FRAM CENTRE

FRAM FORUM 2014

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FLAGSHIP OF FLAGSHIPS

Since the last issue of Fram Forum, Norway has had general elections; the incumbent "red-green" coalition lost its majority and a new government has been instated. In many countries, a similar shift of power could lead to major upheaval. Laws might be repealed, government agencies might be shut down or receive entirely new directives, public funding might be rescinded from one day to the next. Not so in Norway.

Here's a case in point. The Fram Centre was recently given the go-ahead for a new research Flagship programme: MIKON, Environmental impacts of industrial activity in the north (see article on page 27). Most of the groundwork leading up to the decision to fund MIKON was done under the previous government. Yet the go-ahead was signed by the new Minister of Climate and Environment. Perhaps as a sea-faring nation, Norwegians know that ships in motion need a steady hand on the helm. Sudden changes of course may have unexpected consequences.

An important factor in Norwegian stability is that most of the day-to-day work of government is done by civil servants who stay on the job regardless of which parties happen to be in power. With time, they develop profound knowledge of their particular topic. It is these relatively anonymous, apolitical civil servants who delve into the issues and summarise them for the politicians, giving expert guidance for decision-making. Clearly these unsung heroes have done a good job of explaining the urgency of the questions now arising in the north - explaining to both the previous and the present government.

Or maybe it goes even deeper. Ideological debates in Norway can be just as heated as in other countries, but a common understanding of many fundamental issues unites parties from left to right. The importance of the High North is one such issue. What happens here will shape Norway's future - for better or for worse. No surprise, then, that the Fram Centre was awarded more funding than ever for this sixth Flagship programme, with its focus on the changing High North.

Then again, perhaps Norway's rudder *has* shifted, but the change in course will not become obvious for some time yet. This would not be surprising either. As the evidence for global climate change has become increasingly irrefutable, we have seen ever greater emphasis on "mitigation" and "adjustment", not to mention "new opportunities". MIKON is very much in line with this new mind-set.

The overall theme "Environmental impacts of industrial activity in the north" whispers of new opportunities, while MIKON's three subthemes (expanding the knowledge base for ecosystem-based management; impacts on organisms and ecosystems; and integrated studies of environmental impacts) focus on the need for watchfulness, mitigation and adjustment. Given the complexity of these issues, the Department of Climate and the Environment emphasises the need for a multidisciplinary approach. Fortunately, the Fram Centre offers many types of competence.

The Norwegian Institute for Nature Research (NINA) and Akvaplan-niva will be at the helm of MIKON as a whole, and several of the Centre's smaller, more specialised institutes will lead relevant subthemes. Knowledge amassed through the efforts of the five established Flagships will contribute strongly toward reaching the important goals that lie ahead.

In the previous issue of Fram Forum, we wondered if the Fram Centre was building up an entire armada of flagships. This year there is no room for doubt - and MIKON will be the Flagship of the Flagships. As they embark on their joint mission, we wish them smooth sailing!

Janet Holmén, Editor

Tine Sundtoft // Minister of Climate and Environment

Fram means forward!

Photo: Bjørn Stuedal

IN NORWEGIAN, "fram" means forward. The original polar vessel *Fram* used by Nansen and Amundsen certainly went forward. It is today an object of national pride, in its museum at Bygdøy. The research in the Fram Centre is also bringing us forward. It is bringing us essential, new knowledge about climate and environment in the North. We need this knowledge, to better *understand* the complex processes in the Northern environments, and to better *manage* the increasing human activities in the North.

Climate change is particularly rapid and visible in the High North and the Arctic, representing a major challenge to both the environment and the human societies. Pollution by long-transported harmful chemicals is also a great challenge in this region. New scientific knowledge is all-important, including on climate changes and the complicated interplay between the living organisms, the circulation systems in the atmosphere and the oceans, and the coupling to human activities.

The concept of research Flagships at the Fram Centre has worked well. The five flagships received a detailed and positive evaluation by the Norwegian Research Council in November 2012. This year, at the proposal of our Government, the Parliament has increased the total budget of the Fram Centre quite substantially. About half of the increase will be channelled to a new, sixth flagship: Environmental impacts of industrial activity in the north. The Norwegian acronym is MIKON.

