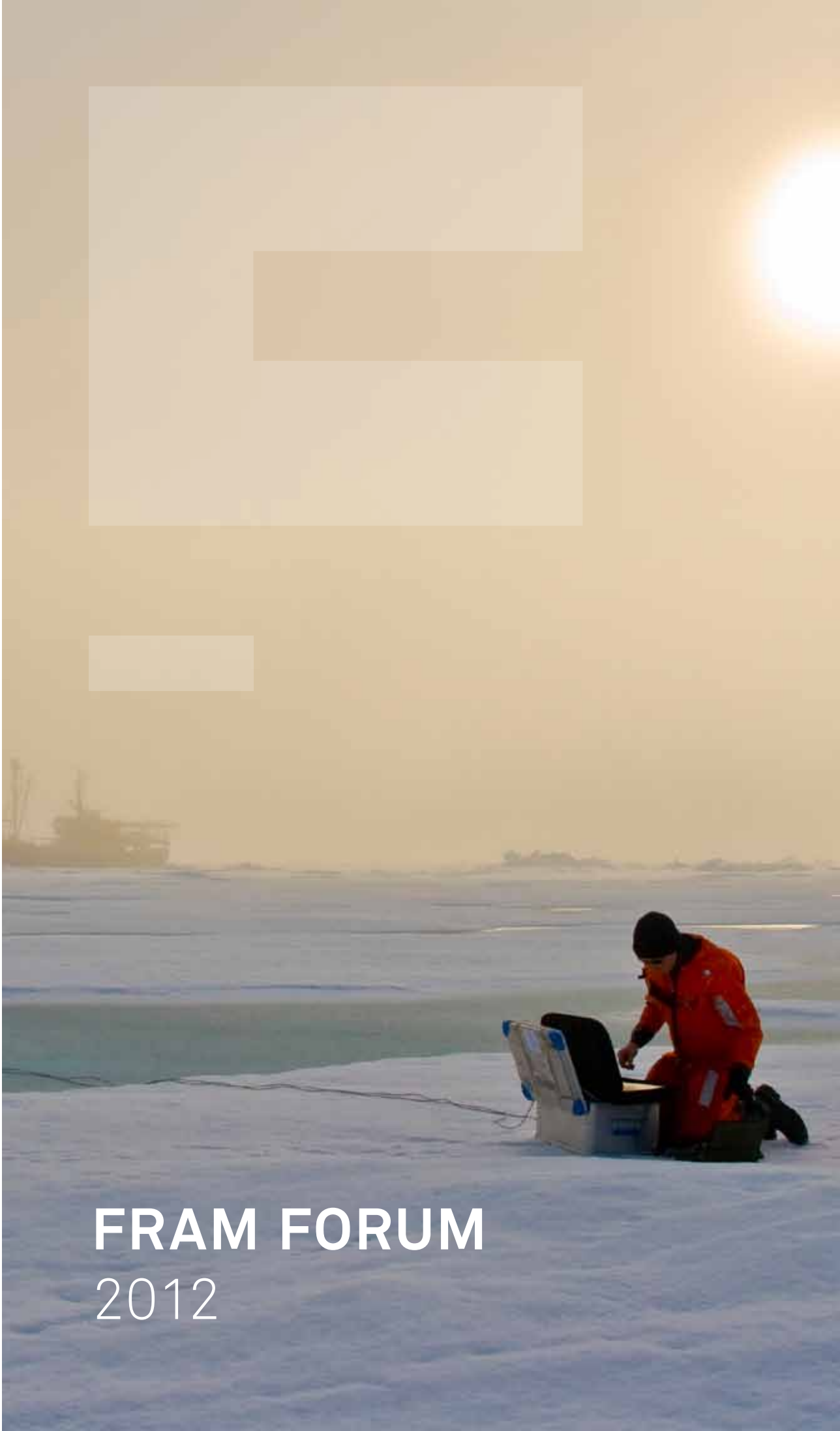
FRAM CENTRE



FRAM FORUM
2012

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FRAM Forum is published once a year on behalf of FRAM – the High North Research Centre for Climate and the Environment. Its aim is to inform the general public about the wide range of activities that take place within the Fram Centre. It is available free of charge to any and all who are interested in topics related to climate, environment, and people in the High North.

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Photo: Harvey Goodwin, Norwegian Polar Institute

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THE FIRST YEAR OF THE FRAM CENTRE

FRAM - the High North Research Centre for Climate and the Environment, was inaugurated at the end of September 2010 and has now been up and running for over a year. In addition to teaching and doing research, the Fram Centre is charged with the task of making research findings accessible to the general public. Outreach is an integral part of our mission and we take it seriously. This journal - FRAM Forum - is an important channel for that outreach. Here, in plain language, we will present highlights from the past year at the Fram Centre.

In compiling this first issue of FRAM Forum, the editors have had a delightful mix of topics from which to choose. But the articles we present here are mainly based on research that was initiated before the Fram Centre was established. They hint at the range of possibilities for the future but are the result of diligent work in the past.

In many ways, the Fram Centre is a reincarnation of the Polar Environmental Centre (POMI). When establishing POMI back in 1998, Norway's Ministry of the Environment gathered expertise on polar environmental issues under one roof, intending this co-localisation of competence to foster multidisciplinary thinking. The researchers at POMI created much new polar knowledge, some of it multidisciplinary; but years passed and somewhere along the way, cross-disciplinary contacts languished.

With the creation of the Fram Centre, multidisciplinary thinking has been revitalised. The Centre's Flagship programmes are designed to encourage collaboration between widely different fields. And at the first meetings to discuss the Flagships, Fram Centre researchers showed enthusiasm, creativity and a sincere wish to bring together different types of competence to resolve important questions about the High North.

The expectations on us are high. Speaking to journalists in December 2011, Norwegian Minister of Foreign Affairs Jonas Gahr Støre said the Government expects the Fram Centre to be "the best", and the results we present "impossible to ignore". To achieve that, over 50 million NOK extra was allocated for the Centre's first year, in addition to the funding to the individual member institutions.

Fifty million Norwegian crowns is a lot of money - but not enough, in itself, to ensure that the Fram Centre does cutting-edge research in all five Flagship areas. This is seed money. It was not given so the Fram Centre can "do research", but so we can *build research momentum*.

The challenge now is to create fruitful multidisciplinary research collaborations that highlight the unique research opportunities the Fram Centre has to offer. If we establish a reputation for being a powerhouse of research creativity and innovation, of educational excellence, where ideas flow freely between disciplines, the Fram Centre can attract even more of the best research talents. Talented researchers produce exciting new research, and exciting research will always find funding - from international as well as Norwegian sources. Once the ball gets rolling, the rest will take care of itself.

Attaining world-class excellence is a lofty goal. It will require years of hard work that transcends disciplinary boundaries, but the Fram Centre has good prospects of becoming "the best". As we move forward, we will naturally pay attention to the path immediately ahead, but we must also remember to lift our eyes frequently and scan the horizon, or we will miss interesting opportunities. In striving for excellence, a narrow perspective is the gravest danger we face.

Janet Holmén, Editor

Erik Solheim // Minister of the Environment and of International Development

Communicating scientific research to the public

Congratulations on the new magazine! FRAM Forum is entirely in accordance with our wishes for a broad communication of scientific research. It is important that the public comes to know about the Fram Centre's activities. That will mean a lot to the understanding of the substantial and global environmental problems that especially impact the Arctic and the High North. This applies particularly to climate change and ecotoxins.

The scientific activity at the newly established Fram Centre is already great, with close cooperation between the natural sciences, technology and the social sciences. I have great expectations on the Fram Centre's ability to create premises for the design of national and international environmental policies through interdisciplinary research.

The production of chemicals is increasing rapidly world-wide, and ever new and harmful substances are discovered in the arctic environment. Ecotoxins are therefore high on the Fram Centre's agenda, and they can already point to an important result. Thanks to research led by Torkjel Sandanger at the centre, the EU's scientific committee is now assessing the content of the substance called parabens in cosmetics. This shows that research at the Fram Centre is at a high level and has clout internationally.

This also shows how crucial it is that research findings are made available to decision-makers and the public alike. Popular science articles in the FRAM Forum will make it possible to increase the understanding for environmental-political decisions. Moreover, it is important to all of us to get to know about behaviour and chemicals that harm us and the environment, so that we can make good choices in our daily lives. If we gain awareness that cosmetics, shampoos and deodorants contain substances that can perturb hormones, we can choose environmentally sound alternatives.

Climate change is perhaps the greatest environmental challenge in the High North and the Arctic. Climate change impacts the flora, the fauna and entire ecosystems. The recent severe birch forest moth attacks on forests in Finnmark county are an example of this. Another example is the tendency of Lofoten-spawning cod to move further north. The coastal population's ways of relating to the ecosystems in the ocean and the indigenous communities' traditional culture have come under pressure. Insight into these phenomena is vital in order to be able to face climate change and develop adaptations and alternatives.

Communicating about and reporting on their research is an activity that is given high priority at the Fram Centre. Results from research on the climate and the environment in the High North is to be communicated to the business communities, the schools, the various management authorities and a wide and varied public, both nationally and internationally. FRAM Forum is important to this strategy.

Sea ice in the Fram Strait
Taken on board the University of Tromsø research vessel *Jan Mayen* in May 2011 during an Arctic Tipping Points cruise.
78°50'43.25"N - 2°50'42.74"E
Photo: rudicaeyers.com - BFE/UIT
Link: http://eu-atp.org

Ole Magnus Rapp

Without the sea, where would we be ...

The world might have missed out on an accomplished violinist. Instead, we got a plain-spoken marine biologist who listens carefully to the hopeful music of small creatures and ocean's pulse.

PAUL WASSMANN has put the weekend and the celebration of his own sixtieth birthday behind him. As usual, he walks the 40-odd minutes to work, and he appears to be practically bubbling with good health.

"Walking gives me time to sort out my thoughts. My head starts off helter-skelter as I go out the door, but it's in reasonable working order when I open the door to my office. Riding a bicycle is not for me. That means paying attention to the bicycle all the time. And I haven't got a car," he explains.

We assumed the professor would have grabbed himself a room with a beautiful view in the nicest building on campus. Instead, we are led through all the stylish parts of what was formerly called the Norwegian College of Fishery Science, and out the back door. Through a narrow path in fresh snow up to what must be one of the university's least imposing buildings, probably erected for temporary use 30 years ago. But Wassmann, his research team and his students like it here. They have named the building "Hyperboreum", the place north of The Hereafter, whence Apollo escaped to think great thoughts, surrounded by eternal summer light, parties and fun.
Rumours of German meticulousness make us turn up on time. Paul Wassmann is also punctual. In the hallway one takes off one's shoes, just like in Svalbard. On campus, we have seen considerably messier offices than this one, and he serves us coffee in charming cups made by his father-in-law.

"He gave us cups to take along on a research mission to the Arctic Ocean. Each participant got a cup with his or her own name painted on it. Now, many years later, it is still a nice memento of a generous man from Kvæfjord," says Paul Wassmann.

Paul Wassmann
Photo: Rudi Caeyers, http://rudicaeyers.com, BFE/UIT

Right
Sea ice: under this beautiful surface, there are fascinating ecosystems to study.
Photo: Rudi Caeyers, www.rudicaeyers.com, BFE/UIT

Left
Wassmann on ice with Carlos Duarte.
Photo: Ole Magnus Rapp

Few have seen more of the ocean than this 60-year-old. And when your name is Wassmann (waterman) it is probably inevitable that you end up doing something ocean-related, even though this particular waterman was born and grew up in inland Germany. It was the term "marine biologist" that set the enthusiastic young boy off. He was about to choose what to study. His parents wanted him to aim for a teaching job at the local Steiner school, and he himself was toying with the idea of focusing on the violin and classical music.

"The term marine biologist blew up a storm of enthusiasm in my brain. Even though I had scarcely ever seen the ocean," he smiles.

And in the midst of all that, as a conscientious objector working in a special village that housed disabled people, he met a young trainee from Norway, Rigmor Moelv, who also inspired a lot of enthusiasm. Young Wassmann turned his eyes to the North, where he knew there had to be a lot of ocean.
Thirty years after he graduated with a degree in Natural Sciences from the University of Bergen, his CV is impressive. What he himself is most proud of, is having guided ten students to PhDs within the many specialist subjects in the field of marine biology. Paul Wassmann is concerned about recruitment, and looks far beyond the nation's borders to build networks and create exciting results.
His first academic interests involved the ocean floor and the complex societies that inhabit the seabed. Or "mud", as the uninitiated would call it. Gradually, Wassmann's focus has risen up through the water column. His research, passion and scientific publications now concern plankton and the ocean's total ecology.

ARCTIC TIPPING POINTS

Arctic Tipping Points is a project close to the professor's heart. With funding from the EU, scientists from several countries have probed into what we might expect from the ocean in the years to come. One finding is that even if higher temperatures lead to increased production, there will not be more food for those who live in and of the ocean. The project has involved several long missions aboard research vessels that have gone as far north as the ice permits. Here, the scientists have become familiar with each other's work and thoughts. Scientists and students have been working day and night with all kinds of samples, and the learning curve has been steep for most of them. Artists from several countries were also invited to come along, as well as media representatives. This has resulted in cartoons, a magnificent book with unique images and a series of articles in newspapers and periodicals. Although Wassmann acknowledges the role of the media, he usually keeps himself in the background. He considers his research more important, and often lets his students take the limelight.

Several times in the course of our conversation, Wassmann digresses and starts talking about his students. He uses words like "promising" and "competent" about those who will soon be ready for their doctorates. If he was young today, he would choose marine biology, but if he had a teenage daughter or son, he would leave the decision to them.

During his latest research mission last spring, Wassmann did something he would gladly recommend to all his colleagues. For years and years, his wife Rigmor has waited patiently at home while Paul was out on research missions: this time he took her along. Eight days on Tromsø University's research vessel R/V *Helmer Hanssen* off Svalbard's west coast and in the Fram Strait gave the experienced psychologist a better understanding of her husband's yearning for the Arctic and the boundless ocean.

"The ocean is important. That's where the future is. And when it comes to energy, the ocean's wind, waves and tides will be tremendously important. And not least for food! In the future, even more of what we eat will come from the ocean, and it is therefore vital that we learn as much as possible about the ocean's ecology and nurture it well," he says.

Wassmann does not try to hide his commitment, and he argues enthusiastically in a strong North-Norwegian dialect. He appreciates order and systems, and revels in terms like "ecosystems".
He also enjoys nature, but without getting hysterical about it. The Moelv/Wassmann family have their home right beside the river in Nordreisa. The neighbours are intrigued by Paul, who avers that nature is pleasant when seen from the terrace, and thinks that the salmon are better off where they are. He is one of the very few Nordreisa residents who are not crazy about salmon fishing.
The neighbours know that Paul knows a lot about salmon biology and behaviour. But he knows at least as much about the history of painting and many "-isms" that are unfamiliar to most people.

"Yes, I'm interested in art, and most of all the art that was created between 1800 and 1950. I often enjoy a quiet moment at a gallery or a museum when I have the opportunity, both in Tromsø and elsewhere in the world," he says.

And he likes people, and the North-Norwegian temperament. Back home in Germany, he was taught to be reserved and unassuming; in Tromsø and Nordreisa he catches himself behaving in a diametrically opposite manner.

"I like spontaneity and open-hearted, plain speaking. In that sense I am more North-Norwegian than German," he says, with a smile.

Wassmann also has great liking for a society virtually free from class differences. He feels comfortable about being observed, but not interfered with. A slightly naïve way of making contact suits him perfectly. Unfortunately, he finds Norwegian research slightly naïve as well, and he *doesn't* like that. Scientific institutions work each on their own, and compete more than they cooperate. He sees a lack of good interdisciplinary networks, and fears that sensational and important results may fail to emerge because of a lack of cooperation.

"Academically, you're only as broad as you can be front-line. Cutting-edge research doesn't come from nowhere, and Norway needs more leading lights to inspire and broaden the base. And we have to look far, far outside the borders," he says.
"And yourself?"
"I'm front-line enough, but will not try to hide that a long-term goal, via the EU's research funds, is to bring others to the research forefront."
"Is the ocean that important?"
"Without the sea, where would we be..."
"And has the world missed out on a promising violinist?"
"That might be just as well. All things considered, ocean ecology is more important. Anyway, the violin is still at home waiting for me if the day should ever come when science no longer needs me. I hope that will not happen."

Mats Björkman taking samples to assess the inventory of nitrogen in the snow.
Photo: Anna-Lisa Wrange

Rafael Kühnel, Mats Björkman // Norwegian Polar Institute

Nitrogen deposition in the Arctic

MOST OF THE EARTH'S ATMOSPHERE, 78%, consists of nitrogen in its molecular form N_2, which is quite stable and unreactive. But some of this stable nitrogen can be transformed to reactive nitrogen oxides (NO_x) and ammonia (NH_3). In the modern industrialised world, reactive nitrogen is mainly released to the atmosphere from combustion engines, during production of energy and fertilizer, and cultivation of legumes and other crops. In the atmosphere, nitrogen oxides can undergo a series of reactions to finally form nitric acid (HNO_3). Nitric acid dissolves easily in water and can therefore be "scavenged" by precipitation and washed from the atmosphere; it can also settle directly on a surface through dry deposition. After deposition the nitric acid dissociates into its bio-available form nitrate (NO_3^-).

During winter some of the reactive nitrogen in the atmosphere will form peroxyacetylnitrate (PAN), which is very stable under cold and dark conditions and therefore suitable for long-range transport into the Arctic. In spring, with increasing temperatures and sufficient solar radiation, this molecule can be broken up again to release the nitrogen in a more reactive form. Ammonia will react to form ammonium (NH_4^+), which is also a very soluble species that is scavenged and deposited rapidly. Due to the lack of reactive nitrogen sources in the Arctic itself, most of the reactive nitrogen that is deposited in the Arctic comes from mid-latitude sources.

After deposition, ammonium and nitrate are available to ecosystems – and they act as fertilizers. The magnitude and timing of deposi-

tion of reactive nitrogen is an important factor for arctic ecosystems since the Arctic is a nutrient-limited region, particularly in terms of nitrogen. Changes in arctic nitrogen deposition may severely perturb arctic ecosystems. This problem is being addressed by the international and interdisciplinary project NSINK ("Sources, sinks and impacts of atmospheric nitrogen in the Arctic"). NSINK traces the fate of reactive nitrogen from the sources through deposition, and studies its impact on local ecosystems in the Ny-Ålesund area. The Norwegian Polar Institute participates in this project, studying transport and wet and dry deposition processes as well as the processes involved in photochemical transformation of nitrogen in the snowpack. Two PhD students are involved (authors Rafael Kühnel and Mats Björkman) along with post-doctoral fellow Tjarda Roberts.

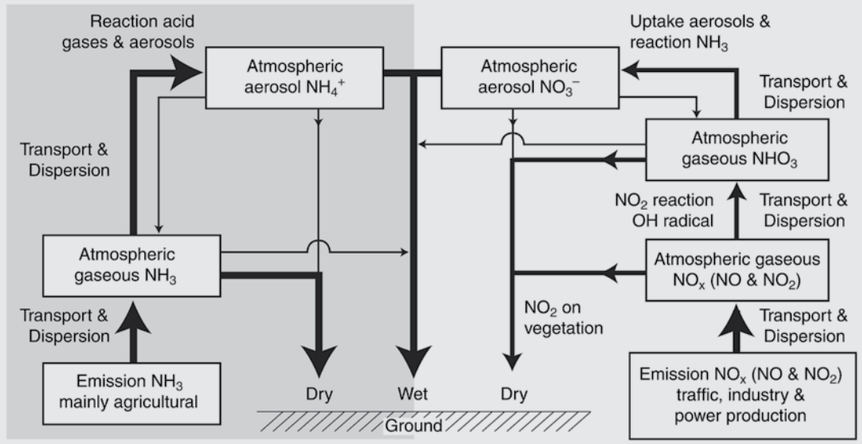
Nitrogen that is deposited along with snow during the winter season is stored in the snowpack. There, it can undergo a series of photochemical reactions, starting when the returning spring sun rises high enough to provide solar radiation, and part of the nitrogen can be released again from the snowpack to the atmosphere. With the starting snowmelt, the remaining nitrogen is flushed from the snowpack and made available to the ecosystems. Nitrogen that is scavenged from the atmosphere in summer, however, is immediately available to the ecosystems.

