously a core element of its success.

A second element is that the process of formulating the plan was organised in a way that gave the outcome a high degree of political legitimacy. For example, stakeholders were given opportunities to comment on the plan. The fact that the plan was adopted by the Storting bolstered its prominence and lent authority to its implementation.

Third, the actual implementation of the plan made use of pre-existing institutional structures. The only new bodies established serve the purpose of coordination and integration at ministerial and agency levels. The use of existing legislation and agencies, rather than going through a time-consuming process of establishing new ones, has provided for swift and effective implementation of the plan.

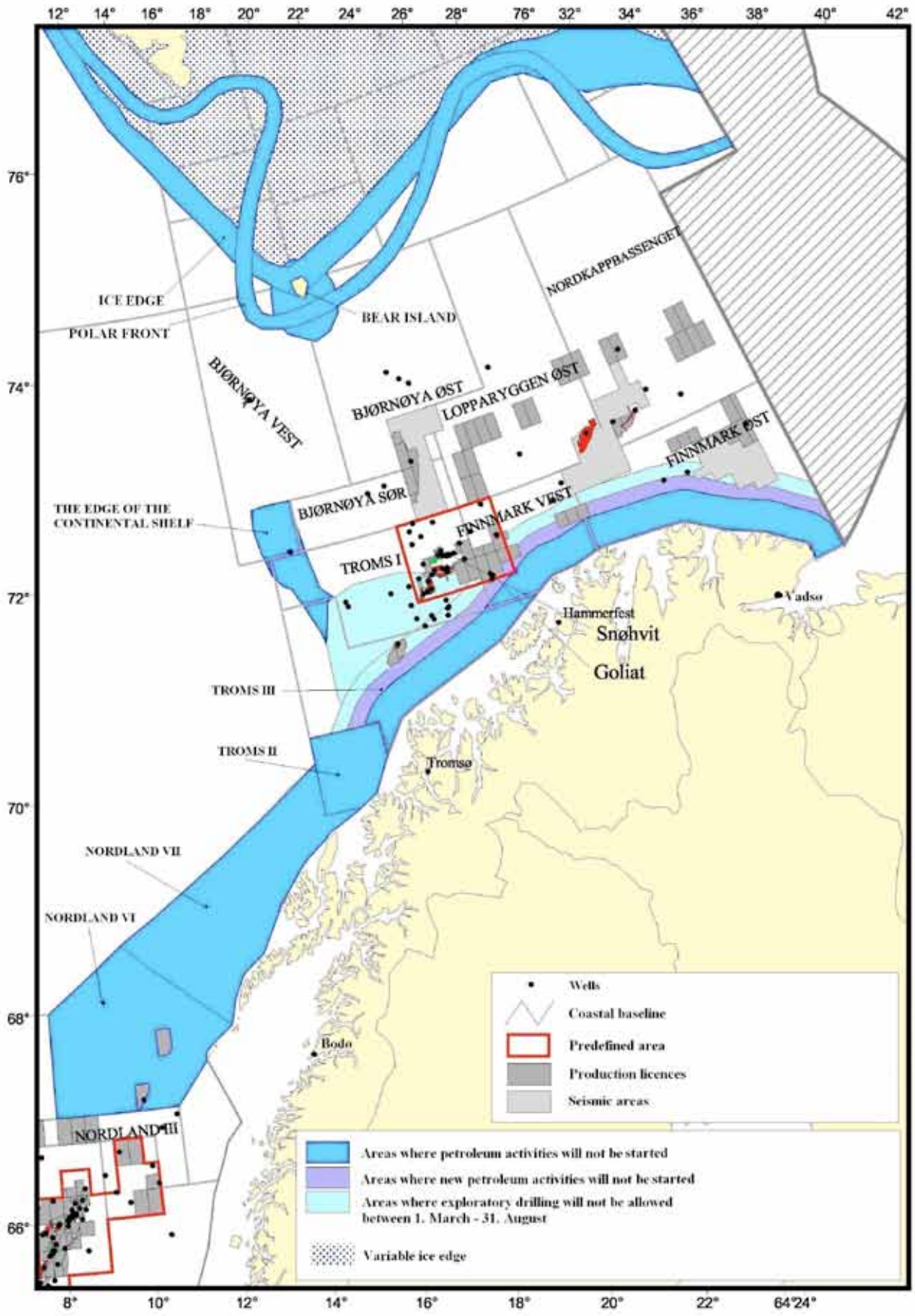
The Management Plan for the Barents Sea is however still a work in progress. As the scientific underpinnings of the plan evolve, so will the plan itself. Work on the plan is also likely to be affected by changing economic political circumstances.

The degree to which these experiences are applicable in other Arctic countries varies. The form and content of Integrated Oceans Management is context-dependent and will vary from case to case. However, Integrated Oceans Management raises a number of issues with commonalities across the Arctic region: ice-covered waters, transboundary cooperation, fisheries management, exploitation of petroleum under severe climatic conditions, long-range transport of pollutants, socioeconomic growth and sustainability issues, and the impacts of climate change. The core issue is however the same: the need to take all pressures on marine ecosystems into account when managing oceans.