The economic activities in the North are increasing steadily: in the petroleum area, minerals processing, shipping, tourism, and fisheries. We need more science-based knowledge in order to manage all these activities on a sustainable basis that will minimise their ecological footprint. It is important to ensure an environmentally responsible development, with the best environmental solutions, which will not conflict with the ecosystems, cultural heritage or societal considerations.

In the coming months, the new flagship will prepare, and then sail. We wish the researchers on board good luck and favourable winds, and are looking forward to important new insights and knowledge in this area.

It is exceedingly important to *communicate scientific research* to the general public, as well as to decision-makers in business and government. The scientists must see communication in popular and understandable terms as a natural and necessary part of their work. Communication is therefore an integral part of each and every project. From the beginning, the Fram Centre has focused on communication, with initiatives in many forms. As part of this emphasis on communication, the first Fram Forum was issued in 2012; this is the third year. I wish you all good reading!

PICTURE OF THE YEAR

Small crustaceans called ice amphipods live in brine channels in sea ice. They are part of the ice fauna, which includes all animals living in association with sea ice. These amphipods feed on ice algae and ice-associated zooplankton and represent a food source for polar cod and seabirds. Research scientist and diver Haakon Hop from the Norwegian Polar Institute uses an electrical suction pump and frame to sample ice amphipods below drifting sea ice. Each sample consists of the material that is collected by sucking the area covered by ten such frames. This allows researchers to quantify the amphipod density. The diving was done at an ice station north of Svalbard during a cruise in July-August 2012, organised by ICE, the Norwegian Polar Institute's Centre for Ice, Climate and Ecosystems. Because the sea ice cover in late summer in the Arctic Ocean has been reduced by 50% over the last 30 years and now constitutes mostly thin, first-year ice, the biomass of ice amphipods has declined to very low levels.

Photo: Peter Leopold

Ole Magnus Rapp *// text and photos*

The wise man and the sea

He was born as far inland as you can get in Norway, and has virtually no view of the sea from his office window. Nor is he an oceanographer or a marine biologist. But is he well versed in all things maritime? You bet!

ALF HÅKON HOEL likes the sea, as viewed both from his research vessel and from the ocean-going kayak he built with his own hands. And he takes pleasure in the fact that his researchers have an overview of the life down there in the watery depths, even though it is remote from where his own expertise lies.

Fifty-six-year-old Hoel is walking proof that political scientists have many uses. For almost a generation he worked in maritime law, on complicated international maritime boundary lines, and on how the global community could induce coastal states to agree on contentious issues. The United Nations, the Arctic Council and the Norwegian Ministry of Foreign Affairs have all benefited from Hoel's insight and his ability to find solutions to a variety of problems. He continues to do research about maritime law and resource management, how to adapt fisheries management to meet climate change, polar issues, and other related subjects.

He looks far ahead, listens and gathers information. Thinks long and hard about the issues. And comes up with answers that feel thoroughly convincing - sometimes before anyone else has even realised there was a question.

"Just think what enormous sea areas we have off Norway. Most of Norway's waters lie north and west of northern Norway. We know something about them, but far from everything," he says.

Now, as regional research director at the Institute of Marine Research, Hoel points out that Norway is a major power in the North, both by virtue of the enormous area Norway "owns", and because of the knowledge the country possesses.

"REALLY" FROM BALSFJORD

Hoel was born and grew up in Raufoss in Vestre Toten in southeastern Norway, where Skumsjø lake was the nearest "sea". He was a mere slip of a boy when he paddled his first canoe on the lake - and became fascinated with canoeing.

Nonetheless, he counts himself as a man of the North. His mother hails from Balsfjord in the far-north county of Troms, and almost every summer for as long as he can remember he spent wonderful days by the sea, where he learned a lot from his grandfather - a skilled and practical tutor. It was also in Balsfjord that he discovered the mountains. Long excursions in the mountains and challenging trips with his ocean-going kayak remain important hobbies for Hoel.

"I still go out to sea, too. Granted, I don't go on as long and extensive trips as my colleagues. My voyages are a bit shorter, and my vessel is rather more modestly equipped. But a paddling trip in an ocean-going kayak is good for both body and soul," he smiles.