Svalbard's geographical position means that it is mostly under the influence of atmospheric pollution transported from the Eurasian continent. Therefore the development of nitrogen emissions in Eurasia and changes in transport patterns from Eurasia to the Arctic are key factors controlling the nitrogen budget in Svalbard. Emissions of reactive nitrogen in Europe are decreasing and this is predicted to continue in the future. However, increased ship traffic made possible by a reduced extent of sea ice could introduce a significant source of reactive nitrogen in the Arctic.

Atmospheric transport of pollution to the Arctic is stronger during the winter. This because of the Arctic Front, a region of strong horizontal temperature gradients that build an effective transport barrier. The Arctic Front is not stationary: it is located further south during winter such that Eurasian sources of air pollution are located within its boundaries. In summer, the Front shifts further north, separating most of the sources from the Arctic.

The Norwegian Institute for Air Research (NILU), has been sampling precipitation in Ny-Ålesund for the past twenty years. A recent finding based on these precipitation data, is that nitrogen deposition in Svalbard is controlled to a large extent by few strong deposition events, probably the result of fast and direct transport from European sources to Svalbard in just a few days. The average nitrogen deposition per year in Ny-Ålesund is 74 mg. Most of the time, deposition is weak and delivers about 17 mg N/m^2 per year. But a single strong event can deposit as much as an additional 225 mg N/m^2. Such occurrences are sporadic, however, causing huge differences in the yearly budgets. For comparison, the average nitrogen deposition in Europe is 550 mg N/m^2, though it varies considerably depending on the location.

Necessary conditions for strong deposition events seem to be that the moisture content of the transporting air is sufficiently high, and that meteorological conditions are suitable for fast transport. Strong cyclones over the North Atlantic in combination with a "blocking" high pressure system over the Eurasian continent may provide the conditions needed for such events to occur in the Arctic. Climate models predict that both cyclonic activity over the North Atlantic and precipitation in the Arctic will increase. The likelihood of more strong deposition events and a higher nitrogen budget in the Arctic is therefore given.



Reactive nitrogen pathways in the atmosphere

Lena Seuthe // Department of Arctic and Marine Biology, University of Tromsø
Kriss Rokkan Iversen // Salt Lofoten AS
Fanny Narcy // Norwegian Polar Institute and Laboratoire d'Océanographie de Villefranche, France; Present address: European Institute for Marine Studies, IUEM, France

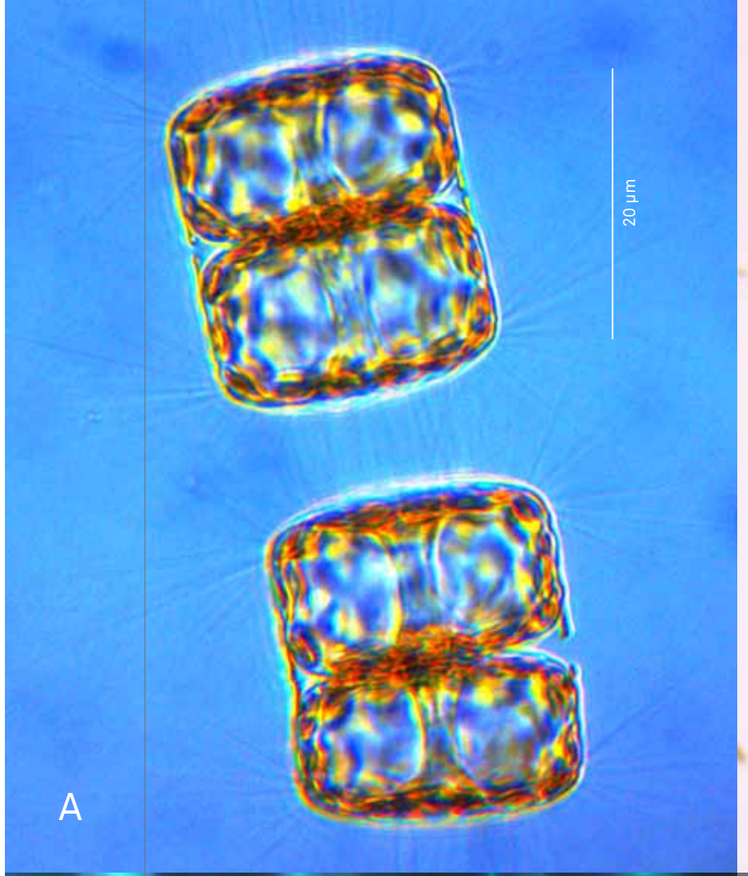
The planktonic food web in arctic seas: from simplicity to complexity

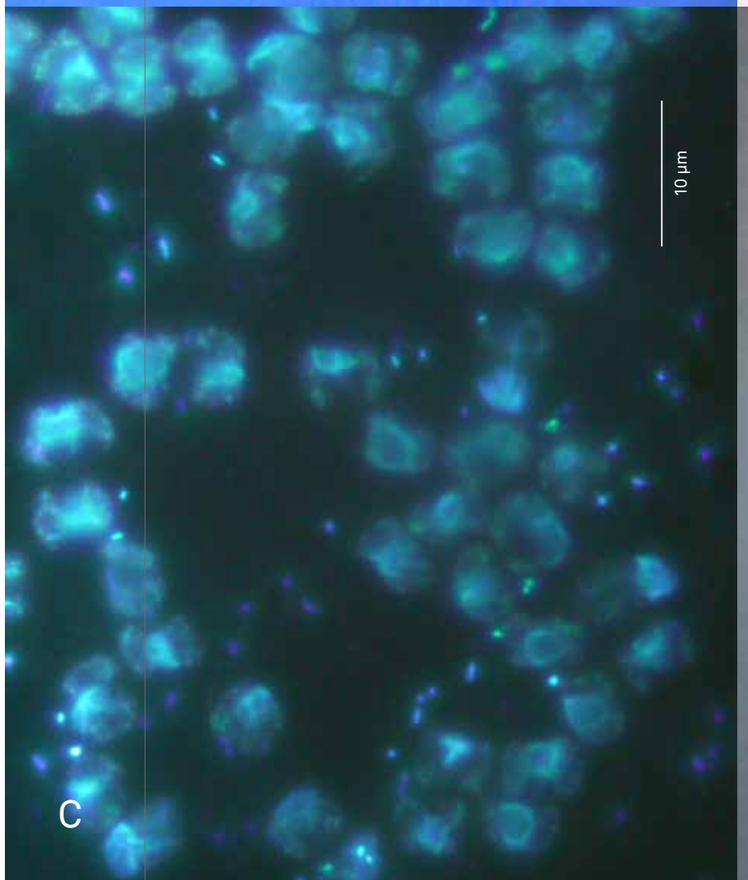
THE WORLD'S OCEANS are inhabited by myriads of organisms, most of them far too small to be seen with the naked eye, floating in the sea as plankton. These microscopic creatures are as different from each other in size and function as a flea and a blue whale or a daisy and a giant redwood tree. Despite their minute size these organisms are essential drivers of crucial biogeochemical cycles on earth, including the carbon cycle. The balance between CO_2-binding algae and CO_2-releasing heterotrophs (i.e. organisms that take up organic matter to fuel their metabolism) largely determines whether the world's oceans act as a sink or source for the atmospheric greenhouse gas CO_2. Hence, these tiny creatures have a profound impact on the world's climate.

On a global scale, the average size of planktonic organisms is thought to increase with decreasing temperature. Thus in cold, high latitude waters, the plankton communities were assumed to be dominated by relatively large algae, such as diatoms, and big copepods. It was postulated that the extensive fisheries in sub-arctic seas are made possible by short and simple planktonic food chains. In such classical food chains, energy bound by large-celled algae is efficiently channelled up to higher trophic levels - such as fish - via large,

Photos courtesy of AMB plankton lab (diatom), Malin Daase (copepod), Kriss Rokkan Iversen (small algae), and Lena Seuthe (ciliate).

These images show
A: diatoms
B: a copepod
C: small algae
D: a ciliate





lipid-rich copepods. Bacteria and bacteria-based food webs of single-celled heterotrophs, such as flagellates and ciliates, were thought to be inhibited by low water temperatures and therefore of minor importance for the structure and function of arctic marine food webs. Reality, however, appears more complex than suspected.

To enhance knowledge of the species in the microbial food web, their roles and interactions throughout the seasonal cycle in the Arctic, the ARCTOS PhD School at the University of Tromsø established three PhD positions in 2006. Our assignment was to focus our research on the smallest planktonic organisms - from bacteria over flagellates and ciliates up to small copepods - in arctic waters. Jointly, the three of us spent a full year investigating the structure and function of the planktonic food web in Kongsfjorden on the western coast of Spitsbergen.

Our data clearly demonstrated that the high-latitude planktonic food web in Kongsfjorden was all but a simple chain of diatoms and large copepods. Diatoms were abundant in April during a spring algae bloom. Nonetheless, both during the bloom and at all other times of the year, algae smaller than diatoms constituted the bulk of algae biomass (top graph next page). In addition, the algae were by no means alone: bacterial biomass exceeded that of algae throughout most of the year and was at times comparable to that of copepods (bottom graph next page). Hence, the picture that emerged from our measurements was that small, non-diatom algae and bacteria formed the basis for a complex planktonic food web, where heterotrophic flagellates and ciliates grazed on algae and bacteria, and were in turn preyed upon by the larger copepods.

Seasonal variations existed in the structure of this food web, which could partly be linked to physical environmental factors, such as light and water column stability. Bacteria and the smallest algae became most abundant during summer, when melt water run-off from land led to a strongly stratified water column with nutrient-poor waters with low salinity at the surface. It is such physical settings that are proposed to become more predominant in the arctic seas as global temperatures continue to rise.

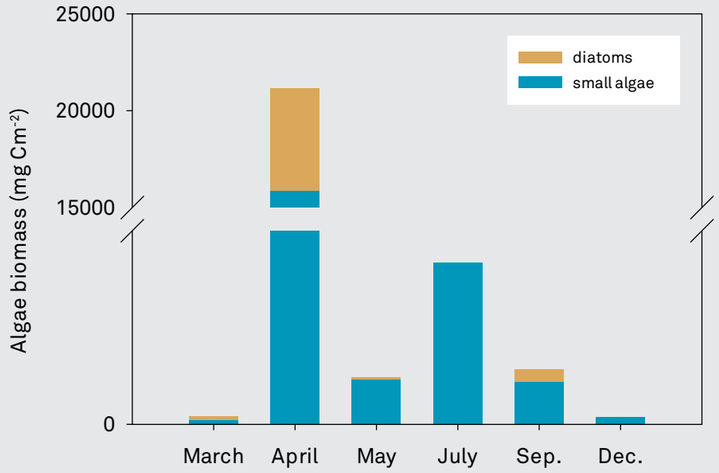
Our findings from Kongsfjorden are part of an ongoing shift in paradigm within the arctic research community: the simplistic food web model is being refined to a more complex one for arctic marine systems. The emerging model includes bacteria and bacteria-eating flagellates and ciliates as crucial components of the plankton community. Further, our investigation supports the idea that bacteria and small non-diatom algae will become a predominant feature of arctic planktonic food webs, as rising temperatures may lead to a freshening of arctic surface waters through ice melt and increased freshwater run-off from land. Such a structural shift within the planktonic community will alter the balance between CO_2-binding algae and CO_2-releasing heterotrophs, with implications for biogeochemical cycles in high latitude seas.

FOR FURTHER READING

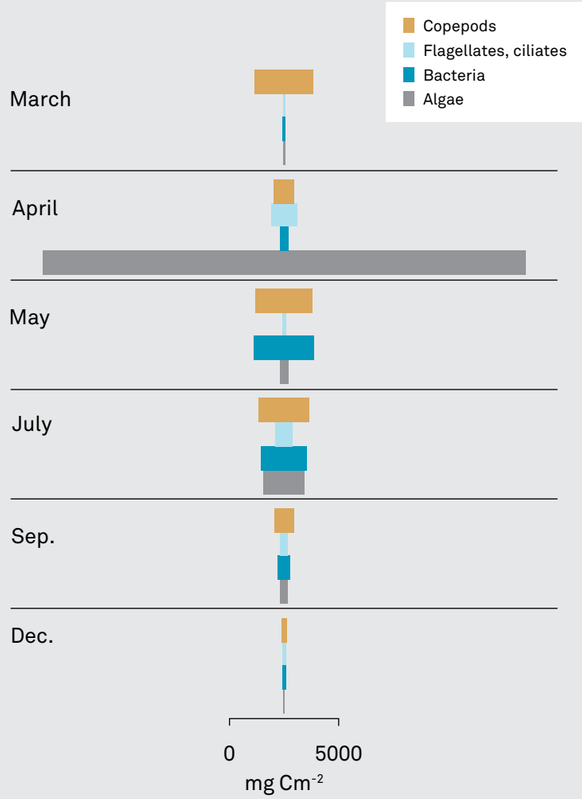
Narcy F (2010) Life strategy of *Oithona similis* and role in trophic interactions in an arctic coastal ecosystem. Ph. D. thesis, University of Tromsø

Rokkan Iversen K and Seuthe L (2011) Seasonal microbial processes in a high-latitude fjord (Kongsfjorden, Svalbard): I. Heterotrophic bacteria, picoplankton and nanoflagellates. Polar Biology 34:731–749. DOI 10.1007/s00300-010-0929-2

Seuthe L, Rokkan Iversen K, Narcy F (2011) Microbial processes in a high-latitude fjord (Kongsfjorden, Svalbard): II. Ciliates and dinoflagellates. Polar Biology 34:751–766. DOI 10.1007/s00300-010-0930-9



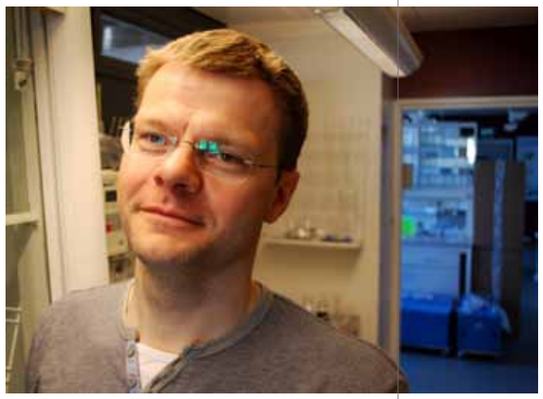
Biomasses of diatoms and smaller, non-diatom algae in Kongsfjorden during different months in 2006. The figure demonstrates that algae other than diatoms constituted the bulk of algal biomass during most of the year in Kongsfjorden.



Biomasses of algae, bacteria, flagellates/ciliates, and copepods in Kongsfjorden during different months in 2006. The data show that bacterial biomass exceeded that of phytoplankton at all times, except in April, and was occasionally comparable to that of copepods. This indicates that bacteria play a crucial role in the structure and function of the high-latitude planktonic food web in Kongsfjorden.

Bjarne Røsjø

NILU research contributed to stricter EU rules on parabens



Torkjel M. Sandanger is a senior researcher at NILU in the Fram Centre in Tromsø. *Photo: Helge M. Markusson, Fram Centre*

THE EU IS IN THE PROCESS of introducing a ban on the use of parabens in skin care products for children under six months old. An important contribution to the basis for the new ban was provided by Torkjel M. Sandanger, a senior researcher at the Norwegian Institute for Air Research (NILU), who has demonstrated high levels of parabens in the blood of heavy users of cosmetic products.
Torkjel M. Sandanger and a group of NILU researchers at the Fram Centre in Tromsø have analysed 350 blood samples from Norwegian women, and have found a very clear link between the women's self-reported use of cosmetic products and the level of parabens in their blood. Among heavy users, the level of parabens in the blood was actually higher than levels of all other potential environmental pollutants surveyed.

"This gives grounds for concern, because parabens are chemical substances which can disrupt the hormonal balance in the body. Studies have shown that substances of this kind which cause hormonal imbalance can have an adverse impact on fertility in both women and men. They can also lead to certain types of cancer if used over a long period of time. There is a pressing need for more studies to be done on the effects these substances have on the population,"
says Sandanger.

BAN IN DENMARK

Parabens are a class of chemicals used as preservatives in a large number of cosmetic products. Parabens have been met with increasing scepticism and concern in the past few years. Many cosmetic products also contain other chemical substances which have unknown or harmful effects. In Denmark, this growing concern caused the government to introduce a ban on 15 March 2011 against the use of propyl- and butylparabens in cosmetic products aimed at children under three years old.
The EU's Scientific Committee on Consumer Safety (SCCS) had previously taken the view that parabens did not pose a health risk, but the Danish ban triggered a new assessment which led to the SCCS in November 2011 recommending a ban on parabens in products aimed at children under six months old. The SCCS cited Sandanger's research as an important basis for the new assessment, together with a handful of other publications on the same theme.
The European Commission, which is the executive organ of the EU, has since followed up the scientific recommendations and is in the process of implementing an entire EU-wide ban. The Commission also wishes to reduce the maximum permissible level of propyl- and butylparabens in all types of cosmetic products. The Norwegian Food Safety Authority follows the EU in such cases, which means that the stricter regulation will also apply in Norway.

http://ec.europa.eu/health/scientific_committees/consumer_safety/docs/sccs_o_069.pdf

PARABENS UNDER PRESSURE

NILU's research into parabens attracted a great deal of attention in 2011. In March, Sandanger appeared on "Schrödinger's Cat", a TV programme devoted to science and research broadcast by Norway's NRK1 channel, in which it emerged that the programme presenter, Hanne Kari Fossum, had twice as high levels of parabens in her blood as Erik Solheim, Norway's Minister of the Environment and International Development. NRK1's TV programme on consumer issues "FBI - The Consumer Watchdogs" had a main feature focusing on the debate on parabens in September, drawing on NILU as one of the main sources of information. In that programme, Sandanger explained that propylparaben is chemically very similar to oestradiol, which is one of the most potent female sex hormones.
Sandanger was also interviewed on NRK1's health and lifestyle programme "Pulse" in November, at the same time as the Norwegian Consumer Council launched an app which can be downloaded to smart phones to check the contents of cosmetic products. The app, called "Hormone Check" warns consumers if the cosmetic in question contains potentially hormone-disruptive chemicals. The Norwegian Cosmetics Association criticised the initiative, but the little app quickly climbed to the top of the list of the most frequently downloaded free apps.
Up until now, it has been difficult to determine whether parabens are capable of causing cancer or hormonal imbalance in humans, but the researchers at NILU took a great step forward when they analysed blood samples from women taking part in the "Women and Cancer Study". The study is headed by Professor Eiliv Lund at the University of Tromsø, who has gathered data and questionnaires from more than 70 000 Norwegian women. NILU analysed blood samples from 350 of these women and compared them with the women's self-reported use of skin creams and other skin care products. NILU's research showed that parabens are demonstrably present in blood samples from randomly selected women.

"If these substances are in your blood, they're also in your liver and in every other place in your body," explains Sandanger.

PREGNANT WOMEN SHOULD BE BETTER PROTECTED

"It's positive that both Denmark and the EU are tightening the rules on the use of parabens, but research suggests that we should also be considering a ban with respect to pregnant women. This is a complicated subject, but it has been shown that the exposure to parabens of a foetus in the womb has more serious consequences than exposure after birth. The EU's Scientific Committee has nevertheless taken the view that there is no reason to introduce such a ban until it has more documentary evidence," says Sandanger.