Further reading:

Hoel AH (ed.) 2009. Best Practices in Ecosystem-based Oceans Management. *Rapportserie Norsk Polarinstitutt,* No. 129

Hoel AH 2010. Integrated oceans management in the Arctic: Norway and beyond. *Arctic Review of Law and Politics*, Vol. 1, No. 2, pp 186-206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THE EDGE OF THE CONTINENTAL SHELF
TROMS I
Hammerfest
Snøhvit
Goliat
Vadsø
TROMS III
TROMS II
Tromsø
NORDLAND VII
NORDLAND VI
Bodø
NORDLAND III
Wells
Coastal baseline
Predefined area
Production licences
Seismic areas
Areas where petroleum activities will not be started
Areas where new petroleum activities will not be started
Areas where exploratory drilling will not be allowed between 1. March - 31. August
Variable ice edge

Svalbard reindeer enjoying the round-the-clock daylight of the arctic spring. Photo: Thor S. Larsen, Norwegian Polar Institute

Biological timing in the Arctic

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Reindeer living in the land of the midnight sun have turned off their biological clock.

The ability to display daily or circadian rhythms is a fundamental feature of living things. It prepares the organism for changes related to the day/night cycle, and long lived organisms also prepare for predictable seasonal changes in their environment. Such biological timing results from the actions of specific "clock" genes. It involves an intimate interplay between endogenous, self sustained oscillators or clocks and the ambient light/dark cycle which synchronises the clocks such that the right things happen at the right time.

Thus, biological timing relies intimately on the daily light/dark cycle. But what happens when there is no night or day, such as during the arctic summer and winter, respectively?

Several studies suggest that reindeer lack a functional biological clock. In a study of free-ranging Svalbard and mainland Norwegian reindeer we equipped the animals with data-loggers which recorded movements continuously for one year.* The results revealed no obvious signs of endogenous, circadian activity rhythm at any time of the year. This was the case both during permanent darkness in winter, when such endogenous rhythmicity is expected to occur, and around the spring and autumn equinoxes when, despite pronounced changes in ambient light levels, only weak and intermittent anticipation of dusk and dawn was detected.

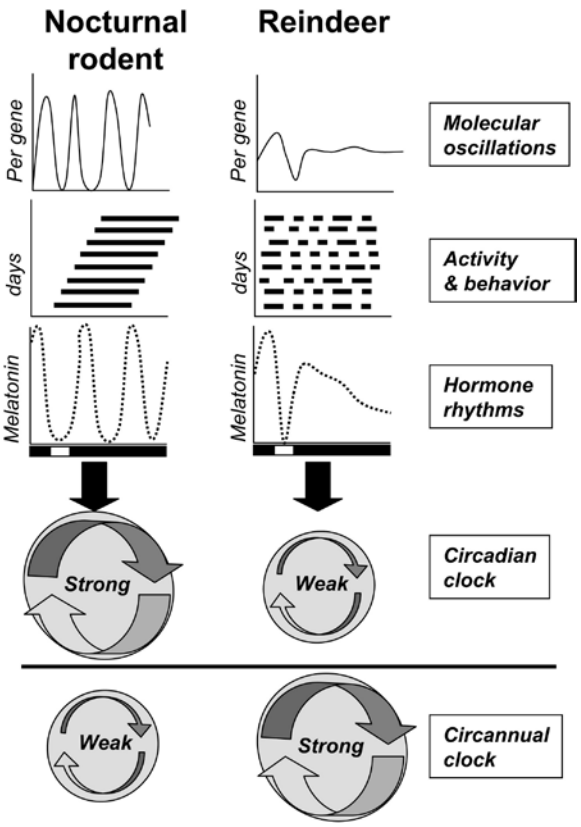
Recently, a collaborative study between the University of Tromsø and the University of Manchester, UK, revealed that in mainland reindeer, the nocturnally secreted pineal hormone melatonin is not rhythmically regulated in the dark, but responds directly to the light/dark cycle. This hormone is critical for daily and seasonal timing in mammals and is regarded as the physiological link to the ambient light/dark cycle. The finding is in complete contrast to other mammals where melatonin is always rhythmic; it is generally synchronized by a biological clock such that in permanent darkness, levels continue to rise and fall rhythmically. Unusually, melatonin secretion in reindeer appears to be controlled by a mechanism that is described as an "hour-glass". This means that the secretion increases once it gets dark and decreases when it gets light, titrating night-length directly rather than being driven by a clock.

We then tested if the basic, molecular clockwork of the reindeer cell is in some way defective. Fibroblast cells were collected from reindeer skin and cultured in the laboratory. Previous studies have shown that fibroblast cells from mice, man and other mammals maintain strong circadian rhythms in culture. The reindeer cells were then treated with a lentivirus which had been engineered to insert clock gene reporters into fibroblasts. The reporter gene was one which codes for a luciferase enzyme, similar to that which makes fireflies glow.

Thus, whenever the clock genes were active the reporter gene was also activated and light was emitted. The daily rhythms of clock gene activity could therefore be tracked in these cells using sensitive photon counting methods. Remarkably, the cells were arrhythmic. In marked contrast, when these reporters were introduced into mouse fibroblast cells, the outcome was highly rhythmic.

Our conclusion is that the behavioural arrhythmicity seen in the wild, as well as the lack of rhythmic melatonin hormone secretion, may be a consequence of defective molecular clockwork in reindeer. Perhaps in environments with no discernable light/dark cycle, such as during summer and winter at high latitudes, driven internal clocks would be strongly selected against, as they might prevent opportunism in such habitats.

This work was done in collaboration with Nicholas Tyler, Centre for Sámi Studies, University of Tromsø, and Andrew Loudon, Faculty of Life Sciences, University of Manchester, United Kingdom.



Schematic model for daily and seasonal timing. Short-lived rodents have strong clock-genes and activity and hormone rhythms are robustly circadian under constant conditions. Seasonal rodents have no spontaneous reproductive rhythms. Reindeer have weak clock genes and no free-running activity cycles under constant photic conditions. Melatonin is acutely responsive to photoperiod and not regulated by a circadian clock. Long-lived seasonal mammals have robust circannual cycles, which, in reindeer, may be entrained by a short period of melatonin information provided at the two equinoxes (Lu et al. 2010, *Curr. Biol*. 20, 533).

*van Oort et al. 2005. Circadian organization in reindeer. *Nature,* 438, 1095.

Little auk - abundant but elusive

ALKEKONGE- a joint Polish/Norwegian research project to study this seabird

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Little auk (*Alle alle*) is the most abundant seabird in the northern hemisphere. The global population is probably in the range of 15 million pairs, of which 1 million pairs nest in 200 breeding colonies in Svalbard. This small alcid species is easily recognised by its black and white plumage, compact body shape and short bill. However, it is rather elusive, since it nests in rocky slopes and will fly great distances to unknown feeding locations where arctic zooplankton is abundant and where the little auk is somehow capable of finding large *Calanus* copepods.

This seabird is known as a specialised planktivore. Its preferred prey is copepods of the genus *Calanus*, which the birds catch, likely individually, during dives to depths of maximum 30 metres. On as single trip, they may collect on average 1000-2000 prey in their gular pouches. *Calanus glacialis* is typically the most abundant species in a catch, along with the largest copepodoid stages of *C. finmarchicus*. It is difficult to imagine how this foraging is conducted. It is difficult to imagine how this foraging is conducted. How

Little auk (*Alle alle*), the most abundant seabird in Svalbard. Photo: Tonje Jerstad

Studying little auk on site in seabird colonies. Tonje Jerstad is holding a fledged chick.
Photo: Kurt Jerstad

do the birds locate patches of prey? How can they select only the largest stages of *Calanus finmarchicus*, and how is it possible to collect that many zooplankters on a single feeding trip?

Specific zooplankton species are typically associated with different water masses, such as Arctic or Atlantic waters. *Calanus glacialis* is a typical Arctic shelf species, whereas the much smaller *C. finmarchicus* is advected to the regions of Svalbard in Atlantic water masses, following the West Spitsbergen Current. The larger *C. glacialis* is a much more valuable food item than *C. finmarchicus*, since it contains ten times the energy. *Calanus* species accumulate lipids seasonally as triacylglycerol and wax esters in lipid sacs, which may be completely filled up by the autumn.

Climate change in the Arctic influences ocean circulation and water masses, which will consequently lead to restructuring of zooplankton communities between cold Arctic waters, with a dominance of large zooplankton species, and Atlantic waters in which smaller species predominate. Little auks tend to restrict their foraging activity to Arctic water masses, where zooplankton are concentrated in patches that are related to oceanographic features, such as fronts, gyres and upwelling areas. Oceanographers may not know very much about the distribution and extent of such patches, but the little auk consistently succeeds in finding them. How long will it continue to be successful? A shift towards a zooplankton community dominated by smaller boreal species is proposed to lead to a reduction in available feeding grounds and reduced population size for little auk .

Recent research has shown that these birds carry out short and long feeding trips. The short trips (2-3 hours) are to the fjord areas next to the colony, whereas the long trips may be 10-19 hours in duration as some individuals (e.g., in Kongsfjorden) may fly more than 200 km to feeding grounds outside the fjord. From the northwest corner of Svalbard, where the largest breeding colonies are located, little auks could potentially fly to the ice edge or to the East Greenland current on the west side of Fram Strait. Loggers attached to the little auk have shown that they generally feed in cold sub-zero waters on long trips. The colonies located near the warmest water masses have the longest feeding trip duration, indicating that they need to fly long distances to find rich patches of arctic zooplankton. Feeding birds on the water have been registered and counted in different areas during ship cruises, but where the birds from specific colonies feed is still unknown. Miniature GPS loggers have been used in an attempt to resolve this question, but the technology is still inadequate.