"We humans are exposed to thousands of chemicals every single day, and the basic idea should be that we don't need even more chemicals in our bodies. Today, researchers must prove that there is a probability that a substance is dangerous before the authorities can ban it, but it would be better to apply the precautionary principle. We know little about how each substance affects the body and the environment, but we know even less about the cocktail effect, that is, the combined effect of multiple chemicals interacting with one another," warns Sandanger.

"In this area people are of course quite free to make their own choices without waiting for stricter legislation. The Consumer Council's app and other aids, such as the website of the Norwegian environmental organisation Grønn hverdag [Every Day Green], have made it quite easy for most of us to avoid products containing parabens," Sandanger adds.

Elina Halttunen // High North Academy, University of Tromsø

High North Academy will increase the quality of research education

ONE OF UNNECESSARY SOURCES of frustration during my recent PhD studies here in North Norway, was the difficulty of finding relevant PhD courses to take, and finding information on the few existing courses. This is something High North Academy (HNA) aims to change for future research students.

The University of Tromsø (UoT) and collaborating research institutes affiliated to the Fram Centre (FRAM) are educating increasing numbers of researchers, and with the current research focus in the High North Issues, there is no indication that the flood of new PhD students will be diverted any time soon. This has led not only to a greater demand for relevant PhD courses in the High North Research Community, but it calls for better for support and career counselling for PhD students under training as well. The fact is that not all young, aspiring students will end up in research positions, and after working with quite specific subjects for several years, some of us need a bit of help in realising our untapped potential. In addition, even a researcher nowadays needs a larger set of tools to work with. For example, research communication is becoming an increasingly important aspect of doing research. Both the European Union and the Norwegian Research Council demand a plan for good research communication and outreach, and the efforts in these areas are regarded as an important part of research projects.

But as usual, education lags behind. UoT offers few courses both in career counselling and research communication. This sad fact was conclusively revealed through the Tromsø Doctoral Students (TODOS) survey in April 2011: over 70% of UoT PhD students noted that the courses offered were insufficiently relevant, inadequately organised, poorly advertised, and not well taught. In addition, courses were rarely offered in English even though over 40% of the PhD students come from outside Norway. The students specifically requested courses in transferrable skills, such as (popular) scientific writing, presentation techniques and poster construction, writing research funding applications, networking, and alternative research communication methods (e.g. film and blogging). In addition, the students asked for multidisciplinary PhD courses, in order to enhance social interaction across faculty boundaries - it helps to know you're not alone.

Some steps have been taken, and in the right direction. But although some courses in transferrable skills have been established, there has been little information exchange between the course organisers; and it has been difficult for students to get information about, and access to, courses organised by individual faculties and graduate schools. This is both confusing for students and non-cost-effective use of teaching resources. Therefore, the need has arisen to start an academy to bridge the gaps in the research training currently offered here in Northern Norway.

In other words, the High North Academy is an initiative for an overarching institution of higher learning and research in the High North, encompassing both UoT and FRAM. The overall aim of HNA is to increase the quality of PhD studies associated with High North issues, to stimulate High North research output and communication, and in the long run improve recruitment to higher education and research in the High North.

AND THIS IS HOW WE INTEND TO DO IT

HNA aims to achieve this ambitious goal by developing and coordinating PhD courses in transferable and quantitative skills. All the courses will be offered in English, and the goal is to arrange courses from the portfolio (see table below) once a year, at the same time, on an intensive schedule, and will include several invited speakers (e.g. staff from the FRAM Flagships and other national and international experts).

The courses in quantitative skills will be organised in collaboration with High North PhD-schools and the Forum for Ecological Modelling. Courses in scientific writing and leadership have already been established and have been very well received among the participants.

HNA will also provide information about PhD courses, training material for courses, and tools for teaching and outreach via its website (highnorthacademy.org). Collecting information on one site should ensure effective information flow between faculties, research schools and interest groups, and serve to promote the PhD programs offered by UoT.

HNA will also promote UoT's and FRAM's role in higher education in High North Research both nationally and internationally. This will be done through both the website and close collaboration with existing international organisations and interest groups, such as Association of Polar Early Career Scientists (APECS), Young Scientists Forum (YSF) and Research Communication and Outreach (ReCO). HNA will co-operate with APECS, YSF, ReCO on the planned courses, and some of the activity will be concentrated around the annual Arctic Frontiers conference in Tromsø.

Course portfolio and schedule for HNA PhD courses in 2011-2013. ECTS=European Credit Transfer and Accumulation System ("study points").

MODULE	COURSE	ECTS	FALL 2011	SPRING 2012	FALL 2012	SPRING 2013	FALL 2013
1	Philosophy and ethics of science	3		×		×	
2	Scientific writing and presentations	3	×		×		×
	New media in research communication	1		×		×	
	Contact with media	2			×		×
	Graphics and art in presentations	2				×	
3	Career development, research funding	1	×	×	×	×	×
	Leadership skills	2	×		×		×
	Entrepreneurship	2		×		×	

HOW IS HNA ORGANISED AND WHO SHOULD YOU CONTACT IF YOU WANT TO KNOW MORE?

HNA will be organised through UoT and across Fram Centre institutions, to include all the PhD schools working with High North Issues (e.g. AMINOR, ARCTOS, AMGG, BARESS, CEPIN, EPINOR, EWMA). HNA will also collaborate with national partners, (e.g. University of Nordland and University Centre in Svalbard) and international partners (e.g. APECS, YSF, Uarctic). A kick-off meeting will be held 27 March 2012 at the Fram Centre.

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Janet Holmén // Editor, FRAM Forum

Push and pull among Finnish reindeer herders

REINDEER HERDING is a time-honoured livelihood in northern Scandinavia. Herds, families and traditional grazing lands transcend national boundaries. Yet boundaries exist, and countries differ in how they regulate herding and who may own reindeer. In Norway and Sweden, essentially all reindeer herders are Sámi, whereas in Finland a majority of them are not. Does a reindeer herder's cultural identity influence how he or she makes decisions? And what impact does national policy have on a herder's ability to make a living?

In a study published last summer, Leo Paul Dana (University of Canterbury) and Jan Åge Riseth (Northern Research Institute Tromsø) addressed these questions. Unlike most previous researchers, Dana and Riseth did a qualitative study, attempting to understand the reindeer herders' motivations and attitudes, rather than focusing on their entrepreneurial activities.

SIMILARITIES AND DIFFERENCES

The study was done in Finland, where several thousand people rely on reindeer herding for all or part of their livelihood. Some of these herders consider themselves Sámi - and are also considered as such by official Finnish policy - but most are ethnic Finns. (In fact, according to the Finnish Reindeer Herding Law, any EU citizen is eligible to herd reindeer.)

Each reindeer is owned by an individual, but for practical reasons owners herd their animals together. Among Sámi, the basic herding unit is the siida, usually a family network. Decisions are made by consensus - not by vote - which puts a premium on dialogue and mutual values. Cooperation helps bind the siida together: members exchange services rather than money. Land ownership is not a part of Sámi tradition. Instead, each siida herds its flocks in traditional grazing areas that shift with the season.

Ethnic Finns also herd individually-owned reindeer in combined herds, but there are important differences. In this case, the basic herding unit (called paliskunta) is a cooperative of reindeer herders responsible for administrating a geographically defined herding area. The roots of these permanent areas can be traced to 1898, when the Russian state initiated structural changes in Finland. The paliskunta system met with strong resistance from nomadic Sámi reindeer herders, but was ultimately adopted and is now the only herding system that is formally recognised in Finland.

CASH AN ISSUE

In the 1960s and 1970s, reindeer herders in Finland started using snowmobiles. Mechanisation required them to purchase commercial goods, and for that, they needed cash. Under this pressure, reindeer herding communities sought new sources of income, such as making and selling handicrafts, and some community members took "ordinary" jobs. Diversification meant that the siida was no longer a purely self-sufficient economy based on exchange of services. And what about the paliskunta? This brings us back to the issue of how cultural identity and national policy influence an entrepreneur's decision-making.

Dana and Riseth had two main research questions:

– How do Sámi and non-Sámi reindeer herders acquire and use resources?
– Do Sámi and non-Sámi reindeer herders differ in how they "do business"?

To find answers they interviewed self-employed herders, both Sámi and ethnic Finns. The eldest was over 70 years old, the youngest merely 12. Some called themselves professional reindeer herders; some identified themselves with other professions but said they also owned reindeer. All participants - Sámi and non-Sámi alike - said they enjoyed reindeer herding. Where government was concerned, participants "agreed to disagree": regardless of ethnicity, some thought the Finnish government did too little to help them, and others felt it imposed too many regulations. But in other contexts, subtle cultural difference emerged.

CULTURAL IDENTITY

Although all the reindeer herders Dana and Riseth interviewed said they had been inspired to a life of herding by a family member or mentor, Sámi participants emphasised aspects that were clearly linked with their cultural background. They said things like "Every Sámi should have reindeer" and "I follow in the footsteps of my father." When asked what they foresaw about their lives five years in the future, many hoped they would still be doing the same things.

Yet here again there were subtle differences. One Sámi said, "This is not a business that we change. This is our way of life. I will herd even if reindeer bring no money," while a non-Sámi said, "...exactly as now, provided the money is good." The older Sámi participants spoke of giving the business to their children while non-Sámi seniors said they would "sell the business."

PULLING AND PUSHING

Dana and Riseth also found that the two ethnic groups differed in their outlook on business. Ethnic Finns tended to view reindeer herding as one of several possible ways to make a profit. But for Sámi participants, herding had more to do with the reindeer themselves than with the income they might bring in. Sámi herders are "pulled" to a life that offers close community with family and reindeer. Authors of a previous study summarised this attitude in a nutshell: "reindeer husbandry forms a 'way-of-life' more than a 'way-of-production.'"

Still, modern reindeer herders need commodities that only money can buy and must therefore earn cash. How do they act when faced with this quandary? Non-Sámi interviewees said they might "give up reindeer herding altogether" or "only do what makes the most money". These options were apparently not open to Sámi respondents. They keep their herds, but are "pushed" into other activities to supplement their income.

NATIONAL POLICY

One way to make ends meet is to claim economic support from the government. Finnish reindeer herders receive a small government subsidy per slaughtered reindeer, above a certain quota. But this quota is rising over time, putting reindeer owners with small herds at an ever greater disadvantage. And there are other problems. As Dana and Riseth point out, Finnish policy is based on the paliskunta, the only officially recognised herding unit. While the paliskunta aims to maximise profit, the siida places emphasis on cultural values and family-centred communal activity.

The subsidy and quota system fits poorly with Sámi tradition, where the reindeer represent much more than just a saleable commodity. In a poignant example, four Sámi members of a paliskunta refused to fulfil their quota, saying their herds were not productive enough to bear the loss. The conflict went to court: the paliskunta won the case and can now force the slaughter of its Sámi members' reindeer.

Finland's reindeer-herding Sámi face the double challenge of being in the minority, and being under strong pressure to turn a monetary profit. Dana and Riseth conclude that Sámi cultural values need specific protection in Finland. To this end, they suggest that the Nordic Sámi Convention act to initiate legislative reform. Regulations must harmonise with Sámi cultural values, lest push comes to shove and contradictory demands make reindeer herding according to Sámi tradition untenable as a way of life.

Based on "Sámi reindeer herders in Finland: Pulled to community-based entrepreneurship and pushed to individualistic firms" by Leo Paul Dana and Jan Åge Riseth, published in the anthology *Entrepreneurship, Social Capital and Governance*, E. Elgar, publisher.

Eva Therese Jenssen // University Centre in Svalbard

Aliens with latitude

FREE SHOE-CLEANING

NEW RESEARCH SHOWS that humans can unwittingly bring alien plant species to Svalbard. Increased travel activity and expected temperature increases over the next decades, may make the establishment of new plant species in the archipelago's vulnerable ecosystem possible. This calls for a closer look at the management policy for travelling to Svalbard. Between 1995 and 2004 there was a 255% increase in the number of tourists visiting Svalbard, according to the Governor of Svalbard. During 2008, almost 69 000 travellers (locals, tourists and visiting scientists) arrived at the Longyearbyen airport. In addition, around 30 000 cruise ship passengers go ashore in Svalbard annually.

Today, there are 165 native plant species in Svalbard. Until recently, two factors helped maintain ecological integrity in the High Arctic and Antarctica: low frequency of visits by humans and a cold climate. Now, both these factors are changing in Svalbard: human traffic is getting heavier and the temperatures are gradually rising.

Scientists from the University Centre in Svalbard (UNIS), Tromsø University Museum and the Australian Antarctic Division have now published the results from an experiment conducted in the summer of 2008 that shows that increased travel activity will lead to the introduction of alien plant species to Svalbard.

In the summer of 2008 Chris Ware had an unusual offer for passengers arriving at Longyearbyen airport: he would clean their shoes free of charge. By scraping soil off the soles of the soles of the shoes, collecting any plant seeds embedded in the soil and then planting them in a climate that simulated the summer season in Svalbard, Ware wanted to find out whether alien plant species could be introduced and successfully established in the archipelago. Samples from a total of 259 pairs of shoes were collected between June and September 2008. The travellers that participated also filled out a questionnaire about when they had last cleaned their shoes, whether the shoes had been in use in the three previous months and if so, in what type of environment (forest, alpine or city).

"A total of 1 019 seeds from 53 plant species were found. Only two species were native Svalbard plants, the rest were plant species not known to Svalbard," says Chris Ware.

Free shoe-cleaning
Chris Ware (left) cleaning shoes at Longyearbyen airport in July 2008. *Photo: Eva Therese Jenssen, UNIS*

REFERENCE

Ware C, Bergstrøm DM, Müller E, Alsos IG (2011) Humans introduce viable seeds to the Arctic on footwear. Biological Invasions 13. DOI: 10.1007/s10530-011-0098-4

300 000 SEEDS ANNUALLY

If 1 019 seeds arrived on 259 pairs of shoes, that gives an average of 3.9 seeds per person. If this average number is representative for the whole year, then up to 300 000 seeds could potentially be carried to Svalbard on the footgear of unsuspecting travellers.

The seeds Chris Ware collected were planted in an environment that simulated summer in Svalbard. The temperature 10°C was chosen to match the average summer soil temperatures recorded from a number of Svalbard sites. Twenty-four-hour sunlight goes without saying. The seeds were monitored for 48 days to see if they germinated successfully.

Twenty-six percent of the seeds (266 out of 1 019) germinated under the test conditions. Eighty-seven percent of those germinated within 14 days, the rest within 48 days, which is well within the growing season in Svalbard.

Prolific invader
Winter-cress *Barbarea vulgaris* is a non-native Svalbard plant which has been introduced to the Russian settlement Barentsburg. *Photo: Bjørn Erik Sandbakk*

FOCUS ON BIOSECURITY

"This study demonstrates that people arriving in Svalbard pose an identifiable hazard to the local environment through the introduction of alien plant seeds that are capable of germination even under current climatic conditions," says project leader Inger Greve Alsos.

"These findings can be an important contribution in a future discussion about a more conservative approach to regional biosecurity, so that the ecological and genetic integrity of the local flora can be maintained," says Alsos.

The entry points to Svalbard have no biosecurity policy that corresponds to the strict policies enforced in New Zealand (Biosecurity New Zealand 2010) and by Antarctic tour operators (IAATO 2010).

The Governor of Svalbard and the Norwegian Polar Institute will soon write a management action plan concerning introduction of non-indigenous plant species to Svalbard. Maybe some time in the near future, travellers to Svalbard must pass through a cleaning process before they can leave Longyearbyen airport and walk out onto Svalbard soil.

The project received financial support from the Svalbard environmental protection fund.

Magdalenenfjorden
Around 30 000 cruise tourists visit Svalbard every year. One of the most popular landing sites is here in Magdalenefjorden on the northwestern coast of Spitsbergen.
Photo: Helge M. Markusson, Fram Centre

Frode Skarstein // University Library, University of Tromsø

In it for the long haul: Adolf Hoel in Norwegian polar history

From left to right
- Adolf Hoel, Director of the Norwegian Polar Institute 1928–1945.
- Hoel surveying at Nordenskiöldfjellet, Svalbard.
- Hoel taking notes in the field.
- Two co-workers outside Hoel's tent in Colesbukta, Svalbard.

All photos: Norwegian Polar Institute Photo Archive

IN AUGUST 1910 Fridtjof Nansen's famed ship *Fram* left Norway on its third and final expedition. In charge was Roald Amundsen. The announced plan was to drift across the frozen polar basin to the North Pole, much like what Nansen had attempted years earlier. The ship was to enter the polar basin through the Bering Strait, but Amundsen's sudden change of course in Madeira in early September is now history. Instead of the North Pole, Amundsen's clandestine plan was the conquest of the South Pole, which he managed late in 1911.

Amundsen reaching the South Pole in 1911 was one of the reasons why 2011 was defined as a year of national celebration in Norway. The other was to mark the 150th birthday of Nansen. The Nansen-Amundsen year has been celebrated nationally and internationally with a range of different activities, including exhibitions and reenactments of Amundsen's South Pole skiing expedition. Both Nansen and Amundsen stand as icons in Norway's polar history, and their role as symbols of Norway's polar pride is almost impossible to overestimate.

> *"At 7 AM on the 8th of June 'Farm' hoisted anchor and from Vippetangen we headed out the fjord. Weather excellent, calm and warm."*

This field diary entry by the Norwegian geologist Adolf Hoel was made the same summer as *Fram* left Norway with Amundsen. The Norwegian naval ship *Farm*, although similar in name, was sleek and slender in appearance and therefore quite different from *Fram*. And also as opposed to *Fram*, *Farm* really was headed northwards the summer of 1910. Not to the North Pole, but close: *Farm*'s goal in 1910 was, as in 1909, the uncharted shores of the arctic archipelago of Svalbard.

An entry in Adolf Hoel's field diary from 1909 illustrates the conditions that met topographers and geologists on Svalbard.

> *"The steam condenses on the tent ceiling causing constant dripping. The sleeping bag and my sweater are constantly wet. Holtedahl is visiting us and we're evaluating the situation. We're virtually sitting on top of each other. One can hardly move without forcing someone else to move. [...] Now and then Reinert sings a bawdy ballad. Hours crawl slowly."*

These events are hardly as momentous as Nansen's attempt to ski to the North Pole or Amundsen's push towards the South Pole. Tedious, never-ending geologising, only interspersed with cold rain and endless waiting for vessels to move teams of researchers in and out of fjords, up and down the rugged Svalbard coastline. Albeit now almost faded into oblivion, the expeditions these quotes stem from are surprisingly significant to today's Norwegian polar self-image.

Starting in 1906 and culminating with Norwegian sovereignty of Svalbard in 1925, Norwegian researchers worked in Svalbard virtually every summer. The main driving force behind most of these expeditions was the diarist cited above, the Norwegian geologist Adolf Hoel (1879-1964), initiator and later director of what was to become the Norwegian Polar Institute. At 28 years of age he embarked on his first Svalbard expedition in 1907 and spent virtually every summer mapping the archipelago until his 46th birthday in 1925. Most of the summers in Adolf Hoel's adult life were dedicated to research in Svalbard. Winters were spent analysing the collected data and every spring Hoel eked out funding from commercial and scientific sources for the coming summer's expedition. His presence on the archipelago became a regular part of the Svalbard summers. This great effort is captured in the nickname he eventually acquires: "Spitsbergen-Hoel". The name is deserved; his involvement with the archipelago is unique, with respect to both the diversity and intensity of his activities, and not least his endurance.