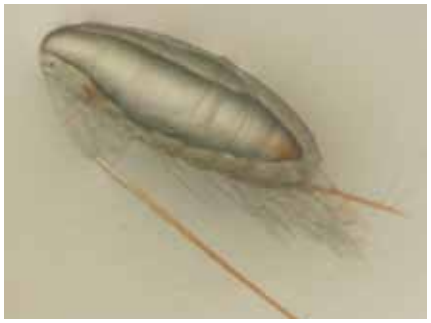
Large amounts of organic matter and nutrients are transported from sea to land by these numerous seabirds. Great colonies of little auks have a substantial impact on arctic terrestrial ecosystems, which are often nutrient-limited. Seabirds that feed at sea and nest on land enrich the tundra ecosystems in the vicinity of their breeding colonies, as can be clearly seen from the green patches below active seabird colonies in Svalbard. This fertilising effect has been studied by means of stable isotopes.

The ALKEKONGE-project (2008-2010) was initiated to find out more about this commonly observed, but little known seabird. A jointly funded Polish-Norwegian Research Project (EEA and Norway Grants) to study the little auk has involved collaboration between the Institute of Oceanology (IOPAS) and the University of Gdansk in Poland, the Norwegian Polar Institute (NPI), and the University Centre in Svalbard (UNIS). Principal investigators from Norway have been Haakon Hop, Arild Sundfjord and Harald Steen (NPI), Jørgen Berge (UNIS), and Ph.D. student Johanna Hovinen. The project has been carried out in fjords

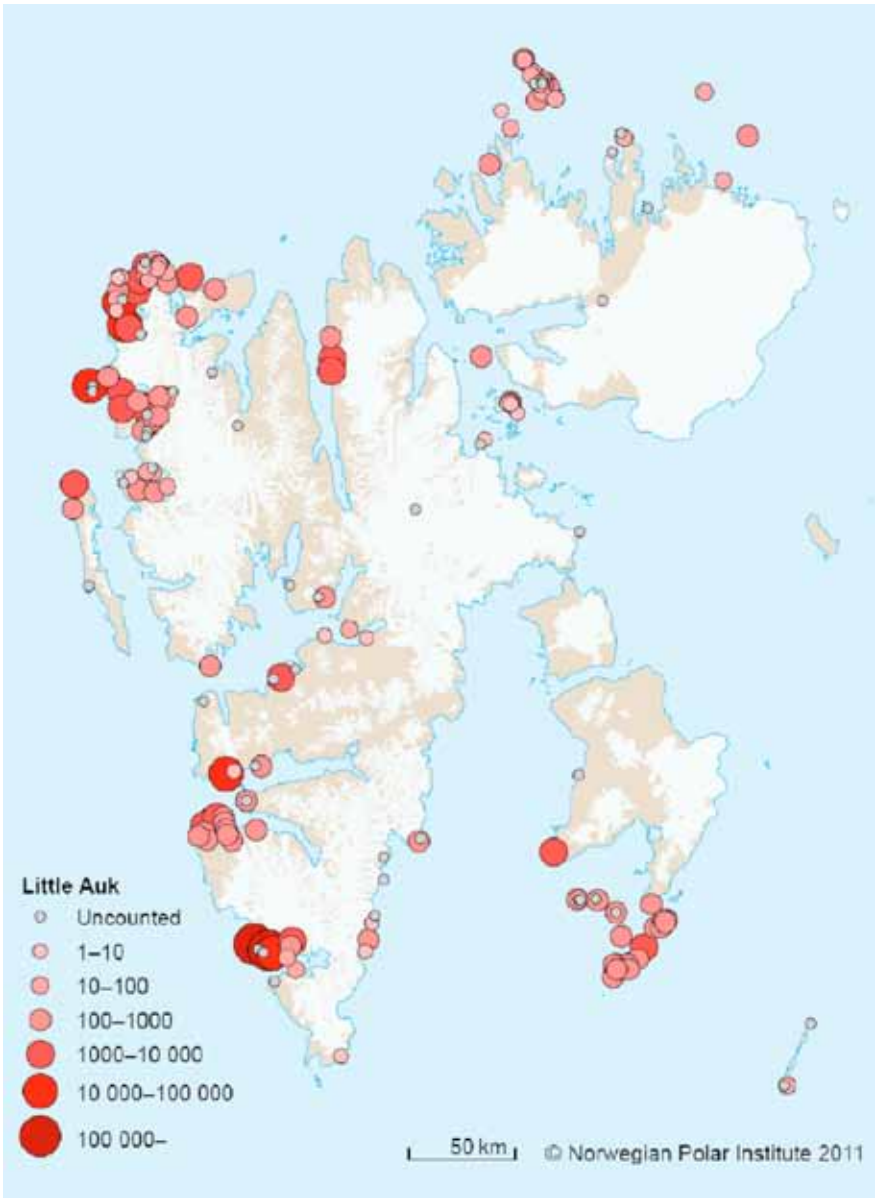
(Hornsund, Isfjorden, Kongsfjorden, Magdalenefjorden, and Smeerenburgfjorden) and coastal waters in Svalbard and along the ice edge in Fram Strait.

The main objective of the ALKEKONGE project has been to estimate the impact of climate warming on arctic zooplankton communities, little auks and their physical environment. The project is expected to improve the knowledge on relationship between physical oceanography, bio-optical parameters, plankton communities and little auk populations in the study areas. Research cruises with *RV Lance* (NPI), *Viking Explorer* (UNIS) and *Oceania* (IOPAS) were conducted during July (2009, 2010) to fjords and coastal areas of Svalbard, and field campaigns were conducted in little auk colonies. The project is currently assembling data for publication.

For further information see the ALKEKONGE web page (www.iopan.gda.pl/projects/Alkekonge) or contact the author for a project brochure (Haakon.Hop@npolar.no).



Fat *Calanus glacialis* with full lipid sac, a favourite food for the little auk.
Photo: Daniel Vogedes



Distribution of the little auk in Svalbard. Map: Anders Skoglund, Norwegian Polar Institute

Fram Centre

The Fram Centre

"The Fram Centre, as it's going to be called, will be among the world's major research centres in the fields of climate and the environment."

This was the wording in Norway's leading newspaper, Aftenposten, when Prime Minister Jens Stoltenberg opened FRAM – the High North Research Centre for Climate and the Environment.

29 September 2010 was a red-letter day for Norwegian High North research. A quintet with considerable political clout demonstrated by their presence that they consider the establishment of the Fram Centre as an important factor in the government's High North Strategy, part 2: "New building blocks in the North".

Participating during the two opening days of the Fram Centre were, besides Prime Minister Stoltenberg, Minister of Education Kristin Halvorsen, Minister of Local Government and Regional Development Liv Signe Navarsete, Minister of Fisheries and Coastal Affairs Lisbeth Berg-Hansen and Minister of Research and Higher Education Tora Aasland.

The opening of the Fram Centre 29 September 2010. From the right: Prime Minister Jens Stoltenberg; Director of the Norwegian Polar Institute, Jan-Gunnar Winther; Project leader Ministry of the Environment, Inger Johanne Wiese; Managing director Polar Environmental Centre/Fram Centre, Are Johnsen; Chairman of the board Polar Environmental Centre/Fram Centre, Aase Tveito; Vice mayor of Tromsø, Gunnhild Johansen. Photo: Ingun A. Mæhlum/Fram Centre

"The Fram Centre is a new building block in the High North Strategy. Several hundreds of scientists, each of them among the world's foremost in their respective fields, will here be gathered under one roof. This is going to be a centre of vigour, a key institution for climate research," said Stoltenberg.

That this is not just lip service was made clear when the suggested state budget for 2011 was presented in early October. The Ministry of Environment allocates NOK 37 million (approx. EUR 4.7 million) to the Fram Centre. Counting allocations from three other ministries, the total appropriation for the centre amounts to close to NOK 50 million (approx. EUR 6.3 million) for 2011, as opposed to NOK 7 million in 2009.

Climate change will constitute the framework for the research activities at the Fram Centre and this framework will be built around five "Flagship" research programmes.

- **Sea ice in the Arctic Ocean, technology and agreements**

Melting of sea ice in the Arctic greatly impacts the global climate. This flagship focuses on social and management challenges to fisheries, shipping and petroleum-related activities. New challenges and technological solutions pertaining to rescue and oil spill response are addressed.

- **Effects of climate change on sea and coastal ecology in the north**

Research in this programme will address the multiple ways climate change impacts the physical conditions of fjords and coasts and how, in turn, habitats and food supply are affected.

- **Ocean acidification and ecosystem effects in Northern waters**

This flagship programme will contribute to a more complete understanding of ocean acidification. This process will affect the productivity of ecosystems, impacting ecosystem-based management and the exploitation of commercial resources, especially in the cold waters of the North, where the uptake of CO_2 is substantial.

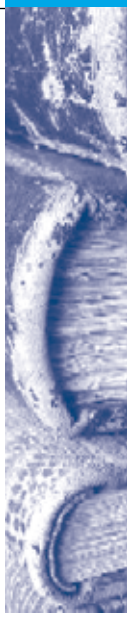
- **Effects of climate change on terrestrial ecosystems, landscapes, society and indigenous peoples**

Changes in Northern terrestrial ecosystems will be highly relevant to society, in particular for agriculture, forestry, reindeer herding and nature-based industries, species and habitat conservation, tourism and recreation. Issues related to climate adaptation in the North, as well the significance of climate change for Sámi culture and settlement will be included this flagship.

- **Hazardous substances – effects on ecosystems and human health**

Climate change reinforces the importance of filling the gaps in our understanding of the distribution of pollutants in the Arctic and their effects on ecosystems and human health. This flagship programme also addresses the need for this knowledge to be incorporated in international agreements and processes.

The Fram Centre includes around 500 scientists in nineteen institutions, who



are involved in multidisciplinary research embracing the fields of natural science, technology and social sciences. As of today, ten of the nineteen institutions are located in the Fram Centre building (formerly the Polar Environmental Centre), but more will move in when the planned enlargement of the building is completed in 2014. The Fram Centre will then employ a total of 500 employees (presently, the centre counts about 300 employees) in a building with a floor space exceeding 23 000 square meters. In addition, the Fram Centre has members whose main activities will be located elsewhere, for instance the Norwegian Institute of Food, Fisheries and Aquaculture Research, NORUT, and the University of Tromsø.