The early Norwegian research efforts in Svalbard were not the result of one grand unified plan to map Svalbard. Rather, these expeditions were the result of the relentless efforts of a handful of individuals to secure funding for yet another season of research. This lack of a preexisting plan makes the expeditions easy to forget. Yet, as one season of research followed another, a virtually unbroken chain of Norwegian research effort on the archipelago eventually spanned from 1906 to 1925. This is an immense effort, and without the dedication of Adolf Hoel and his kind, it is in no way certain that Svalbard would have come under Norwegian sovereignty. And a Norway without Svalbard would, to a large degree, have been a polar nation of the past and not of the present.

The author is a writer and research librarian at the University Library, University of Tromsø

Anne Nyeggen // Head of Communications, Norwegian Institute for Air Research

No methane from the permafrost

There were large emissions of methane from wetlands and gas leakages from Russian gas fields in 2008 and 2009, but so far there are no clear indications of increased emissions from the thawing permafrost.

BY MEANS of isotopic analyses of methane, a research team has been investigating the reasons for the increase in atmospheric methane concentrations that have been measured at the Zeppelin Atmospheric Monitoring Station at Ny-Ålesund in Svalbard. The results from 2008 and 2009 show that there were particularly large methane emissions from wetlands and gas leakages from Russian gas fields during these years. There are no signs that emissions from hydrates on the ocean floor reach the atmosphere.

"For the time being, we don't see any clear indications of increased methane emissions from thawing permafrost either," says senior scientist Cathrine Lund Myhre from the Norwegian Institute for Air Research (NILU).

The study is published in Geophysical Research Letters.

DISTURBING METHANE INCREASES

Next to CO_2, methane is the most important contributor to man-made global warming, and the gas has both man-made and natural sources of emission. Measurements that NILU has conducted at their monitoring station on Zeppelin Mountain at Ny-Ålesund in Svalbard have shown a steady rise in methane concentrations over the past five years.
These results have been concurrent with methane increases measured at other stations in the Arctic, as well as globally. But researchers are particularly worried about the great potential sources of methane in the Arctic.
Huge amounts of carbon are stored in permafrost both on land and on the ocean floor. These sources may emit large amounts of methane if the permafrost thaws.

"In that case, we will get what is called positive feedback," explains Lund Myhre.
"When the permafrost thaws, large amounts of methane are released. This contributes to still more warming and increased thawing of the permafrost, which in turn contributes to still more increase in the emissions of methane."

WHY IS METHANE ON THE INCREASE IN THE ATMOSPHERE?

Over the past few years, research on methane has been intensified; scientists want to understand the changes that impact the level of the gas in the atmosphere:

REFERENCE

Fisher et al.: Arctic methane sources: Isotopic evidence for atmospheric inputs, Geophysical Research Letters, Vol. 38, 2011, L21803, 6 pp., doi:10.1029/2011GL049319.

"There was a particularly great increase of methane in 2007 and 2008. Isotope measurements of methane at Zeppelin, that we have conducted in cooperation with Royal Holloway, University of London, show that a particularly large proportion of the methane came from arctic wetlands in northern Russia.
"This may be due to the summer of 2007 having been unusually warm in the Arctic. On the whole, wetlands are a main source of methane emissions during the summer," explains Lund Myhre.

As regards the increase recorded during spring 2009, the scientists have found that leakage from gas pipelines may explain parts of it.

"It's remarkable that gas pipelines leak so much as to give an increase in regional methane concentrations. This is something people should be interested in reducing, as such leakages are not profitable from a financial point of view either," says Lund Myhre.

The scientists were particularly interested in seeing whether there were any indications of emissions from methane hydrates. Great quantities of the ice-like substance can be found on the ocean floor near Zeppelin Mountain and west of Spitsbergen. Research cruises to study the phenomenon were organised and coordinated with measurements at Zeppelin.

"So far, we cannot see any indications of the methane increase coming from this source. But this may change, particularly in shallow ocean areas, if the temperature in the Arctic continues to rise," says Lund Myhre.

Methane hydrates are crystals formed of methane bound to water. Methane leaks from these hydrates, but for the time being, the methane does not reach the sea surface and escape into the atmosphere to any significant extent. However, this depends on the temperature: at higher ocean temperatures, methane hydrates dissolve more easily in seawater. This is one of the concerns.
An increase in the methane concentration has also been measured in the southern hemisphere. It is presumed that this is due to greater emissions from tropical wetlands in the Amazon and Indonesia as a consequence of changed and increased precipitation, and of tropical fires during the autumn of 2006.

COMPLICATED MEASURING METHOD

The research team has been using so-called isotope measurements to figure out where the methane originated. Different methane sources have different proportions of the carbon isotopes ^{12}C and ^{13}C. This fact is used in combination with modelling of the air transport to Zeppelin in order to identify sources and source areas. The method is particularly challenging to use in the Arctic, because the sources give weak isotopic signals.

"This demands a high level of precision from both the measuring devices and the measuring methodology," says Lund Myhre.

The work on the isotopes and the analyses are headed by and carried out at Royal Holloway, University of London.

MORE METHANE

Whereas NILU's measurements from 1998 to 2005 showed relatively stable concentrations, there have been annual increases from 2006 to 2009. The increases were particularly visible during autumn 2007 and late autumn 2009.

On 26 December 2009, a level of 1975 ppb (parts per billion) was measured. This is the highest methane level ever measured at the Zeppelin station. There have been other episodes with very high values since then as well. The global level also reached a new record in 2009 with 1803 ppb, an increase of 5 ppb since 2008.

Around 60 per cent of the methane in the atmosphere at present comes from man-made sources. The most important of these sources are farming (ruminants), rice paddies, rubbish dumps, coal, oil, gas and fires. The most important natural sources are wetlands, termites, geological sources, oceans, wild animals and fires.

There are also vast natural reservoirs of methane stored in the permafrost, both on land and under the ocean. An increase of methane in the atmosphere may be due to either an increase in emissions from one or more sources, or to a change in methane decomposition.

Atmospheric methane mainly breaks down through chemical reactions and is eliminated on a timescale of about 10 years. It is expected that many of the natural methane sources will be impacted by climate change, such as changes in temperature, particularly in the Arctic, and changes in precipitation.

ABOUT THE PROJECT

The study is an international research cooperation between NILU and the University of Tromsø in Norway, the universities of London, Southampton and Oxford in England, and the Royal Netherlands Institute for Sea Research. Project leaders are R.E. Fisher and E. Nisbet from Royal Holloway, University of London.
The project has been supported by the Natural Environment Research Council, as part of their contribution to the International Polar Year, and by Royal Holloway. The EU has also contributed with funds from the GEOMON Programme, among others.

The Zeppelin Atmospheric Monitoring Station (left) and the view east over Kongsfjorden.
Photos: Kim Holmén, Norwegian Polar Institute

Lars Folkow, Arnoldus S. Blix //
Department of Arctic and Marine Biology, University of Tromsø

How reindeer keep their cool

REINDEER ARE PROTECTED from the winter cold by a thick fur coat of prime insulating quality. But this pelt doesn't just keep the cold out, it keeps the warmth in too. This is fine when the animals are resting, but could cause problems when they are active and generate more heat. Therefore, reindeer also need efficient mechanisms to get rid of excess heat. A recent publication in the Journal of Experimental Biology (JEB), written by us and our colleague Lars Walløe from the University of Oslo, describes the strategies reindeer employ when they are subjected to heat loads.

In principle, reindeer have three lines of defence to handle such situations: They can dispose of excess heat by panting with the mouth closed to evaporate water from the nose, by panting with the mouth open to evaporate water from the tongue, or they can activate a cooling system that selectively cools the blood supply to their brain. These mechanisms have been studied and described separately in previous publications. What the new paper does is describe how reindeer coordinate their three defences in a stepwise transition between different tactics, and how this affects their brain/body temperature.

We trained reindeer to stand in a climatic chamber at 10-50°C and to trot on a treadmill at ambient temperatures of 10-30°C, to cause their body temperature to rise. We simultaneously recorded the animals' physiological responses (breathing rate, brain and blood temperature, blood flow to head and tongue).

In the early stages of a run the breathing rate rose from 7 breaths per minute to an impressive 260 breaths per minute - the animals were panting. By inhaling large amounts of dry air through their nose and evaporating water from its mucous membranes, they cooled blood in the nasal mucosa before sending it back to the rest of the body through the jugular veins. In this way, they kept their body temperature down.

However, as the reindeer continued to run, the exercise further increased their heat load. Then the animals switched to open-mouth panting, throwing their mouths wide open and letting their large and well vascularised tongues flop out. At this time we recorded an exponential increase in tongue blood flow. By moisturising the tongue and panting so that large volumes of air moved over it, the reindeer ensured that enough heat was removed to cool the blood flowing through the tongue. In fact, blood flow through the animals' tongues peaked at the same time as their brain temperature reached a critically high 39.0°C.

At that point the reindeer switched to their third tactic: they selectively cooled the brain by diverting cooled venous blood from the nose away from the body and up into the head. There the cool blood entered a network of heat exchanging blood vessels and cooled the warm arterial blood destined for the brain, thus preventing the brain from overheating. Even though only about 2% of the respired air passed through the panting reindeer's nose, the colossal amounts of air inhaled provided enough cooling power for the reindeer to keep its brain cool. But they only used this strategy as a last resort when the other cooling tactics were no longer sufficient.

When these results were published, they attracted substantial - and encouraging - media interest worldwide. This interest was sparked by a press release from JEB which was accompanied by a "teaser", a popular science summary of the most important findings of the paper, based on interviews with the authors, and was published under the heading "Inside JEB".

The story was soon picked up by both scientific and non-scientific media (e.g., Science Magazine, BBC, The New York Times) and has since appeared in hundreds of journals, newspapers and websites around the world, eventually also including Norway. Hopefully this reflects appreciation for and genuine interest in a solid piece of scientific work, although the exoticism of the topic and the pre-Christmas timing of the publication may have contributed to the massive interest.

FOR FURTHER READING

The story
Blix, A. S., Walløe, L. and Folkow, L. P. (2011) Regulation of brain temperature in winter-acclimatized reindeer under heat stress. J. Exp. Biol. 214, 3850-3856.

The teaser
Knight, K. (2011) Rudolph's cooling strategy revealed. J. Exp. Biol. 214, i (doi: 10.1242/jeb.066621).

Panting reindeer. *Photo: Kia Krarup Hansen*

Text: Øystein Mikelborg, Ken Pedersen // Norwegian Polar Institute
Photos: Ken Pedersen // Norwegian Polar Institute

Polar operations in Antarctica – operating the Troll Research Station, Dronning Maud Land

RESEARCH IN POLAR AREAS involves many challenges, logistics being a case in point. Great distances combined with a relatively cold climate and a general lack of infrastructure creates a demanding situation as regards the organisation of transport, equipment and security. Nowhere is this more apparent than in Antarctica, where the distances are vast, the climate at times extreme and the infrastructure very scattered.
While building up Troll as a year-round research station in Dronning Maud Land, the Norwegian Polar Institute has also built up a considerable back-up support organisation for purchasing, transport, staffing and training as well as the operational and technical running of the station.
Operations in Antarctica also involve special security challenges. Besides the traditional polar challenges related to climate, crevasses and the like, the prominent element of large machines and heavy lifts involves an additional risk. There is always a doctor present, and a well-equipped sick bay at the station, but still, the closest hospital is far away should the need for more advanced medical treatment arise. Preventive measures through training before arrival are therefore considered important, as well as practical on-site training.

STAFF

Operations in Antarctica require unique skills. Relevant expertise has been gradually developed at the Norwegian Polar Institute through the Norwegian Antarctic Research Expeditions, which have been carried out annually since 1999. Add to that a year-round presence in Antarctica since 2005, when the Troll research station first opened as a year-round station. The Antarctic Section at the Norwegian Polar Institute's Operations and Logistics Department consists of seven permanent employees based in Tromsø. In addition, there is an overwintering team of six people who are hired to spend about thirteen months at Troll thus including the entire winter season. For each summer season in the south (November - February), eight to ten more people are recruited from a regular staff pool consisting of former "overwinterers" and other specialists (mechanics, electricians, plumbers, carpenters etc.) with a lot of experience from the Arctic and/or the Antarctic.
In 2011, the logistics department had a little more than 3500 staff days in the Antarctic in connection with the operation of Troll, and to support ongoing research projects. Troll accommodates personnel that run the Norwegian Polar Institute's own research projects as well as external ones, and there is also staff from Kongsberg Satellite Services (KSAT) and the Norwegian Institute for Air Research (NILU).

Unloading supplies at the ice edge, 260 km away from Troll Station.

The Troll Research Station is built for seven to eight people spending the winter, but houses 30-40 people during the summer season; at times up to 70 people stay at the station for shorter periods.

SEA TRANSPORT

Operating Troll as a year-round station requires around 7-800 tonnes of fuel, provisions, building materials as well as other equipment and supplies that have to be transported in to Troll. Most of this is brought by ice-going ships in to the ice edge, and the supplies are freighted overland (or over ice) the last 260 km to Troll. The Norwegian Polar Institute cooperates with the other countries that are established in Dronning Maud Land about ship rentals and has for the past three seasons had a contract with the Danish-owned Royal Arctic Lines to use the 10 300 tonne ice-reinforced container ship *Mary Arctica*. This ship is a modern vessel built in 2005 and does not use heavy oil. The ship needs about three weeks for the passage from Europe to Cape Town in South Africa, where the last supplies are loaded on board. The crossing from Cape Town to our place of discharge at the ice edge (5o°E) takes 8-10 days, depending on ice conditions along the way. Usually, the ship arrives at the place of discharge around the middle of December and unloading all the supplies normally takes around three days.

Hauling a year's supply of fuel, equipment and commodities from the ice edge to Troll Station takes all summer long.

LAND TRANSPORT

From the place of discharge at the ice edge, the supplies are transported about 260 km over snow and ice to Troll. This journey, which takes two or three days each way, passes through crevassed areas that require extra high alertness on the part of the drivers. Heavy full track vehicles of the piste-grooming type, commonly used to prepare alpine ski slopes, are used for the land transport. These vehicles pull large sleds where the supplies are placed in standard 20-foot containers. Each vehicle pulls a load weighing around 35-40 tonnes. The speed of the vehicles varies somewhat according to the snow conditions, but is usually about 12-14 km/h. The land transport starts when the ship arrives and continues until the very end of the summer season, around the end of February. Having a vehicle fleet in the best possible working order at any given time is an absolute prerequisite for carrying out the transport task efficiently. To achieve this, proficient mechanics are needed and it is members of this profession the Norwegian Polar Institute hires in the largest numbers for the summer season in the south.

AIR TRANSPORT

Troll has its own airfield, established on the ice about seven kilometres from the station itself. The airstrip is 3000 metres long and 60 metres wide. It is kept operative during the entire summer season and can also be opened for use during the winter period, if necessary. Ensuring high operative status requires that many resources go towards airstrip maintenance equipment. The airstrip also has a mobile lighting set for use in the dark and in poor visibility, something which is absolutely necessary in connection with flights during the dark period of the year.

Besides Troll, the only place capable of receiving large inter-continental aircraft as well as smaller types of planes for transport of personnel in this part of Antarctica, is the Russian base Novolazarevskaya.

Personnel transport between Cape Town and Dronning Maud Land is mainly by air. This is organised through Dronning Maud Land Air Network (DROMLAN), but the Norwegian Polar Institute also carries out flights to Troll as solely Norwegian operations.

In 2011, the Norwegian Polar Institute arranged a winter flight to Troll for the first time. This was done on the darkest day of the year at Troll, 22 June. The flight was carried out with a Gulfstream 550 from a Swedish company (European Flight Service). The Gulfstream is a modern ultra-long-range plane, a fact which made it unnecessary to refuel at Troll.

The Norwegian Air Force has also flown to Troll on a number of occasions, among them the opening of the station in February 2005, when HRH Queen Sonja arrived on board a C-130 Hercules that also carried out the first official landing at Troll Airfield. Norwegian Prime Minister Jens Stoltenberg was also flown to Troll in a C-130 Hercules when he visited the station in 2007.

An Ilyushin-76 comes in for a landing at Troll Airfield.

RESEARCH ACTIVITY

The Troll Research Station was established with the main objective of being the base for Norwegian land-based research activity in the Antarctic. The Norwegian Polar Institute has built up an infrastructure that facilitates these activities. Four full track vehicles of the type TL-6 (Swedish-produced carriage), with detachable living and working modules, are earmarked for research; this makes it possible to do land-based research far away from Troll. This equipment was used for instance in 2007-2009, for the Norwegian-American Traverse from Troll to the South Pole and back during the International Polar Year. The equipment is also used annually in connection with the ICE project on the Fimbul Ice Shelf. In addition to these heavy full track vehicles, there is also lighter transportation equipment, such as snow scooters, to cover the needs of smaller projects that often operate closer to Troll.

The Tor field station is a small research station about 110 km east of Troll in the Svarthammeren area, where there are large petrel colonies. This station is mainly used by biologists in connection with ornithological studies of bird life in the area, but other scientists may also use this station if they need to.

In recent years, some permanent research installations have also been established at Troll, in cooperation with other nations:

– A gravimeter in cooperation with Finnish scientists (Finnish Geodetic Institute)

– MARA (Moveable Atmospheric Radar for Antarctica), in cooperation with Swedish scientists (Institute of Space Physics, Kiruna)

– Ground temperature loggers (belonging to the South African National Antarctic Programme)

– A seismic station (NORSAR)

– Automatic weather stations (the Norwegian Meteorological Institute)

– Trollsat (Kongsberg Satellite Services - KSAT), establishing antennas to download data from satellites in polar orbit as well as communication antennas

– A Galileo ground station (Galileo is the European equivalent of the American GPS system)

– An air monitoring observatory (the Norwegian Institute for Air Research - NILU)

DAILY LIFE AT THE STATION

Activities at Troll are mainly divided into two seasons: summer and winter.

Summer

The summer season lasts from the beginning of November to late February/early March. It is during this period that activities are at their peak, both in terms of logistics and infrastructure, and in terms of research-related projects. There is a lot of work to be done during the summer, of which the most resource-demanding are the transport of supplies from the coast to Troll, maintenance of transport equipment and other machinery (the power station, appliances, power tools, and so on) and keeping the airfield in operative condition. In addition to this, the infrastructure at Troll can always be improved, and research projects need support. The workdays are long and there are few days off during the 4-month summer season at Troll. Leisure time after dinner in the evenings (at 8 PM) and the single day off every other week, is used for mountain treks, work-outs, film nights and other social activities. The quarters at Troll are optimised for the activities that go on during the summer season, so living is cramped for everybody and there is very little opportunity for any private life to speak of. But Troll residents have good opportunities to communicate with family and friends at home in Norway, both via the Internet and by telephone.

Winter

During the winter season, things settle down and the pace is slower. Only six people spend the winter at Troll: a research technician, a doctor, a cook, a mechanic, an electrician, and a works technician. Their most important task is to run the station during the winter period, i.e. see to it that the power station produces electricity, that the instruments and the technical equipment work as they should, as well as seeing to day-to-day maintenance. There is more leisure time during the winter season, and there are ample opportunities to go on excursions in the surrounding areas, work out, study, practice various hobbies, and so on. The challenges involved in establishing the necessary infrastructure and expertise to run the year-round station in Antarctica have been great - maybe greater than anybody had imagined beforehand. Having now come as far as 2012, we can at least note that the main components are in place, and that the research station's operational organisation leaves nothing to be desired when compared to that of the other national operators in Dronning Maud Land. Development remains to be done at Troll and in the coming years, we will continue expanding the infrastructure and increase the efficiency of our logistics to cover the ever-increasing demand for research in the Antarctic.

Troll residents gather for a chat before dinner. Sushi is on the menu this evening.

Tor Field Station, 110 km east of Troll Station, lies near a colony of Antarctic petrels.

Helge M. Markusson // Outreach coordinator, Fram Centre

What happens when the forest turns black?

For several years running, the birch forest moth has been wreaking havoc on vast areas of mountain birch forest in the Northern Norwegian counties of Troms and Finnmark. Scientists are now trying to find out what happens when the moth has eaten its fill.

A SINGLE LITTLE BUG on its own doesn't cause much damage, but if they arrive by the millions and one species takes over when the first one quits, the result is many thousands of square metres of black, dead forest.

The culprit is the birch forest moth, and the big problem is that there are several species of it.

The birch forest moth is a grey-white species in the family Geometridae, whose larvae live in various trees, bushes and herbs.

Until a hundred years ago, the autumnal moth *(Epirrita autumnata)* operated all on its own in the north, but with climate change, the winter moth *(Operophtera brumata)* has spread into areas where the autumnal moth used to be the only species of birch forest moth. The two species have been taking turns tucking in, first the autumnal moth and then the winter moth. And the result is inevitable: stripped of leaves, the forest goes black.

"The trees don't have time to recover after one attack before they fall victim to attack number two," says Jane Uhd Jepsen, scientist at the Norwegian Institute for Nature Research at the Fram Centre.

A RESEARCH PROGRAMME IN THE TOP-LEVEL RESEARCH INITIATIVE

Through a newly established research programme, scientists at the Norwegian Institute for Nature Research and the Department of Arctic and Marine Biology at the University of Tromsø are trying to find out what happens after the voracious birch forest moth has eaten its fill.

The project, which is partly financed through the Fram Centre's project "Effects of climate change on terrestrial ecosystems, landscapes, society and indigenous peoples", is divided into several different studies.

FOR FURTHER READING

This project is presented in greater depth on pages 46–49.

DEAD FOREST BEARS NEW LIFE

When the birch forest moth attacks, it leaves behind large amounts of dead wood in the forests. That is good news for some.

"This wood constitutes a sudden glut of resources for many insect and fungus societies. Along a gradient that stretches from an area with serious outbreaks and a lot of dead wood to an area with healthy forest and little dead wood, we have been collecting insects all summer long in what we call window traps.
"These samples will form the foundation for a characterisation of the composition of the insect society, as well as of the importance of such concentrations of resources for the dynamism in selected groups of insects," says Ole Petter Vindstad, research fellow at the University of Tromsø, who is working on the project.

GRAZING PRESSURE

"We are also looking at how grazing pressure from herbivores impacts the forest's ability to regenerate after a birch forest moth attack", says Jepsen.
"We have established twelve experimental research plots of 30 × 30 metres, six on each side of the Norwegian-Finnish border, and are comparing the development of the vegetation and forest regeneration in these districts with development in open areas where reindeer have free access.
"In addition, within each of the large research plots, we have set up small research plots where grouse, hares and small rodents are shut out. The sampling areas have been established with a long-term perspective, as natural forest regeneration is a slow process. The research plots are there to stay for at least 10 years," explains Jepsen.

MANAGEMENT

Cooperation with FeFo (the company in charge of county-owned land in Finnmark) and the Governor of Finnmark, has also led to the initiation of a study of the importance of management measures that may promote natural forest regeneration, including felling of timber and interventions in the vegetation cover.

"At two locations, we have staked out 20 areas measuring 30 × 30 metres, which will be cut clear this autumn. We will compare the development of the vegetation and the forest regeneration in these areas versus areas that have not been subjected to logging.
"A scarification experiment has also been initiated, where we intervene in the vegetation cover manually and compare natural regeneration from seeds there and in areas that have not been intervened in," concludes Jepsen.

The overriding objective of the interdisciplinary Nordic top-level research initiative "NCoE - How to preserve the tundra in a warming climate" or "NCoE-Tundra" is to study the importance of small and large herbivores as a possible counterweight to climate-driven bush encroachment on tundra areas.
The programme consists of a total of eight work packages.

The Fram Centre is involved in work package No. 4, the objective of which is to substantiate the interaction between severe attacks by birch forest moths and herbivores, especially reindeer and small rodents, and the part played by grazing in forest regeneration after damage inflicted by birch forest moths.

Jane Uhd Jepsen, Martin Biuw // Norwegian Institute for Nature Research
Rolf A. Ims // Institute of Arctic and Marine Ecology, University of Tromsø

NCoE-Tundra

A new Nordic Centre of Excellence with focus on climate-driven shrub and tree line expansion in tundra ecosystems

SCIENTISTS HAVE REASON TO BELIEVE that a warming climate will permit trees and shrubs to migrate northward, invading the tundra. If so, that may have serious implications for the species that currently inhabit these ecosystems - including humans.

What if climate change makes it impossible to maintain traditional reindeer herding? Intriguingly, some evidence suggests that grazing reindeer and other native plant-eaters might counteract the northward march of trees and shrubs.

TUNDRA ECOSYSTEMS UNDER PRESSURE

There is currently much scientific and public interest in the fate of tundra ecosystems under climate warming. The northern tundra biome covers about one fifth of the world's land surface and plays a crucial role in regional and global climate regulation. It harbours ecosystems with a large number of endemic species adapted to this very special environment. According to conventional projections in climate change scenarios, subarctic forests and shrublands are expected to expand into tundra areas. For instance a moderate 2°C increase in global mean temperature above preindustrial levels is projected to cause a reduction in tundra areas by 42% globally and as much as 88.1% in Northern Fennoscandia and NW Russia. Indeed, we can already see a trend towards increased productivity across the northern tundra biome, which can be at least partially attributed to more shrub cover.

These prospects are dramatic for the northern tundra, which could be facing a biodiversity crisis with extensive loss of habitat and species, including endemic ones such as the arctic fox. The projected shifts in the tundra-forest boundary would also alter the quality and quantity of forage for caribou and reindeer, and would force changes in the use of seasonal grazing grounds. This could threaten the foundation for traditional reindeer husbandry as it is practiced in northern Fennoscandia today.

NATIVE HERBIVORES AS "ECOSYSTEM ENGINEERS"

The good news is that native herbivores, such as reindeer, voles, lemmings and even certain insect pests, may act as "ecosystem engineers" in ways that could potentially counteract the climate-driven encroachment process. For instance grazing by large herbivores such as reindeer and muskoxen can effectively limit the spread of shrubs in tundra regions, and voles and lemmings can play the same role in the forest. One exciting implication of this is that it may be possible to design management interventions to help mitigate the local effects of climate change in tundra regions.

Grazing is not the only process that can control encroaching vegetation. In Fennoscandia any limiting effect of reindeer grazing on shrub and forest expansion is likely to interact with the periodic disturbances provided by recurring outbreaks of geometrid moth (in particular winter moth *Operophtera brumata* and autumnal moth *Epirrita autumnata*). It is likely that moth outbreaks will become more severe because of climate warming, potentially killing off the forest and shrub vegetation over large areas. Subsequent grazing by reindeer may then prevent or slow down the natural regeneration of the forest. This is already evident in Northern Finland where large tracts of reindeer grazing ground - formerly covered by birch forest - remain treeless after a large moth outbreak in the mid 1960s. It has even been suggested that the combined effects of moth outbreaks and reindeer grazing may cause a complete regime shift, from forest to secondary tundra. If so, this may have dramatic implications in terms of the forest/tundra balance and its controls on regional or even global climate.

Experimental exclosures to exclude large and small herbivores in a moth-damaged forest. *Photo: J.U. Jepsen*

A JOINT NORDIC RESEARCH NETWORK

In 2011 the Nordic Council of Ministers/NordForsk launched three new Nordic Centres of Excellence (NCoE) under the Top-level Research Initiative program “Effect studies and adaptation to climate change”. FRAM Centre researchers from Tromsø University, the Norwegian Institute for Nature Research and Norut Northern Research Institute are involved in one of these, the NCoE-Tundra: How to preserve the tundra in a warming climate? NCoE-Tundra provides an inter-disciplinary platform for a team of Nordic researchers with expertise in arctic and northern ecology, socio-economics, climate and remote sensing.

The scope of NCoE-Tundra is to study how interaction between climate processes and herbivores (and to some extent their predators) modifies regional vegetation patterns, and to integrate this perspective with reindeer husbandry and the Sámi culture that depends on it. Ultimately, the goal is to learn how the impact of reindeer on vegetation can be optimally applied to prevent shrub encroachment and forest expansion into tundra ecosystems. To achieve this goal, eight specific work packages (WPs) have been formed, each dealing with a particular topic. Fram Centre researchers are making substantial contributions to WP4 (led by Rolf A. Ims, University of Tromsø, with contributions from NINA) and WP5 (led by Bernt Johansen, Norut).

In WP4 we collaborate with Finnish colleagues to document the effects of native herbivores on the natural succession and soil processes in birch forest following one of the most severe moth outbreaks on record, which occurred during the last decade. In 2011, twelve experimental exclosures designed to keep large herbivores (primarily reindeer) away from the vegetation, were constructed in moth-damaged forest along the fenced Norwegian-Finnish border. To separate the effects of large and small herbivores, many small cages were set up within the exclosures to keep out smaller herbivores such as hare, ptarmigan, voles and lemmings. We make use of the fact that management practices differ in the two countries. On the Finnish side, reindeer grazing intensity is high year-round, whereas it varies seasonally on the Norwegian side. This allows us to examine the relationship between grazing, and succession and forest regeneration.

The natural succession of the forest vegetation will be followed closely and contrasted to nearby unfenced areas in order to determine if moth outbreaks and grazing can indeed cause a complete shift from forest to secondary tundra. The implications of such controls on vegetation can be profound, not only in terms of ecosystem resilience and local subsistence, but also through regional and even global climate feedback.

NCOE-TUNDRA PARTNERS

- Turku University
- Umeå University
- Tromsø University
- Finnmark University College
- Norut Northern Research Institute
- Arctic Center
- Finnish Meteorological Institute
- Norwegian Institute for Nature Research
- Oulu University

Schematic overview of the main research questions addressed by the eight work packages (WPs) in NCoE-Tundra. Fram Centre researchers are involved in WPs 4 and 5.

Can wild and semi-domesticated herbivores counteract a climate-driven expansion of shrubs and trees into the northern tundra?

To what extent are arctic-alpine food webs controlled by predation?
(WP1)

What are the effects of herbivores on tundra vegetation?
(WP2)

How does reindeer grazing affect rare arctic-alpine plants?
(WP3)

Can reindeer grazing prevent or redirect the natural succession of forest vegetation after insect outbreaks?
(WP4)

What are the large scale impacts of herbivory on vegetation? Remote sensing synthesis
(WP5)

Socio-economy of reindeer herding systems: how have past and present herding practices affected tundra shrub cover?
(WP6)

How do changes in tundra vegetation influence local and regional climate?
(WP7)

Synthesis and recommendations
(WP8)

Gunnar Sætra // Institute of Marine Research

Long-term cooperation with new challenges

Norwegian and Russian marine scientists have been cooperating for more than half a century. Climate change is now making them face new challenges.

On the steps
It is 55 years since Norwegian and Russian marine scientists initiated a formal cooperation. A Russian delegation of marine scientists visited Bergen in the winter of 1957. This picture was taken when a group of Norwegian marine scientists returned the visit in the autumn of 1958.
Photo: Archives of the Institute of Marine Research

DURING THE WINTER OF 1957, a group of Russian marine scientists visited their Norwegian colleagues in Bergen. There had been sporadic contacts between Norwegian and Russian marine scientists both before and after the revolution in 1917, but the meeting in Bergen came to be considered as the start of the formal cooperation between Norwegian and Russian (Soviet) marine scientists.

FROM HERRING AND COD...

At the end of the 1950s, there were signs of depletion in the large fish stocks in the Norwegian Sea and the Barents Sea, and the marine scientists started to look into whether this could be connected with overfishing. The herring population had started to decline after the peak year of 1956, and there were tendencies to reductions in the cod fisheries after peak catches in the mid 1950s.

Norwegian marine science got started around 1860, and at around the same time Czarist Russia started doing research on the great fish stocks in the Barents Sea. The Russians completed their first research mission outside the Norwegian coast as early as 1860. They then surveyed the large stock of Norwegian spring-spawning herring (NSSH herring) and the seasonal cod fishery in the Lofoten islands.

Also during the first years after 1957, the NSSH herring and the North-East Atlantic cod played a key part in the Norwegian-Russian (Soviet) cooperation on marine science. Both countries had major financial interests in the fisheries of these species, and both species stayed temporarily off the coasts of both countries. A cross-border exchange of knowledge therefore became important, even though Norway and the Soviet Union were on different sides of the Iron Curtain. Gradually, the scientists started working together more and more often, and 1956 saw the start of the first 0-group surveys or fry surveys. On these missions, the year's fry population was measured for most of the fish species that are harvested. Also the shrimp population in the Barents Sea was measured during these missions. Later on, there have been more joint survey missions, in order to measure, among other things, the capelin population (starting in 1973), cod (from 1980), juvenile herring (from 1984), whale (from 1987), seal (from 1990), Greenland halibut or turbot (from 1992) and red king crab (from 1994). The research missions have been designed in different ways. During some of them, Norwegian and Russian (Soviet) research vessels have operated together, Russian scientists have participated on board Norwegian vessels and vice versa, or scientific data have been exchanged.

On the same steps
Norwegian and Russian marine scientists meet in March every year for scientific discussions and planning of the coming survey missions. In 2011, "the March meeting" was arranged in Murmansk.
Photo: Gunnar Sætra, Institute of Marine Research

...TO ECOSYSTEMS AND NEW CHALLENGES

In 2001, the old research missions to survey individual fish stocks coalesced to comprise surveys of the entire ecosystem in the Barents Sea. Presently, research is being conducted on everything from microorganisms on the seabed, phytoplankton and zooplankton, the large fish stocks, seal, whale, ecotoxins and pollution, to birds in the sky. The research missions cover the entire Barents Sea and are conducted from late August to early October. In addition, research missions surveying individual fish stocks are still conducted.

Climate change has brought about new challenges for marine scientists. The ice edge is retreating ever farther northwards. Consequently, new areas are opening up and the marine scientists want to investigate these.

"This involves new requirements as regards the design of the research missions and where they are to be conducted"

said the Heads of Research Ole Arve Misund (the Institute of Marine Research, Norway) and Yuri Lepesevich (Knipovich Polar Research Institute of Marine Fisheries and Oceanography, Russia) after the Norwegian-Russian symposium on marine science and oceanography held in Longyearbyen in Svalbard, last autumn.

IMPORTANT CONTRIBUTIONS

Around 1990, most of the fish stocks in the Norwegian Sea and the Barents Sea were in a critical condition. Norwegian and Russian marine scientists recommended record low catch quotas, something which

was followed up by the Norwegian-Russian Fisheries Commission. The commission introduced strict regulations; as a result, catch quotas could be raised again in the mid-1990s. Already at the time, then Norwegian Minister of Fisheries Jan Henry T. Olsen declared that the management of the fish stocks in the north is "the best in the world". The Norwegian-Russian marine science collaboration has contributed important expertise and has thus participated in creating the foundation for "the world's best fisheries management".

DIFFERENT TRADITIONS

Marine scientists who have participated in the Norwegian-Russian scientific cooperation say that it was a meeting between two different traditions, but that it worked well all the same.

"In the beginning, we were more concerned with measuring the sizes of fish stocks than our Russian colleagues. They spent more time studying stomach contents to find out what the fish ate and thereby see connections between the different species. Simply put, they were concerned with what we today call ecological connections, while we counted fish," says one of the most prominent veterans of Norwegian marine science, Odd Nakken.

Nowadays, the scientific proximity between the two parties is closer. At the same time, experiences include Russian authorities refusing to let Norwegian research vessels enter the Russian economic zone.

"We never experienced that during the cold war, when the name of the country was the Soviet Union. It's a paradox," says Nakken.

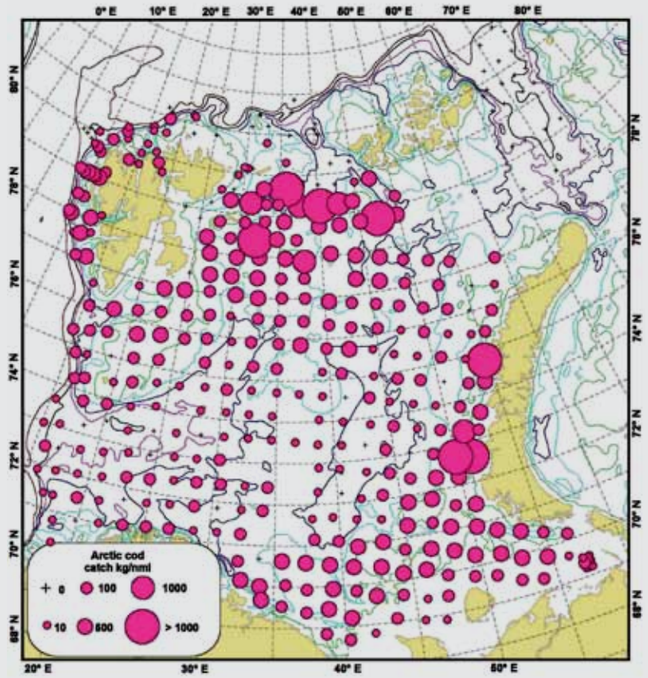
COMMUNICATING PERSON TO PERSON IS IMPORTANT

When the first joint research missions started in the 1960s, the Norwegian and Soviet research vessels had to calibrate their sound measuring equipment in relation to each other. That meant that they had to visit each other's ships, a fact which led to extensive personal communication between scientists from Norway and the Soviet Union.

"It was nice meeting Russian colleagues. We got the chance to talk shop as well as discussing more everyday matters. I can't remember that we ever talked about politics," says Nakken.

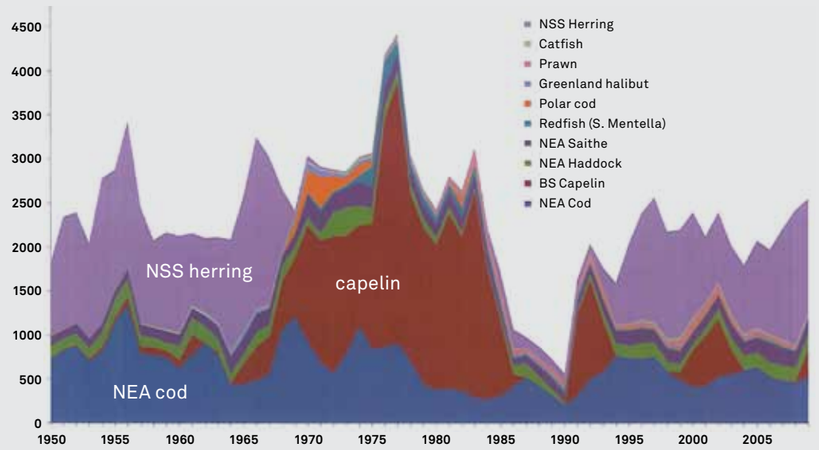
He thinks that the person to person communication researchers got while visiting each other's ships and through the regular scientific meetings has been important to the development of the Norwegian-Russian scientific cooperation.

Norwegian–Russian marine science collaboration occurs first and foremost between the Institute of Marine Research (IMR), Norway, and the Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO) in Murmansk in Russia. The Russian Federal Research Institute of Fisheries and Oceanography (VNIRO) in Moscow also participates in the cooperation. In addition, the marine scientists make use of knowledge contributed by various other universities and institutes in both countries.