The Fram Centre secretariat coordinates research and communication on research activities, besides organising the day-to-day running of the centre as a whole. The Fram Centre's co-operative body consists of a joint centre meeting where the leaders of the nineteen member institutions have voting rights and elect a centre leader. Joint research programmes are led by a research management group elected by the centre meeting.

Fram Centre members
Akvaplan-niva – Norwegian Institute for Water Research
CICERO Centre for International Climate Environmental Research Oslo
Institute of Marine Research
National Coastal Administration
National Veterinary Institute
NGU – The Geological Survey of Norway
Nofima – The Norwegian Institute of Food, Fisheries and Aquaculture Research
NORUT – Northern Research Institute
Norwegian Institute for Air Research – NILU
Norwegian Institute for Nature Research – NINA
Norwegian Institute for Agricultural and Environmental Research
Norwegian Institute for Cultural Heritage Research – NIKU
Norwegian Mapping Authority
Norwegian Polar Institute
Norwegian Radiation Protection Authority
Norwegian School of Veterinary Science
SINTEF Group
University of Tromsø
UNIS – The University Centre in Svalbard
Associated member: Polaria

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The Nansen–Amundsen Year

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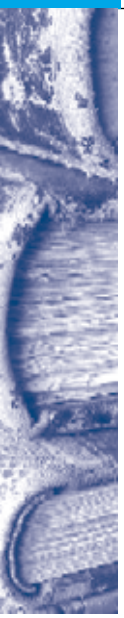
This year Norway is celebrating two of its greatest heroes, the polar explorers Nansen and Amundsen. On the 10th of October it will be 150 years since Fridtjof Nansen's birth and the 14th of December marks the hundredth anniversary of Roald Amundsen's arrival at the South Pole. What have these two strong personalities meant for the polar nation of Norway?

When Fridtjof Nansen traversed Greenland on skis in 1888, it changed Norway. The notion that Norwegians could participate in international efforts to chart the Arctic had not previously crossed many people's minds. After the traverse, it was suddenly self-evident that the nation should mount polar expeditions and over the next few decades Norway contributed with major research expeditions both north and south.

Nansen and Amundsen loom as two of the greatest polar explorers of all time. Nansen because he was a clever innovator and a brilliant scientist. It was with Nansen's expedition to Greenland that skis were first established as a means of transport in polar regions. The *Fram* Expedition of 1893-1896 will always stand as a triumph of ingenuity: Nansen commissioned the construction of a ship that would withstand being frozen into the ice, thus enabling him to test a scientific hypothesis by floating with the ocean currents through the unknown

Fridtjof Nansen in 1903.
All photos © Norwegian Polar Institute



Arctic. When Nansen came back from the Arctic Sea he brought the world new understanding of these regions. The work he did later in his scientific career helped lay the foundation for modern physical oceanography and climate research.

No one set more polar records than Roald Amundsen. He was first to sail the entire Northwest Passage (1903-1906), and first to stand on the South Pole (1911). In addition, he sailed the Northeast Passage (1918-1920) and flew over the North Pole with the airship *Norge* in 1926. Amundsen was exceptionally skilled in planning and logistics, and the expedition to the South Pole was a triumph of polar efficiency. In many ways it was the perfected version of the techniques Nansen's expedition had introduced – dog teams, skis and sleds – that won the race to the South Pole.

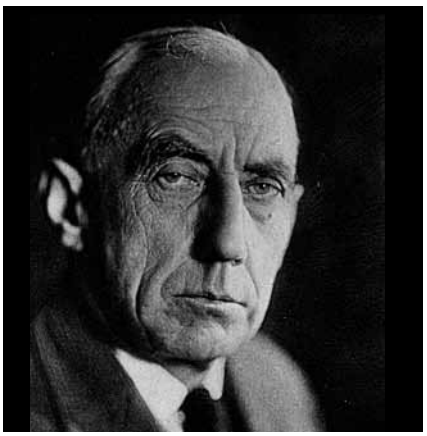
Unlike Nansen, Amundsen was not a scientist; but studying the world's newly discovered regions required a wide range of skills. According to Nansen, it was impossible to persuade Amundsen to be "inclined to participate in the interpretation of the results [...] Nevertheless, his expeditions have yielded scientific advances of high standard, and have broadened knowledge about our Earth." In fact, Amundsen became an important component of Nansen's scientific program and his expeditions were an important contributing factor in the development of geophysics in Norway.

Nansen and Amundsen left deep imprints in history. When Nansen returned home with *Fram* in 1896, he was received like the Viking King personified. He became a central figure in the evolution of Norwegian identity and culture in the years leading up to the dissolution of Norway's union with Sweden in 1905. Nansen expressed strong political opinions that could rouse and unite the people, though he was also sometimes perceived as controversial. His international status and humanitarian efforts have given him a special role in the nation's history. This is probably what he is most famous for today. In Amundsen's case, contemporary society both admired him and argued about him, and since his death the successful polar explorer has often been the subject of discussion. Nonetheless, he has undoubtedly played an important role in Norwegian self-knowledge and construction of the Norwegian identity.

The Nansen–Amundsen Year is an opportunity to highlight what these two giants have meant in terms of knowledge about the planet we live on, scientific insight, polar knowhow, and our perception of Norway as a polar nation. Above all, this year prompts us to reflect on the question: What have Nansen and Amundsen meant for what it means to be a Norwegian?

Fram in the ice in 1893. Expedition member Hendrik Blessing in search of algae.

Amundsen at the South Pole 1911.



Roald Amundsen. Portrait by Vang Studio Photo, Andersen Lamb Corp. Brooklyn, N. Y.

Norwegian – Chinese polar research agreement

In September, Norway and China entered into a new partnership in polar research. The agreement was signed by the respective directors of the Polar Research Institute of China and the Norwegian Polar Institute in conjunction with the World EXPO 2010 in Shanghai. In the agreement, the parties agree to promote and develop common research projects.

The Norwegian delegation was headed by Tora Aasland, Minister of Research and Higher Education, who said, "The international interest in the polar regions is growing, not least as a result of the increased interest in climate issues. Research is essential both in understanding the causes of climate change and its effects, and in finding solutions. Since climate change is a challenge which must be seen in a global perspective, international research cooperation is vital to ensure the best possible knowledge base. In this respect, we are pleased to see China's increasing interest in and commitment to Arctic issues, not least Arctic research."

China is already well established in some "Norwegian" research venues, notably the research village of Ny-Ålesund in Svalbard, where the Chinese Arctic and Antarctic Administration opened their own research station in 2004.

Director of the Norwegian Polar Institute Jan-Gunnar Winther commented, "The Chinese are strongly committed to polar research and contribute advanced instruments, laboratories, climate models and – not least – sharp minds."

Norway has much to gain through collaboration with the top scientists of this huge nation. Joint projects will facilitate understanding and foster communication.

Priorities for the years 2010-2015 include glaciology, sea ice (both physicochemical processes and ecosystems in the ice), paleoclimate research and the "Kongsfjorden system" a flagship program in Ny-Ålesund.

Youthful enthusiasm

APECS, the Association of Polar Early Career Scientists, is an international and interdisciplinary organisation for undergraduate and graduate students, postdoctoral researchers, junior faculty members, educators and others interested in the Polar Regions. While the 2000 plus APECS members are spread around the world in over 50 different countries, the directorate is based at the University of Tromsø, hosted by the University, the Research Council of Norway, and the Norwegian Polar Institute. This year APECS coordinated the young researcher activities for the largest polar science meeting ever, the International Polar Year Oslo Science Conference. More than 550 young researchers participated in various activities at the conference with over 400 receiving financial assistance from the Research Council of Norway and partnering organisations. In addition to in-person events, APECS is also at the forefront of using new technology to bring together early career and senior scientists, promote scientific collaborations and education and outreach. Using online platforms APECS hosts virtual poster sessions, webinars, and meetings which have become a very popular among both young researchers and established scientists on the research forefront all around the globe. For more information, visit http://apecs.is

CryoSat launched

Ice responds rapidly to changes in the Earth's climate. When global average temperatures rise, the ice melts. But ice is not just a passive target of climate change; it also plays an important role in the climate cycle. Small changes in ice extent and thickness may have far-reaching implications for climate and sea level. Studying these interconnections requires detailed knowledge about changes in ice on land and sea.

Satellites have been used to study ice for many years now, and although they provide huge amounts of valuable information, they also have frustrating limitations: it has been

Photo: Francisco Fernandoy

difficult to measure the thickness of moving ice, such as glaciers, and certain weather conditions preclude ice monitoring.

Therefore the scientific community rejoiced at the successful launch of the European Space Agency's Earth Explorer CryoSat, a satellite specifically designed to monitor the frozen parts of our globe. This satellite carries highly advanced equipment, including a microwave- and radar-based altimeter that can see through cloud cover. With the help of CryoSat, researchers can detect changes as small as one centimetre in the thickness of floating sea ice and the ice sheets covering Greenland and Antarctica. The satellite's technology also allows scientists to focus on specific areas of interest, for example the edge of an ice sheet or the front of a glacier.

Precise data will help researchers – including those affiliated with the Norwegian Polar Institute's ICE Centre – understand the complex interplay between ice and climate.

www.esa.int/esaLP/LPcryosat.html

Arctic Frontiers

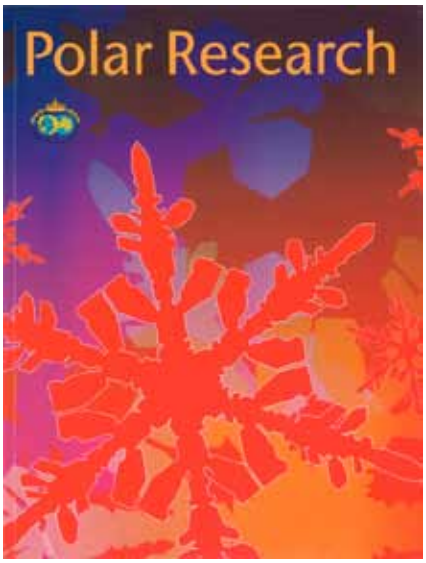
The Arctic Frontiers conference is an annual event held at the University of Tromsø, coordinated by Akvaplan Niva, with support from a wide range of stakeholders in the Arctic nations and the European Union. The 2010 conference had the theme "Living in the High North".