World record
Never before have cod been recorded as far north in the Barents Sea as in 2011.
Graph: Institute of Marine Research

Landings in the Barents/Norwegian Seas 1950–present



Catches
The development in catches of different fish species from the Norwegian Sea and the Barents Sea. The collapse in 1990 imposed new requirements on fisheries management.
Graph: Institute of Marine Research, December 2011

Climate, fishing and the Barents Sea Ecosystem

Nina Buvang Vaaja // Head, Arctic Council Secretariat

The Arctic Council Secretariat at the Fram Centre

AT THE LAST MINISTERIAL MEETING in Nuuk, Greenland on 12 May 2011, the Foreign Ministers of the eight Arctic states decided to establish a permanent Arctic Council Secretariat in Tromsø. The permanent secretariat is to be operational from May 2013, when Canada takes over the Chair from Sweden.

A temporary secretariat has been located in the Fram Centre since 2007, and this will continue to be in function until the permanent secretariat is ready to take over. In 2012, the temporary Secretariat has four employees, and one intern. The Secretariat is an administrative service unit, assisting the Chair of the Arctic Council with planning and arranging meetings, with administration and with information/outreach, primarily via the web site www.arctic-council.org. The web site is available in both English and Russian.

To prepare for the opening of the permanent secretariat in 2013 the Arctic Council has established a task force to negotiate the necessary agreement and the administrative framework. The task force has proposed that the recruitment process to identify the new Director and the rest of the team who will be working at the Secretariat from May 2013, should start in 2012. The Secretariat will employ up to ten people. Its functions will be the same as before, but with additional focus on continuity, coordination, institutional memory (archive and other administrative tasks) and outreach.

When the new building of the Fram Center is completed in 2014, the Arctic Council Secretariat will move into its new, permanent premises. The Secretariat will be a truly international tenant in the Fram Center: it will recruit its employees from the eight Arctic states and have English as its working language. Through a "Host country agreement" with Norway, the Secretariat will be established as an international unit with diplomatic immunity.

The work of the Arctic Council is producing tangible results. Pollution was the main focus during the first decade of Arctic cooperation. It is still a key issue. We saw unacceptable levels of environmentally hazardous substances and heavy metals in the Arctic in spite of the distance from industrialised areas. In our second decade of Arctic cooperation, we turned to climate change. We became aware that we have front row seats for observing climate change. The comprehensive reports of climate change in the Arctic have been of major importance in highlighting the speed at which climate change is taking place and its implications.

In the third decade of Arctic cooperation, we are turning our attention to adaptation, while continuing to deal with pollution and climate change. In May 2011, the member states signed the first legally binding agreement negotiated under the auspices of the Arctic Council. The agreement establishes a binding framework for search and rescue cooperation between the member States of the Arctic Council.

Photos: Ulrik Bang

FACTS

In 1996 the Ottawa Declaration established the Arctic Council as an intergovernmental forum promoting cooperation, coordination and interaction among the Arctic States, with the involvement of the Arctic Indigenous communities and other Arctic inhabitants on topics of mutual concern, particularly issues of sustainable development and environmental protection in the Arctic. The Foreign Ministers of the Council meet every second year. The most recent meeting was 12 May 2011 in Nuuk. The next Ministerial Meeting will take place 15 May 2013 in Kiruna, Sweden.

Members: Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden and USA

The Arctic indigenous communities are also represented in the Arctic Council by the category "Permanent Participants". There are six Permanent Participants: the Aleut International Association, the Arctic Athabascan Council, the Saami Council, the Inuit Circumpolar Council, Gwitch'in Council and the Russian Association for indigenous peoples (RAIPON).

WORKING GROUPS

There are six working groups in the Arctic Council:

– Arctic Contaminants Action Program (ACAP)
– Arctic Monitoring and Assessment Programme (AMAP)
– Conservation of Arctic Flora and Fauna (CAFF)
– Emergency Prevention, Preparedness and Response (EPPR)
– Protection of the Arctic Marine Environment (PAME)
– Sustainable Development Working Group (SDWG)

Gunn Sissel Jaklin, Janne Schreuder // Nansen–Amundsen Year 2011 Secretariat, Norwegian Polar Institute

Nansen–Amundsen Year 2011

THE YEAR 2011 combined two jubilees of great significance for Norway: the polar explorer, great scientist, humanitarian and Nobel laureate Fridtjof Nansen was born 150 years ago, and polar explorer and air pioneer Roald Amundsen and his men conquered the South Pole 100 years ago. Not known as hero-worshippers, Norwegians nevertheless regard these two men as true national heroes.

TROMSØ AND THE SOUTH POLE

In Norway, the year 2011 was devoted to commemorating Nansen and Amundsen and their achievements. Tromsø was the venue for the opening and the final event of the year: Foreign Minister Jonas Gahr Støre undertook the official opening on 23 January, and HRH Crown Prince Haakon Magnus took part in the celebrations of the South Pole conquest on 14 December. Prime Minister Jens Stoltenberg participated from the South Pole, as he addressed the Crown Prince and the crowd of spectators at Tromsø's main square via live satellite transmission. Jan-Gunnar Winther, director of the Norwegian Polar Institute (NPI), was also present at the South Pole. He reported from his crossing of the Antarctic ice, retracing Amundsen's route accompanied by NPI historian H.D. Jølle, Olympic skier V. Ulvang and explorer/writer S.P. Aasheim. About ten Norwegian expeditions to the South Pole commemorated Amundsen's achievement in 2011.

In Tromsø, primary schoolchildren learned about Nansen and Amundsen throughout the year, approaching the themes in many creative ways. Many children also tracked the progress of the NPI South Pole Expedition by reading their fact-filled blog.

EVENTS

During the year, more than 300 events took place in Norway and abroad. Films were shown, books published, and theatre performances, concerts, debates and talks were held. The people of Norway showed great interest in the Nansen-Amundsen year 2011.

Norwegian embassies abroad also arranged seminars and exhibitions. In Oslo, HM King Harald, along with Prime Minister Stoltenberg and UN Secretary General Ban Ki-moon addressed a great crowd of people at University Square on Nansen's birthday on 10 October. The National Library, the Nobel Peace Centre and the Fram Museum showed new exhibitions, and King Harald unveiled a statue of the South Pole party.

IMPORTANT MEN – NEW KNOWLEDGE

Can anything new be learned from or about Nansen and Amundsen? The answer is a resounding Yes! One example is the exhibition "Snowhow: What the polar heroes learned from the Inuit, the Saami and the Arctic seafarers" at the dry dock of the sealing vessel M/S *Polstjerna* in Tromsø. It reveals to modern exhibition-goers just how much Norway's polar icons

HRH Crown Prince Haakon Magnus converses with Prime Minister Jens Stoltenberg via video link between Tromsø and the South Pole during the festivities on 14 December 2011. *Photo: Nansen-Amundsen Year 2011 / Lars Åke Andersen*

HRH Crown Prince Haakon Magnus listens with interest as a Tromsø schoolgirl shares what she and her classmates learned during the Nansen-Amundsen Year 2011. *Photo: Nansen-Amundsen Year 2011 / Lars Åke Andersen*

Ann Kristin Balto of the Norwegian Polar Institute presents an outdoor exhibition. *Photo: Nansen-Amundsen Year 2011 / Lars Åke Andersen*

learned from people adapted to the harsh conditions of the Far North. The knowledge that Amundsen and Nansen gained from Northern people about clothing, kayaks, dog sleds, sailing in ice, and other things was crucial the success of their expeditions in the Arctic and Antarctic.

The year saw the publication of several new books that shed light on the complex characters of Nansen and Amundsen, including a biography of Nansen by NPI historian H.D. Jølle. The Fram museum published Nansen's diaries and those of the members of the Fram expedition to the North and the expedition to the South Pole. Historian Robert M. Friedman wrote a play - first shown at Hålogaland Theatre in Tromsø, which also contributed to a more nuanced understanding of the two polar heroes.

AIM AND STRUCTURE

The aim of the Nansen-Amundsen Year 2011 was to spread knowledge about and create interest in Nansen's and Amundsen's lives and achievements, and to focus on their roles in building the Norwegian nation and as polar heroes. Their contributions to science and the arts were highlighted, in addition to Nansen's achievements as a diplomat, politician and humanitarian of global stature.

To organise the jubilee year, the Government appointed a steering group led by the Ministry of Justice, with members from the Office of the Prime Minister, the ministries of Foreign Affairs, the Environment, Trade and Industry, and Education and Research, and from the National Library, the Nobel Peace Centre and the NPI. The initiative to celebrate the year came from the NPI, which also hosted the Secretariat.

For more information, see www.nansenamundsen.no.

2011 | NANSEN AMUNDSEN

Janet Holmén // Editor, FRAM Forum

New geodetic observatory in Ny-Ålesund

JUST BEFORE CHRISTMAS the Norwegian Ministry of the Environment announced their decision to allocate funding for construction of a new geodetic observatory in Ny-Ålesund, Svalbard. The news was greeted with jubilation at the Norwegian Mapping Authority.

"This is the best Christmas present we could possibly get," said General Director Anne Cathrine Frøstrup. "High-precision measurements are the foundation of everything the Mapping Authority does."

The observatory measures movement in the earth's crust, its rotation, and its exact position in the universe. The antenna in Ny-Ålesund is part of a global network of geodetic observatories that play a crucial role in satellite-based communication. Without high-precision data on where the satellites are in relation to the earth and each other, GPS systems would not work and many of us would – literally – be lost.

And that's not all: the geodetic observatory provides information that allows scientists to monitor the earth's climate with great precision. Monitoring changes in climate, sea level, and glaciation requires a stable reference point. For example, if sea level rises at the same rate as an adjacent landmass bounces back after the last ice age, there will be no apparent change in the coastline. But the change exists. By measuring the position of land and sea in relation to the universe, rather than to each other, it is possible to detect changes that cannot be seen.

But the current observatory already does all that. Why build a new one?

As explained in the press release from the Ministry of the Environment, some of the existing equipment is outmoded and must be replaced; the demand for precision has now outstripped the capabilities of the old antenna.

"New technology and a combination of more measurement techniques will provide greater accuracy in these data, which are part of a world-wide observation and research network," says State Secretary Heidi Sørensen at the Ministry of the Environment.
"I'm glad the government has now decided to build a new geodetic observatory in Ny-Ålesund."

This important new research infrastructure has been on the Mapping Authority's wish list for quite a long time. According to Per Erik Opseth, director of the geodetic division, upgrading the facilities has had top priority.

"The fact that the government has decided to finance a new observatory will help secure our position internationally, and will increase our competence and significance in both earth observation and climate monitoring," he says.
"This is a red-letter day for us."

Other institutions and organisations are also pleased by the news.

"[This decision] is very important for Ny-Ålesund," says Knut M. Ore, Chairman of the Board of Kings Bay AS, which runs the international research village of Ny-Ålesund.
"For the research community in Ny-Ålesund and for research in general," says Ore.

Alongside the Norwegian Polar Institute, the Alfred Wegener Institute (Germany) and Institut Paul Emile Victor (France), the Norwegian Mapping Authority is one of the largest research institutes with permanent bases in Ny-Ålesund. Kim Holmén, international director at the Norwegian Polar Institute, has long emphasised the importance of the Svalbard antenna for the global network of geodetic observatories.

The fact that the observatory and other research activities are co-localised in Ny-Ålesund gives opportunities for interdisciplinary cross-pollination. "Having all of this research in one place gives a powerful combination of knowledge that is unique in the Arctic," says Holmén. He feels that the Mapping Authority can play an important part in Ny-Ålesund's future and broaden the village's potential. "I congratulate the Mapping Authority and look forward to continued fruitful collaboration," he says.

It will take five years from groundbreaking until the new antenna is ready to use. Once everything is in place, the old and new equipment must be run in parallel for three years to ensure that all data series are complete. Only then will the old antenna be dismantled.

The old antenna stands right beside the airstrip in Ny-Ålesund.
Photo: Kim Holmén, Norwegian Polar Institute

Helge M. Markusson // Outreach coordinator, Fram Centre

The last place you'd expect a black-legged kittiwake to want to live!

A man-made precipice in one of Norway's largest industrial plants has become the number one most desirable place of residence for the area's black-legged kittiwakes. Totally unexpected to both scientists and the plant's owners, the Statoil company.

"Yes, you can safely say that this came as a surprise to us!" says Geir Helge Systad, seabird ecologist at NINA, the Norwegian Institute for Nature Research.

Systad works at NINA's local department at the Fram Centre, where one of his tasks is to keep track of the black-legged kittiwake population along the Norwegian coast. This is one of the projects in the SEAPOP programme (see fact box). The black-legged kittiwake is a medium-sized seagull which is most easily recognised by its black wing tips and a more tern-like flight than other gulls. This is the world's most numerous seagull species, but scientists have recorded a decline in the number of black-legged kittiwakes in recent years. The population decline is so severe that the species is now on the Norwegian red list, an assessment of the risk of extinction. Species that suffer population decline and that risk becoming extinct in parts of Norway are designated "endangered species" and end up on the red list.

"At Hjelmsøya island in Finnmark county, for instance, we have recorded a population decline of almost 90% since monitoring started in 1984. All over the North Atlantic, we observe reduced numbers of this species. We believe one of the main reasons is food shortage," says Systad.

But there is no such decline at Melkøya, just outside the city of Hammerfest in Finnmark county. By the time the construction work for the giant gas plant was completed, the island's topography had undergone major changes: the excavation work to lay the foundation for the industrial plant left a sheer rock wall with surfaces ideally suited as nesting places for black-legged kittiwakes. And the kittiwakes moved in. The man-made cliff face now houses around 2500 breeding pairs of black-legged kittiwakes!

Black-legged kittiwakes in an unexpectedly industrial setting. *Photo: Geir Helge Systad, NINA*

A black-legged kittiwake and two chicks on the cliff face overlooking the gas plant at Melkøya. *Photo: Geir Helge Systad, NINA*

SEAPOP

SEAPOP (short for "seabird populations") was started in 2005 and is a comprehensive, long-term programme to monitor and survey Norwegian seabirds.
The participating institutions are all Fram Centre members: the Norwegian Polar Institute, the University of Tromsø and NINA, the Norwegian Institute for Nature Research. The NINA division in Trondheim is also involved in the programme.
SEAPOP aims to survey the distribution of breeding, moulting and resting seabirds, as well as seabirds that spend the winter in the north, in terms of numbers, time and space along the coast of Norway and Svalbard within a ten-year cycle (which corresponds to the expected validity of such data). The programme also aims to identify the reasons for changes that occur during the same period of time.

"Before the completion of the construction work on the island, there had been no reports of black-legged kittiwakes nesting here, only that they used the island as a place to rest. This is a different matter entirely, and the island now appears to be the number one desirable address for black-legged kittiwakes," says Systad with a smile.

The smiles on the faces of the plant's operators, Statoil, weren't quite as wide when they discovered the size of the colony. Twenty-five hundred pairs make an infernal racket; they don't have to chip in and cover the cost of waste collection or clean-up either. And they have only one thing on their minds: breeding. All the same, the story may have a happy ending.

"True, Statoil could legally have demolished the entire 'neighbourhood'. Luckily, Statoil has strict in-house guidelines on biological diversity and the company's environmental department found solutions that accommodate all parties. They are paving the way for future coexistence, for instance by relocating workmen's huts, and they will do what they can to avoid disturbing the birds during the vulnerable nesting season," explains Systad.

Why do the black-legged kittiwakes want to live right in the middle of an industrial zone?

"They're pretty much like us humans when it comes to behaviour patterns. The rock face is 'tailor-made' for kittiwake housing - nests - and the birds have few other natural enemies here. For example, we don't see many white-tailed sea eagles at Melkøya. We know that the black-legged kittiwake conducts thorough reconnaissance before it settles down and builds a nest. The sight of other kittiwakes nesting contentedly signals that this is a suitable place to breed."
"Rather like us when we're house-hunting?"
"Yes, you could put it that way," says NINA-fellow Geir Helge Systad.

Gunnar Sætra // Institute of Marine Research

Educational about ocean acidification

A mixture of facts and drama is being used to communicate how sea water is getting more acid and what consequences that may have for life in the ocean.

"This was awesome! I learned a lot!" exclaims Mari Guttormsen.
"So did I. It was really interesting!" agrees Vilde Gjærum.

The two students at Nordkjosbotn upper secondary school clearly enjoyed the performance about ocean acidification that they attended at the Fram Centre in September 2011. This educational happening was created at the initiative of the Fram Centre Flagship *Ocean acidification in northern waters*.

Through a mixture of factual information and dramaturgic techniques, Kriss Rokkan Iversen and Kjersti Eline Tønnesen Busch showed the students how sea water is becoming more acidic and what consequences that may have for life in the ocean. The students learned about the chemical reactions that occur when the ocean absorbs CO_2 from the atmosphere; they got an introduction to how various species with shells containing calcium carbonate are built up and what might happen to them as the ocean gets more acidic. Afterwards, the students summed it up as having been both exciting and educational.

"The performance lasted all of one and a half hours and it held the students' attention straight through. That's well done!" says biology teacher Anne Siig Meen at Nordkjosbotn School.

Scientist Maria Fossheim at the Institute of Marine Research heads the Fram Centre's ocean acidification flagship. She says that research on the effects of ocean acidification is still at the starting line, but they are giving communication high priority.

"We want research and research communication to walk hand in hand. We are therefore going to inform the general public about our research while it is still in its early days. Students at the upper secondary level are one of many important groups that we target," says Fossheim.

The performance was created by Kriss Rokkan Iversen and Kjersti Eline Tønnesen Busch at the research, communication and consultancy company Salt. Both have doctorates in marine biology and they are enthusiastic about the assignment from the ocean acidification flagship and the Fram Centre.

"This is really exciting! This way of communicating about research is entirely new. Imagine getting the chance to tell people about research problems scientists are working on while the research is actually being done!" exclaims Rokkan Iversen.

Helge M. Markusson // Outreach coordinator, Fram Centre

Presenting Fram research to Dutch students

How do seals and reindeer survive in arctic areas? To explain this to Dutch students, we carved up the heads of a reindeer, a seal and a pig.

FORTY-SEVEN STUDENTS from Arenthem College in the Dutch city of Arnhem visited Tromsø in May 2011. Among the activities offered to the students was an educational event organised by the Fram Centre, in cooperation with the Department of Arctic Biology at the University of Tromsø and Polaria Arctic Experience Centre. A key partner in the scheme was Troms senior high school, who mediated the contact. The cooperation meant that the Dutch students got a tailor-made teaching plan where they learned more about arctic conditions, as well as how and why research is being done on arctic issues.

And in order to explain how things work, the laboratory was moved into the Polaria building. Lecturers cut open the heads of a reindeer, a seal and a pig to show the difference in how animals survive in salt water and in arctic areas, versus non-arctic areas. The visit also gave the Dutch students an opportunity to watch the seals being fed at Polaria, see films about Svalbard, and attend other lectures, some of them at the University of Tromsø.

Samuel Geiseler (M.Sc.) from the University of Tromsø shows Dutch youths how animals function in the Arctic. *Photo: Helge M. Markusson, Fram Centre*

Helge M. Markusson // Outreach Coordinator, The Fram Centre

Onwards and upwards

WE USED TO HEAR IT a little too often, this tale about successful relocation of public sector jobs from Oslo to "the provinces". But now Tromsø has become the capital of Norwegian research on the High North - and people outside Norway's borders are taking notice.
Things happened fast in 2009. The government decided to go in for expanding the Polar Environmental Centre. The intention was to establish a climate- and environment-oriented research centre with clout in Tromsø. Impetus came from the Ministry of the Environment, who saw a need for coordinated research on climate and the environment. The inducement was promises of fresh research funds, one of the results of the government's white paper "New Building Blocks in the North", part 2 of its High North strategy.
Over the ensuing 13 months, 19 research institutions came together to establish FRAM - the High North Research Centre for Climate and the Environment, or the Fram Centre for short. The scientists sat down and agreed, across disciplinary and institutional boundaries, on joint research efforts. On 29 September 2010, Norwegian Prime Minister Jens Stoltenberg officially opened the centre, and six days later the state budget confirmed that new funding was indeed being allocated to research on the High North in 2011.

THE FRAM CENTRE FLAGSHIPS

In addition to research done at the various member institutions, the Fram Centre framework includes five research programmes, our Flagships. Flagship research is financed mainly by the Ministry of the Environment, along with the Ministry of Fishing and Coastal Affairs, the Ministry of Education and Research and the Ministry of Foreign Affairs:

- *Hazardous substances - Effects on ecosystems and human health*
- *Effects of climate change on the sea and coastal ecology in the north*
- *Effects of climate change on terrestrial ecosystems, landscapes, society and indigenous peoples*
- *Ocean acidification and its impact on ecosystems in northern seas*
- *Sea ice in the Arctic Ocean, technology and agreements*

These five important fields have one thing in common: they concern our future.

EXPECTATIONS

This could have become yet another story about decentralisation, or moving jobs out of Oslo. But in contrast to many earlier decentralisation measures, the focus here is not on the number of jobs, but on the research itself.
The work the scientists are doing within the Fram Centre framework is going to be put to practical use; it is intended to benefit ordinary people - you and me - to benefit the politicians we have elected and the civil servants we have employed to manage the resources in the part of the world we call home.
Minister of Foreign Affairs Jonas Gahr Støre emphasised in a newspaper interview in Tromsø on 10 December 2011 that the expectations were high: "The Fram Centre is going to be the best, and the results they present are going to be impossible to ignore."

The Fram Centre glows under the Northern Lights. *Photo: Knut Jenssen, Fram Centre*

ATTENTION

The Fram Centre has received massive support and drawn attention throughout 2011, the first year of its existence.
In 2011, allocations totalling 52.5 million Norwegian crowns were channelled from the four ministries to the Fram Centre and its five research flagships, and the same amount of funding is expected in 2012. In addition, there are the allocations and revenues that the 20 member institutions receive. This adds up to a sum that by no means insignificant.
The support from top politicians has been massive. Neither the Prime Minister nor the Minister of Foreign Affairs has held a single speech on the High North during the past year without mentioning the importance of the Fram Centre.
Two other countries, Canada and Iceland, both members of the Arctic Council, are now looking to Tromsø for ways to develop research on the High North. As a concrete result of this interest, there are plans to present the Fram Centre to members of parliament and universities in Ottawa in the spring, with a view to using the Fram Centre as a role model.

ADAPTATION

Nothing happens without wheels being set in motion, and it would be presumptuous to claim that the Fram Centre has attained its position through its own efforts alone. Several new commercial enterprises founded on research have been established through hard work, a drive for innovation, and intuition, and several old enterprises have expanded.
Kongsberg Satellite Services, with main offices in Tromsø, has built up a position as world leader in its field.
Bioprospecting, i.e., searching through the natural world in the hope of finding new chemical entities that might be of use to humankind, is a field under constant development, and Tromsø is on top of the situation.
The decision to establish a permanent secretariat for the Arctic Council in Tromsø will give the city a voice with international influence.
The fourth floor of the main Fram Centre building is currently being rebuilt to accommodate BarentsWatch, a comprehensive surveillance and information system for the northern maritime zones.
A considerable enlargement of the same building is also being planned, to ensure the best possible outcome of the Fram Centre's ongoing expansion.
The new facilities are to be completed in the second half of 2014.

Projects in the Fram Centre Flagships for 2011

Effects of climate change on sea and coastal ecology in the north (Fjord and Coast)

Physical-biological coupling: Oceanography and habitat use by predators and their prey

RESEARCH AREAS/PROJECT TITLES	PROJECT LEADER	PARTICIPATING INSTITUTIONS	FLAGSHIP	E-MAIL PROJECT LEADER
Climate variability and change in oceanographic conditions in fjords and coastal waters	Jofrid Skardhamar	HI, UiT, Bjerknes Centre	Fjord and Coast	jofrid.skardhamar@imr.no
Climate impacts on drift patterns of eggs and larvae of red king crab and coastal cod	Ole P. Pedersen	HI, UiT	Fjord and Coast	ole.p.pedersen@uit.no
Climate impact on anadromous salmonids	Kari Norheim Guttorm Christensen	VI, ApN, HI, NINA, NP	Fjord and Coast	kari.norheim@vetinst.no, guttorm.christensen @akvaplan.niva.no
Atlantic salmon: Biological and genetic knowledge and resource use among local people	Martin Svenning	NINA, NIKU	Fjord and Coast	einar.eythorsson@niku.no martin.svenning@nina.no
Drift of fish larvae and its effect on Norwegian seabird populations	Kjell Einar Erikstad	NINA, HI, NP	Fjord and Coast	kjell.e.erikstad@nina.no
Seabird habitat use	Børge Moe	NINA, NP, HI, UiT	Fjord and Coast	borge.moe@nina.no
Modeling trophic interactions and ecosystem dynamics	Øystein Varpe	NP, UiT, HI	Fjord and Coast	Oystein.Varpe@npolar.no

Structure, function and change in Arctic and boreal fjord ecosystems

RESEARCH AREAS/PROJECT TITLES	PROJECT LEADER	PARTICIPATING INSTITUTIONS	FLAGSHIP	E-MAIL PROJECT LEADER
Physical environment	Oddvar Longva	NGU, HI	Fjord and Coast	Oddvar.Longva@NGU.NO
Mapping nature-types in North Norway and Svalbard	Nina M. Jørgensen	ApN/NIVA, HI	Fjord and Coast	nina.jorgensen@akvaplan.niva.no
Benthic biodiversity and ecosystem function in Svalbard and North Norway	Lis Lindal Jørgensen Kari Ellingsen Sabine Cochrane	HI, NINA, APN, UiT, UNIS, HiFi	Fjord and Coast	lis.lindal.joergensen@imr.no kari.ellingsen@nina.no sc@akvaplan.niva.no
Effects of jellyfish on benthic communities	Paul Renaud	ApN, UNIS, NIVA	Fjord and Coast	pr@akvaplan.niva.no
Impacts of eiders predation on benthic communities in a range of climatic zones	Sveinn Are Hansen	NINA, HI, NP, UiT	Fjord and Coast	sveinn.a.hanssen@nina.no
Climate induced effects on sea urchin grazing on kelp	Lis Lindal Jørgensen Hartvig Christie	HI, HiFi, NIVA	Fjord and Coast	lis.lindal.joergensen@imr.no hartvig.christie@niva.no
Trophic impacts of the red king crab	Jan Sundet	HI, UiT	Fjord and Coast	jan.h.sundet@imr.no
Climate and mussels	Michael Carroll	ApN, UNIS, UiT	Fjord and Coast	mlc@akvaplan.niva.no
Lower trophic levels and carbon-fluxes in Arctic fjord systems	Tove Gabrielsen	UNIS, UiT	Fjord and Coast	tove.gabrielsen@unis.no

Human dimensions of ecosystem response to climate change

Documentation and use of local/traditional ecological knowledge (LEK) on ecological change, climate change, resource use and cultural environments in fjord and coastal areas	Elin Myrvoll Einar Eythorsson Arild Buanes	NIKU, UiT, NORUT	Fjord and Coast	elin.myrvoll@niku.no einar.eythorsson@niku.no Arild.Buanes@norut.no
Changing conditions for valuation and use of coastal areas and resources	Arild Buanes Einar Eythorsson Marit Myrvoll	NORUT, UiT, NIKU	Fjord and Coast	Arild.Buanes@norut.no einar.eythorsson@niku.no marit.myrvoll@niku.no
Historical and current use of marine living resources – ecosystem structure	Paul Renaud Elin Myrvoll	ApN, NIKU	Fjord and Coast	pr@akvaplan.niva.no elin.myrvoll@niku.no

Arctic ocean – technology and system of agreements (Sea Ice in the Arctic Ocean)

RESEARCH AREAS/PROJECT TITLES	PROJECT LEADER	PARTICIPATING INSTITUTIONS	FLAGSHIP	E-MAIL PROJECT LEADER
Characterization of Arctic sea ice properties from remote sensing observations	Torbjørn Eltoft	UiT, Norut, NP	Sea Ice in the Arctic Ocean	torbjorn.eltoft@uit.no
Long-term variability and trends in the Atlantic Water inflow region	Vigdis Tverberg Vladimir Pavlov	HI, NP, UNIS, UiT international partners	Sea Ice in the Arctic Ocean	vigdist@imr.no vladimir.pavlov@npolar.no
Modelling of sea ice circulation, ice cover and ecosystem	Ole-Anders Nøst	NP, HI, ApN, NILU, SINTEF, UNIS	Sea Ice in the Arctic Ocean	ole.anders.nost@npolar.no
Pre-project biology in the Arctic ocean	Harald Steen	NP, HI, NINA, UiT, ApN, UNIS	Sea Ice in the Arctic Ocean	harald.steen@npolar.no
Industrial exploitation and use of the Arctic marine area	Mette Midtgard	NORUT, Nofima, TØI	Sea Ice in the Arctic Ocean	Mette.Ravn.Midtgard@norut.no
Arctic futures	Peter Arbo	UiT, Norut, Nofima, NP	Sea Ice in the Arctic Ocean	peter.arbo@uit.no
Regulating Arctic shipping	Tore Henriksen	UiT, ApN, FNI, MarinTek	Sea Ice in the Arctic Ocean	tore.henriksen@uit.no
Logstics and maritime operations: modelling and simulations	Jørn Eldby	SINTEF, ApN, NTNU, DnV	Sea Ice in the Arctic Ocean	jorn.eldby@sintef.no
Oil in ice	Lionel Camus	ApN, HI, NILU, NINA, NIVA, Norut, NP, NRPA, SINTEF, UiT, international partners	Sea Ice in the Arctic Ocean	lionel.camus@akvaplan.niva.no
Pre-project shipping	Jørn Eldby	SINTEF, Kystverket, Norut, UiT, ApN, Ocean Futures, MarinTek	Sea Ice in the Arctic Ocean	jorn.eldby@sintef.no

Ocean acidification and ecosystem effects in northern waters (Ocean acidification)

Processes related to the Arctic and the sea ice

RESEARCH AREAS/PROJECT TITLES	PROJECT LEADER	PARTICIPATING INSTITUTIONS	FLAGSHIP	E-MAIL PROJECT LEADER
The role of Arctic sea ice as a carbon pump observed in Fram Strait / Characterization of CO_2 fluxes from sea ice	Mats Granskog	NP, HI, international partners	Ocean acidification	mats.granskog@npolar.no
Elaboration of a ferry-box based system for the ocean acidification parameters measurements	Kai Sørensen	NIVA, international partners	Ocean acidification	kai.sorensen@niva.no
The studying of the present OA state of the Norwegian waters	Kai Sørensen	NIVA, UNIS	Ocean acidification	kai.sorensen@niva.no

Effect of ocean acidification on species and ecosystems

Influence of ocean acidification and temperature on sperm motility, fertilization and embryonic development in Atlantic	Helge Tveiten	Nofima, ApN, NRPA	Ocean acidification	helge.tveiten@nofima.no
Ocean acidification effects on key components of the ice-associated ecosystem in the Arctic	Haakon Hop	NP	Ocean acidification	haakon.hop@npolar.no
Effects of OA on the reproduction of the reef building cold water coral *Lophelia pertusa*	Johanna Järnegren	NINA	Ocean acidification	johanna.jarnegren@nina.no
Synergic effects of ocean acidification, increasing temperature and decreasing salinity on Arctic calcifying organisms: mesoplankton vs. holoplankton	Clara Manno	UiT, Brest University	Ocean acidification	clara.manno@uit.no
Arctic Tipping Points: Impacts of acidification and increased temperature on early life-stages of benthic organisms	Paul Renaud	ApN, NP	Ocean acidification	pr@akvaplan.niva.no

Social sciences

The economics of ocean acidification	Claire Armstrong	UiT, NIVA	Ocean acidification	claire.armstrong@uit.no

Effects of climate change on terrestrial ecosystems, landscapes, society and indigenous peoples (Terrestrial)

Vegetation state change and herbivore management

RESEARCH AREAS/PROJECT TITLES	PROJECT LEADER	PARTICIPATING INSTITUTIONS	FLAGSHIP	E-MAIL PROJECT LEADER
Moth-reindeer-birch dynamics in northernmost Fennoscandia	Jane U. Jepsen Rolf A. Ims	NINA, UiT	Terrestrial	jane.jepsen@nina.no rolf.ims@uit.no
Large scale impacts of herbivory on vegetation	Bernt Johansen Eirik Malnes	Norut	Terrestrial	bernt.johansen@norut.no eirik.malnes@norut.no
TUNDRAscape: Analyzing the effect of climate and human uses on tundra ecosystems by remote sensing	Per Fauchald	NINA, NIKU, UiT	Terrestrial	per.fauchald@nina.no

Ecosystem effects of extreme climate events and season

Svalbard terrestrial ecosystem – climate impacts and trophic interactions	Eva Fuglei	NP, NINA, UNIS	Terrestrial	eva.fuglei@npolar.no
Arctic winter processes and global change impacts	Jarle W. Bjerke	NINA, NORUT, several international institutions	Terrestrial	jarle.werner.bjerke@nina.no
Climate variations and contaminants in the Pasvik border area – effects on limnic ecosystems.	Guttorm N. Christensen	ApN, NINA, NIVA, UiT, Bioforsk	Terrestrial	guttorm.christensen@akvaplan.niva.no
Climate-dependent infectious agents and diseases in reindeer (wildlife diseases)	Morten Tryland	NVH, VI, UiT	Terrestrial	Morten.Tryland@veths.no

Capacity for adaptation in indigenous people and local societies

RESEARCH AREAS/PROJECT TITLES	PROJECT LEADER	PARTICIPATING INSTITUTIONS	FLAGSHIP	E-MAIL PROJECT LEADER
Local land-use change in a changing climate: farming practices, nature-based tourism, and outdoor recreation (LUCC)	Astrid Ogilvie	CICERO	Terrestrial	astridog@cicero.tromso.no
Climate & reindeer	Marius Warg Næss	CICERO, NINA, University College of London	Terrestrial	m.w.nass@cicero.uio.no

Adaptive management of ecosystem services

GOOSEHUNT (Reducing damage to agriculture by migratory geese by means of population control; investigating the use of adaptive organisation and co-management of hunting)	Ingunn Tombre	NINA, NIKU, Norut, Aarhus University	Terrestrial	ingunn.tombre@nina.no
MIGRAPOP (Adaptive management of migratory populations; developing novel tools at the interface between ecology, economy, agriculture and society)	Ingunn Tombre	NINA, NIKU, Bioforsk, national and international partners	Terrestrial	ingunn.tombre@nina.no

Hazardous substances – effects on ecosystems and human health (Hazardous substances)

Human health and society

RESEARCH AREAS/PROJECT TITLES	PROJECT LEADER	PARTICIPATING INSTITUTIONS	FLAGSHIP	E-MAIL PROJECT LEADER
Total exposure of newborns and selection bias in MISA	Jon Ø. Odland	UiT, NILU	Hazardous substances	jon.oyvind.odland@uit.no
Follow up of children	Jon Ø. Odland	UiT, NILU	Hazardous substances	jon.oyvind.odland@uit.no
PFAS and diabetes 2 in the NOWAC study	Torkjel Sandanger	NILU, UiT	Hazardous substances	Torkjel.Sandanger@nilu.no
SAMINOR2	Magritt Brustad	UiT, NILU, SSHF	Hazardous substances	magritt.brustad@uit.no
Analysis of the impact on humans and society	Natalia Kukarenko	UiT, NILU	Hazardous substances	Natalia.N.Kukarenko@norut.no
Exposure of the newborn and changes during pregnancy	Jon Ø. Odland	UiT, NILU	Hazardous substances	jon.oyvind.odland@uit.no
Sør-Varanger and Arkhangelsk – an integrated case study	Torkjel Sandanger	UiT, NRPA, NGU, ApN, Norut, NILU, NVH, SSH, Unilab	Hazardous substances	Torkjel.Sandanger@nilu.no
Exposure scenarios for the Northern Norwegian population	Torkjel Sandanger	UiT, NILU, ApN, Norut, NRPA, NVH/VI	Hazardous substances	Torkjel.Sandanger@nilu.no

Animal health and ecosystem

COPOL II	Geir Wing Gabrielsen Anita Evenset	ApN, NIVA, NILU, NRPA, NP	Hazardous substances	gabrielsen@npolar.no Anita.Evenset@akvaplan.niva.no
Temporal trend analysis – COPOL WP2	Jan O. Bustnes	NINA, NILU, ApN	Hazardous substances	Jan.Bustnes@nina.no
Raptor	Jan O. Bustnes	NINA, NILU, international partners	Hazardous substances	Jan.Bustnes@nina.no
SKUA	Jan O. Bustnes	NINA, NP, international partners	Hazardous substances	Jan.Bustnes@nina.no
Workshop on the topic Multistressor	Geir Rudolfsen Jan O. Bustnes	All participants in the Fram Centre	Hazardous substances	geir.rudolfsen@nrpa.no Jan.Bustnes@nina.no
Contaminant effects on polar bear energetics	Heli Routti	NP, UiT, NILU, UiB	Hazardous substances	heli.routti@npolar.no
Mouse model to study immunosuppression after exposure to pollutants	Jacques Godfroid	NVH, NP, HI, Univ. Belgium	Hazardous substances	Jacques.Godfroid@nvh.no
Modelling – transport, fate and bioaccumulation of contaminants	Eldbjørg Heimstad	NILU, ApN, NIVA, NRPA, NGU	Hazardous substances	esh@nilu.no

"Oil in ice"

Pollution from petroleum activities and shipping in the north – effects on arctic ecosystems and human health	Anita Evenset	ApN, NIVA, NILU, Norut	Hazardous substances	Anita.Evenset@akvaplan.niva.no

ABBREVIATIONS

ApN: Akvaplan-NIVA Inc.; **Bioforsk:** Norwegian Institute for Agricultural and Environmental Research; **CICERO:** Center for International Climate and Environmental Research – Oslo; **DnV:** Norwegian Veritas; **FNI:** Fridtjof Nansen Institue HI: Institute of Marine Research; **HiFi:** Finnmark University College; **Kystverket:** Norwegian Coastal Administration; **NGU:** Geological Survey of Norway; **NINA:** Norwegian Institute for Nature Research; **NIKU:** The Norwegian Institute for Cultural Heritage Research; **NILU:** Norwegian Institute for Air Research; **NIVA:** Norwegian Institute for Water Research; **Nofima:** The Norwegian Institute of Food, Fisheries and Aquaculture Research; **Norut:** Northern Research Institute; **NP:** Norwegian Polar Institute; **NRPA:** Norwegian Radiation Protection Authority; **NTNU:** Norwegian University of Science and Technology; **NVH:** Norwegian School of Veterinary Science; **SINTEF:** The Company for Industrial and Technological Research; **SSHF:** Centre of Sami Health Research; **TØI:** The Institute of Transport Economics; **UiB:** University of Bergen; **UiT:** University of Tromsø; **UNIS:** The University Centre in Svalbard; **Unilab:** Unilab Analysis Inc.; **VI:** Norwegian Veterinary Institute

Recent doctorates

Maria Degerlund

Species concepts and functional aspects of cold-water diatoms (Bacillariophyceae)

Diatoms are tiny algae, usually single-celled, with a cell wall of silica. Together with other microalgae, they constitute the foundation of the marine food web. This makes it important to know which species grow in various areas, and what roles they play within the ecosystem. A biogeographical study based on several years' worth of data about phytoplankton during the spring bloom showed great similarity between the communities of species along the coast of Norway and the northern parts of the Barents Sea. The study also highlighted the need for a time series for phytoplankton in these marine areas. A detailed taxonomic and physiological study of *Chaetoceros socialis*, one of the most important spring-blooming diatoms, showed pseudocryptic population diversity in populations from north Norwegian waters and the Bay of Naples in the Mediterranean Sea. "Pseudocryptic" means that the populations were genetically distinct, but showed only minor differences in morphology. *C. socialis* from Norway and from Italy differed substantially in their physiological and biochemical responses when experimentally exposed to 2.5, 8 and 13°C. The results suggest that the two populations belong to different species and that the taxonomy and biogeography of *C. socialis* should be revised.