This year, the Policy section had sessions entitled "Changes in strategies for the Arctic" and "Sustainable communities in the Arctic". Speakers included ambassadors and high-ranking politicians from several Arctic nations alongside representatives for commercial, conservation, and research interests. This part of the conference was broadcast live over the Internet. The Science section was subdivided into four main themes: Ice and climate, Sustainable communities in the High North, Marine biodiversity under change, and Frontiers in E-learning. This section included 153 lectures and 70 poster presentations.

All in all, over 750 people from 26 nations participated in the week-long event.

Most of the presentations from this and other Arctic Frontiers conferences can be downloaded from the Arctic Frontiers website

www.arcticfrontiers.com



Polar Research moves to open access

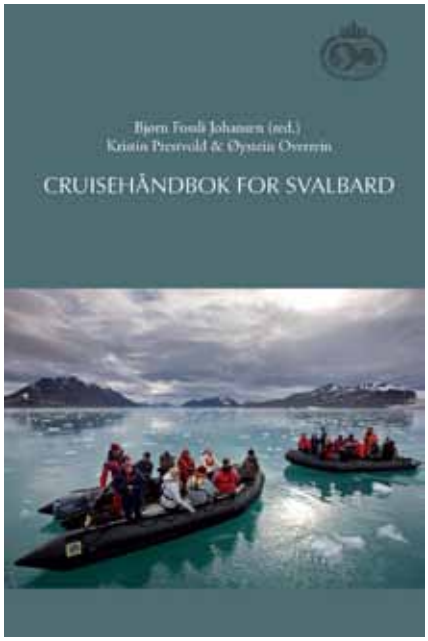
Since 1982, the Norwegian Polar Institute's international peer-reviewed journal *Polar Research* has "promote[d] the exchange of scientific knowledge about the Arctic and Antarctic across disciplinary boundaries". On 1 January 2011, *Polar Research* became an open-access journal. This means that the entire content of the journal will be accessible free of charge to anyone with internet access. Authors will not be required to pay for publication, and since the journal will be published under a Creative Commons license, authors will retain the right to use their own work for non-commercial purposes.

"This is a bold leap forward for us," says Chief Editor Helle Goldman. "As an open-access journal *Polar Research* will be immediately and freely accessible to readers around the globe that are connected to the Internet."

The journal will be available exclusively online. This has two major advantages: it saves paper, making *Polar Research* a "green" journal; and since accepted articles will be posted online as soon as the proofs have been approved, articles will reach the readers more quickly.

"This is a very favourable development for contributors and readers alike," adds Goldman, "and I look forward to seeing how the change will help us better serve the polar scientific community."

www.polarresearch.net



Svalbard facts

For several years, the Norwegian Polar Institute's Cruise Handbook for Svalbard has been accessible at http://cruise-handbook.npolar.no/en. This resource provides valuable information about Svalbard's geological history, vegetation and wildlife, cultural heritage and much more. The Norwegian version of the Handbook has now been published, giving Norwegian-speaking readers a handy fact-filled reference book small enough to take along in the field.

Order at sales@npolar.no (249 NOK)

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PhD

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Effects of environmental factors on migratory behaviour of northern Atlantic salmon

Margit Elisabet Dyrland
Multi-instrument studies of polar mesopause region temperature and airglow variability.

Andreia Plaza Faverola
Characterization of sub-seabed fluid flow and hydrate systems at Nyegga, offshore mid-Norway: Integration of seismic imaging and velocity modelling

Jan Magne Gjerde
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Rock Art and Landscapes. Studies of Stone Age rock art from Northern Fennoscandia

Ingeborg Gammelsæter Hallanger
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Influence of climate on accumulation of contaminants in Arctic marine pelagic food webs. (joint supervision with the Norwegian Polar Institute and NIVA)

Ingvild Ulrikke Jakobsen
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Marine Protected Areas in International Law: A Norwegian Perspective

Roger Jørgensen
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Siw Turid Killengreen
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Sources of spatial variation in food web structure in low Arctic tundra. (Joint supervision with the Norwegian Polar Institute)

Magnhild Elisabeth Gangsøy Kristiansen
The epidemiological, clinical and immunological spectra of chronic hepatitis C (HCV) infection in Northern Norway

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Neuronal hypoxia tolerance in diving endotherms.

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Regional labor mobility

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Borealisme og kulturnasjonalisme. Bilder av nord i norsk og russisk folkeminnegransking 1830-1920

Jasmine Magali Nahrgang
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The Sámi People's Right to Self-determination

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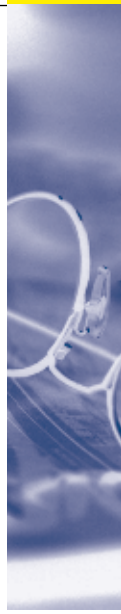
The Saami Traditional Dress & and Beauty Pageants: Indigenous Peoples' Rights of Ownership and Self-Determination over Their Cultures



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