Link to the thesis: http://hdl.handle.net/10037/3679

University of Tromsø
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18 November 2011

Jane Amtoft Godiksen

Stable oxygen isotopes and growth increments in Arctic charr otoliths: Revealing thermal habitat use and climate impacts

Climate models predict that both temperatures and precipitation will increase over the next century. These factors strongly influence how early in spring the ice breaks up on frozen lakes, which in turn determines the growing season for Arctic charr. In Svalbard, where lakes are ice-bound most of the year, deep snow on top of the ice can drastically shorten the growing season. This study focuses on how climate variation influences the growth of otoliths – tiny rock-like structures that are part of the balance organs in the charr's inner ear. Another question was whether climate variation influences what temperature habitat the Arctic charr selects. The results show that oxygen isotopes in the otolith can reveal what temperatures a charr has been exposed to at different times during its life. Comparison of climate data and growth patterns in the otolith reveals how these fish respond to changes in climate.

University of Tromsø
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Joint supervision with the Norwegian Institute for Nature Research

4 February 2011

Solrunn Hansen

Maternal concentrations, predictors and change in profiles of organochlorines, toxic and essential elements during pregnancy and postpartum. The Vietnamese Mother-and-Child Study and the Northern Norwegian Mother-and-Child Study

Persistent toxic pollutants and certain poisonous metals can escape from modern commodities and spread all around the globe with air and ocean currents. The fetus and growing child are particularly vulnerable to negative effects. The concentration of various pollutants in the mother's blood and breast milk may give some indication of how great a risk they pose. In addition, physiological changes in the mother's body during pregnancy and nursing are likely to influence the levels of these chemicals - with potential impact on her offspring. In this doctoral project, Solrunn Hansen has studied organochlorines in the blood of women in northern Norway and southern Vietnam. In addition, she analysed ten metals in blood from the Norwegian women at three different times during pregnancy and lactation: five toxic metals and five essential elements. Her results showed that Norwegian women generally had rather low levels of pollutants; Vietnamese women had high levels of two DDT breakdown products but slightly lower levels of PCB than the Norwegian women. Another finding was that organochlorine levels increased with the mother's age, but decreased for each birth, particularly if the child had been nursed. Fish consumption was strongly related to the amounts of arsenic, mercury and selenium in blood. Hansen concludes that precaution is still relevant, and recommends dietary advice for pregnant women.

University of Tromsø
Faculty of Health Sciences
Department of Community Medicine

Joint supervision with the Norwegian Institute for Air Research

9 September 2011

Marit Nøst Hegseth

Cellular responses induced by environmental stress factors in arctic seabird chicks

This project examined how Arctic seabirds respond to two environmental stress factors that are common in the Arctic: starvation and halogenated organic contaminants. Two of the birds' cellular defence systems were in focus: the antioxidant system, which protects against the negative effects of oxygen, and autosomal lysosomes in the liver, which are part of the cellular "waste management system". Samples were collected from three seabird species, black-legged kittiwake, northern fulmar, and herring gull. The samples were taken from birds living in the wild in Svalbard or near Tromsø. A feeding experiment on captive herring gull chicks was also done. The results revealed major differences between the defence systems in these species, and that both systems (in chicks) are affected by diet, species physiology, fasting, and exposure to contaminants. Some of the effects of contaminants were dose-dependent. Since contaminant concentrations in the samples were lower than those reported in samples from wild-living birds, the effects might be more pronounced in wild seabird populations. Some of the cellular effects observed in this study have been associated with deleterious effects on the health of other animal species. Additional studies of cellular systems in seabirds would provide a starting point for regular monitoring of seabird health status, which might contribute towards improved management.

University of Tromsø
Faculty of Biosciences, Fisheries and Economics
Department of Arctic and Marine Biology

Joint supervision with the Norwegian Polar Institute

29 November 2011

Lisa Bjørnsdatter Helgason

Levels and effects of halogenated organic contaminants in arctic animals: How does seasonal emaciation affect biotransformation and tissue distribution?

The main objective of this thesis was to examine levels of "old" and "new" environmental pollutants in arctic animals. Contaminant concentrations, their breakdown over time and possible biological effects were studied in arctic seabirds and their eggs. In addition, the study examined how seasonal variations in fat stores of herring gulls and arctic fox influenced the distribution and breakdown of contaminants in various body tissues. Many environmental contaminants such as "old" organohalines and "new" brominated flame retardants are fat-soluble, which means that they are stored in fat tissue. The study showed that when arctic animals are obliged to live off their fat reserves, for instance during a food shortage or while rearing their

young, the contaminants are redistributed in the body and concentrations in sensitive organs rise. Animals exposed to contaminants had developed greater ability to break down foreign compounds. Intriguingly, it also emerged that starvation in itself – independent of contaminant exposure – influenced the animals' ability to break down and eliminate foreign compounds.

University of Tromsø
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Department of Arctic and Marine Biology

Joint supervision with the Norwegian Polar Institute

7 January 2011

Kriss W. Rokkan Iversen

The microbial food web in a changing Arctic Ocean: Seasonal structure and function, regulatory mechanisms and carbon dynamics in Svalbard waters

A changing climate means changes in the physical environment in arctic seas, with fresher and warmer surface layers as one of the consequences. Microscopic organisms appear likely to gain importance. Predicting the consequences of climate change in marine ecosystems in the Arctic requires knowledge about the structure and function of the microbial food web at different times of the year and in different areas. This thesis builds upon seasonal studies in Kongsfjorden, Svalbard, studies of the role of microorganisms in vertical transport of carbon in the Barents Sea, and experimental data on physical and chemical mechanisms that regulate these systems. The results show that the microbial food web plays an important role in the ecosystem, not least by distributing energy to animals in the water column and at the seabed. The microbial food web can thus serve as a buffer and provide a degree of flexibility in the marine ecosystem when arctic water masses respond to changes in climate.

University of Tromsø
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Department of Arctic and Marine Biology

14 April 2011

Louise Kiel Jensen

Acute and long-term effects from petroleum discharges on temperate and arctic Calanus species

Interest in exploiting oil reserves in the Arctic is growing. Several oil fields will soon be opened up in the Barents Sea, which has a diverse ecosystem and many well-managed fish populations. To minimise conflicts between these interests, environmentally sound risk analyses are needed. There is reason to believe that arctic species do not react to oil spills in the same way as the species found farther south. In addition, oil breaks down more slowly in the Arctic than in warmer climates, which means that arctic species would be exposed to oil for longer times than their southern counterparts. This study focused on two closely related copepods, the sub-arctic *Calanus finmarchicus* and the arctic *C. glacialis*, and their responses to oil exposure in laboratory experiments. It emerged that brief exposure to volatile substances from oil can increase mortality in both species. Long-term exposure to low doses of oil has effects on both species that, although not fatal, may ultimately have impact on population dynamics. Uptake of the various components in oil by *C. finmarchius* is dependent on the substance's molecular weight and chemical properties.

Link to the thesis: http://hdl.handle.net/10037/2839

University of Tromsø
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Norwegian College of Fishery Science

11 November 2011

Maaike Knol

Marine ecosystem governance in the making: Planning for petroleum activity in the Barents Sea–Lofoten area

Expanding petroleum activity in the Barents Sea–Lofoten area has worked as a catalyst for the development and introduction of the first integrated, ecosystem-based management plan in Norway. The thesis provides an analysis of the practices and instrumentation of marine ecosystem governance, which encompasses the broader dynamics around the introduction of integrated, ecosystem-based management. It follows processes of co-production at the science–policy interface and analyses how scientific knowledge is mobilised and translated into governance practices and policy instrumentation for the regulation of oil and gas activities and their related risks and uncertainties. The thesis emphasises the centrality of uncertainties and knowledge gaps in marine governance practices, and develops the argument that the focus on knowledge gaps illuminates the dominant framings of risk. Although the production of more knowledge can lead to a refinement of the very notion of risk, this thesis emphasises that scientific and social indeterminacy are constant challenges to be dealt with.

Link to the thesis: http://hdl.handle.net/10037/3111

University of Tromsø
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Norwegian College of Fishery Science

25 March 2011

Helene Hodal Lødemel

Primary production and the relevance of small autotrophic and heterotrophic cells in arctic marine ecosystems

The main objective of this thesis word was to examine primary production and the role of small autotrophic and heterotrophic organisms in arctic marine ecosystems. Autotrophs bind carbon from the air, usually through photosynthesis. Heterotrophs get their carbon by consuming other organisms, their sustenance thus ultimately depending on primary production by autotrophs. Primary production was studied in Kongsfjorden in Svalbard, and in the northern Barents Sea in the area where sea ice gives way to open water. The distribution of small autotrophic and heterotrophic single-celled organisms was examined in a transect running across the Arctic Ocean from Alaska to Svalbard. Changes in the population structure and activity of bacteria communities were studied in the cold, subarctic waters of Balsfjorden, in northern Norway. Small cells contributed a surprisingly large proportion of the total primary production during the phytoplankton bloom along the ice edge. A significant part of the production took place at depths that are difficult to estimate from satellites. Small single-celled heterotrophs predominated in the Arctic Ocean. The species composition in Balsfjord shifted throughout the year, with differences between large groups and sub-groups. Those groups that were most active were present only in small numbers. This indicates that the structural composition of bacterial communities is largely regulated through top-down control of specific groups of bacteria.

University of Tromsø
Faculty of Biosciences, Fisheries and Economics
Department of Arctic and Marine Biology

2 December 2011

Eike Müller

Dispersal and recruitment in the Arctic. Studies of migration and germination in arctic-alpine vascular plants

In this thesis work, Eike Müller studied arctic plants, most of them from Svalbard, and tried to figure out whether they would be able to establish themselves in new locations if temperatures increase in the Arctic. Both molecular techniques and germination experiments were used. The germination experiments showed that most of the vascular plants in the High Arctic are able to produce viable seeds. This not only helps ensure their ability to colonise new areas, but also shows that these plants can rearrange their genes to improve their resilience in the face of changes in climate. Several species had seeds that germinated unexpectedly well and a large proportion of them were viable. But the experiments also showed that germination was strongly influenced by low temperatures. Molecular analyses of purple saxifrage (*Saxifraga oppositifolia*) showed that the plant can spread to new territories without losing its genetic variation. These experiments reveal the extent to which plants spread naturally in the High Arctic, but also show that human activity disperses seeds. It is also possible to conserve plants that are unable to reproduce if their surroundings grow warmer. One solution might be to collect seeds and store them in seed banks.

University of Tromsø
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Department of Arctic and Marine Biology

16 November 2011

Henrik Andreas Nygård

Scavenging amphipods in the high Arctic: Studies of benthic and sympagic amphipods in the genera Onisimus and Anonyx

The main objective of this study was to learn more about the ecology of scavenging amphipods, particularly species within the genera Onisimus and Anonyx. The ice-associated Onisimus species were of particular interest, but since their habitat makes them difficult to study, the researchers examined related species instead. By studying shallow-water scavenging amphipods they were able to take samples frequently. The high temporal resolution enabled them to give detailed descriptions of life cycles and reproduction of *Onisimus caricus* and *O. litoralis*. The thesis work also includes a description of the seasonal variations in the amphipod scavenging guild in two fjords in Svalbard. The knowledge gained from studies of benthic Onisimus species was then extrapolated to their ice-associated relatives. This showed that *O. nanseni* probably follows life strategy similar to that of *O. litoralis*, and is an income breeder (which means that it supplies its offspring with nutrients the parent amphipod consumes during the reproductive cycle itself, rather than from energy stored previously). Additionally, the two species are probably similar in providing extended parental care by investing in a "start pack" of energy for the offspring. The researchers also hypothesised that *O. nanseni* and *O. glacialis* need a high reproductive output to compensate for the varying extent of their sea ice habitat.

Link to the thesis: http://hdl.handle.net/10037/3382

University of Tromsø
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Department of Arctic and Marine Biology

2 May 2011

Lena Seuthe

Planktonic food webs in the Arctic Ocean: structure and function in contrasting seasons and physical settings across Fram Strait

One of the main aims of this study was to delineate the structure and function of the planktonic food web. The other was to determine whether food webs based on bacteria are less common in arctic waters than in warmer seas. Seasonal variations in the species composition of the planktonic food web, and in the roles played by the various species, were studied in Kongsfjorden in Svalbard, and in the northeastern part of Fram Strait. The natural temperature gradient between these two study areas enabled the researchers to probe whether the food webs differ as a function of water temperature. In Kongsfjorden the bacteria were found to be extremely active and were an important part of the food web nearly all the time. Along with tiny phytoplankton, they formed the basis for a complex microbial food web, and the same was found in the colder waters of Fram Strait. Comparison of these new data with reports in the literature showed that bacteria-based microbial food webs are common in arctic waters. This could potentially have significance for crucial biogeochemical processes such as the balance between uptake and release of carbon dioxide.

University of Tromsø
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Norwegian College of Fishery Science

8 December 2011

Gro D. Villanger

Effects of complex organohalogen contaminant mixtures on thyroid hormone homeostasis in selected arctic marine mammals

Arctic marine mammals are exposed to complex mixtures of organic halogens such as PCBs (which were formerly used as coolants and insulators in electrical equipment), pesticides such as DDT and chlordanes, and flame retardants containing bromine. These halogenated compounds accumulate in the body, and at high levels they can perturb the thyroid hormone balance, among other things. In this thesis, the relationships between individual contaminants and thyroid hormone levels were studied in marine mammals from different parts of the Arctic: polar bears (*Ursus maritimus*) from the European Arctic, beluga whales (*Delphinapterus leucas*) from Svalbard, and hooded seals (*Cystophora cristata*) from East Greenland. In the case of the seals, mother–pup pairs were studied. The findings show that the complex mix of contaminants affects the thyroid hormone system in all three species, and that some of the various contaminants may act in combination. In addition, newborn and young marine mammals appear vulnerable to thyroid hormone disruption caused by contaminants that they get via their mothers' milk. The compounds transferred with milk are the same as those know to affect thyroid hormone balance in human babies and children, where they also interfere with the development of the nervous system. This raises concern not only for the future health of the young arctic marine mammals studied in this thesis work, but also for their ability to adapt to climate change in the Arctic.

Norwegian University of Science and Technology
Department of Biology

Joint supervision with the Norwegian Polar Institute

28 October 2011

Steffen Aagaard Sørensen

Late Glacial – Holocene climate variability and sedimentary environments on northern continental shelves. Zonal and meridional Atlantic Water advection

The overall objective of this PhD project was to advance our understanding of oceanographic variability in the Nordic Seas over the last 20 000 years. The study focused on the transport of warm Atlantic Water into the SW Barents Sea and along the West Spitsbergen slope into the Arctic Ocean. Sediment cores were taken in four places on northern continental shelves and analysed to determine what conditions were like when the sediments formed. For example, the mix of species of foraminifera (tiny plankton) reveals whether the sea was warm or cold. Analysis of stable oxygen and carbon isotopes and the chemical composition of sediments can also provide valuable information. The reconstructed temperatures of Atlantic Water entering the Arctic Ocean through the eastern Fram Strait showed a difference of about 5°C between glacial and interglacial conditions. The study also showed an approximate 2°C warming during the last 100 years. A temperature increase of this magnitude is unprecedented over the past 2000 years.

Link to the thesis: http://hdl.handle.net/10037/3007

University of Tromsø
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Department of Geology

22 March 2011

Anne Helene S. Tandberg

Colonisation, speciation events and evolution of benthic organisms in the Norwegian Sea

Tandberg has studied amphipods living on the seabed along the coast of Norway and around Svalbard. The thesis gives a detailed description of 23 closely related species. Knowledge about these tiny animals is important because they can signal changes in the environment, changes that can have impact at higher levels in the ecosystems. Amphipods can be affected by changes in external conditions such as temperature, ocean currents, salinity, oxygen content, the amount and composition of nutrient salts and other factors in the water around them. We need to know which species live in northern seas today, so we can compare with data collected in future surveys of the seabed, and detect any changes. Tandberg's data allow us to see if there are as many amphipods as there were earlier, if the amphipods in an area are the same species as before, and if any new species have arrived. Future studies can reveal if new species have joined those that were already there, or if the new species replaced the old ones. Many of these species are food for other animals. Changes in the species composition at the seabed can perturb the nutritional basis on which other species in the food chain depend.

University of Tromsø
Faculty of Biosciences, Fisheries and Economics
Department of Arctic and Marine Biology

19 December 2011

New books in 2011

Five tidbits from the Norwegian Polar Institute Library

Living in Denial: Climate Change, Emotions and Everyday Life

Kari Marie Norgaard. Cambridge, Mass.: MIT Press, 2011. xix, 279 pp. ISBN 978-0-262-51585-6 (h.)

Our climate is changing more rapidly than we like. Many scientific reports are ringing alarm bells. Still the world seems to go on almost ignoring all the warnings. Why this denial? Numerous authors have addressed the question at a political level. This book brings an interesting sociological perspective to bear on the issue: a researcher in the US uses "Bygdaby", the fictional name of an actual rural community in Norway, as a case study to explore social and psychological barriers to action.

Sea Ice in the Physical and Biogeochemical System

Chief Editor Mats Granskog. Cambridge: International Glaciological Society, 2011. (Annals of Glaciology; Vol. 52, No. 57)

Sea ice is a key factor in the Arctic climatic system. Here is a collection of state-of-the-art international sea ice research. Mats Granskog from the Norwegian Polar Institute was asked to edit this work, which contains 43 papers in two volumes. Most of them were first presented at a symposium in Tromsø. The compilation is highly relevant and a fine achievement for our research centre.

Adresse Ny-Ålesund: fortellinger om folk på tundraen

Åse Kristine Tveit. Trondheim: Tapir akademisk, 2011. 152 pp. ISBN 978-82-519-2731-4

Librarians also write books, and here we have an extremely enjoyable and interesting book about our beloved research community in the High North. Tveit is not least skilled at creating portraits of the individuals who were key to developments in Ny-Ålesund in the inter-war period. People like Ferdinand, the master carpenter, and Berta, the caretaker.

Nordområdene: visjon og virkemidler. Oslo: Utenriksdep.

132 pp. (Stortingsmelding nr. 7 (2011-2012))

The Norwegian government presented its new White Paper on the High North in Bodø in November 2011. In it, "the government sets ambitious targets for how the High North strategy should be pursued over the next 20-30 years." Check out what the Norwegian government has actually committed itself to in areas such as trade cooperation with Russia, international polar research, petroleum exploration and extraction in the Barents Sea. (PDF available at www.regjeringen.no) (See also "The Norwegian Government's High North Strategy", report by the Norwegian Ministry of Foreign Affairs.)

Satellittkrigen: Norges militarisering av polområdene og verdensrommet

Bård Wormdal. Oslo : Pax, 2011. 192 pp. ISBN 978-82-530-3450-8

This is a book about a rather sensitive subject for both the Svalbard Treaty and the Antarctic Treaty. Satellites orbit above us, taking ever more detailed and precise close-ups of life on earth. Data are downloaded via Norwegian receiver stations near both north and south poles, and used for military purposes. At question time in the Norwegian parliament on 13 December 2011, Jonas Gahr Støre, the Norwegian Minister of Foreign Affairs said, among other things: "The fact that data downloaded in Svalbard can also be of value for military users, is not per se problematic in relation to the Svalbard Treaty." Interesting sentence...

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