INUIT ART

Hoel builds his own kayaks according to old Inuit methods. This is an important part of his hobby, and the enjoyment factor of working with his own hands in the "boatyard" is a major reward.

"I don't fish," he interjects. "That's because I haven't got the patience, and anyway it wouldn't be such a great idea trying to land a huge wolf fish on board a sea kayak," he smiles. But he stresses that he likes eating fish and is no slouch in the kitchen, where he delights in impressing his wife, his two daughters and visiting guests with his talents as a cook.

Alf Håkon Hoel tends to smile a lot, and few have heard him raise his voice. A slight speech impediment gives a very human dimension to this gifted academic. Experience has taught him that people listen better when his articulation isn't always what they expect.

CHAT OVER A CUP OF COFFEE

Hoel was head of the Department of Political Science at the University of Tromsø when Tore Nepstad called him from the Institute of Marine Research and invited him over for a cup of coffee and a friendly chat. Hoel had an inkling of what was afoot and prepared himself mentally. And yes, this was a job he might well be interested in.

The chat over the coffee cups led to the political scientist moving into a big marine research community in Tromsø Science Park. Two years have gone by since he moved and he has had no regrets. The Institute of Marine Research is now stepping up its research in the far north with Alf Håkon Hoel in the driver's seat. The Institute has grown steadily, with new colleagues arriving all the time. New challenges also arise constantly. Recently, the Institute opened a completely new office in Svalbard. In Tromsø, the plan is to house the institute's scientists in a new wing of the Fram Centre, provided the Norwegian government can find money to fund construction.

HEAD HUNTER

Alf Håkon Hoel is not unaccustomed to seeking out good people to fill vacancies. He knows what to look for, and he has diplomatic skills. For many years he was a member of the nine-person committee that selected new candidates for the Norwegian foreign service.

"A good diplomat should be involved in society and interested in what is going on. Solid professional experience is good ballast, but human qualities are the key to success in the job," he adds.

He doesn't deny that a bit of diplomacy can come in handy at the science park, where both the buildings and the egos tend to be large and colourful. Hoel likes collaboration - especially across professional, institutional and scientific boundaries - and welcomes a little healthy competition at the same time.

QUIET AND UNASSUMING

Hoel is known as a skilled organiser, with a calming personality. People say that with his quiet, unassuming manner, Hoel "makes the Institute an enjoyable place to work."

Perhaps the enjoyment comes from the fact that Hoel lets his scientists be scientists: he has faith in their capabilities, and trusts that they will do their job. He would rather spend time building bridges between disciplines, creating useful platforms and making the outside world aware of the essential and important role played by the Institute of Marine Research. He enjoys spreading knowledge, and produces a steady stream of articles, both within his own field and outside it. He also wants his researchers to be seen, heard and understood by the outside world.

"Here at the Institute of Marine Research we have to keep in mind that we have a purpose. We don't exist for our own benefit, but have functions and roles to play in society."

"Our job is to make a contribution," he adds. "What we do should be important and relevant."

GAPS IN KNOWLEDGE

Hoel is keen to talk about the excellent working environment at the Institute, which he believes is created by the sum total contribution of all its employees.

"We are a national institute, and we must think of both Norway and the world," he emphasises.

Over the next few years, the Institute's staff in the far north is intended to grow to around 100, almost twice the current number.

Alf Håkon Hoel is eager to fill gaps in our current knowledge. Many facts remain unknown about life in the northern seas, facts that are necessary for accurate resource management.

"We need more ecosystem-based management, where we see the totality, not just the individual species. We also expect a considerable growth of fish farming here in the north, and our institute will need better expertise to face the many challenges that aquaculture brings," he observes.

THE BIG PICTURE

Alf Håkon Hoel likes talking about his job, and he likes to see the big picture, in combination with the details. He sees his own background in political science as an advantage, as it allows him to draw his knowledge of society and the political world into the natural science sphere.

As regional research director of the Institute of Marine Research, Hoel is concerned about Norway's great responsibilities at sea. Almost 80% of Norway's seas are north of the Arctic circle, within "his" area.

"Many research tasks still await us there. Important questions that concern many people still need answers. But we're working on them, and we'll be stepping up our efforts, working together with our good colleagues across the borders," says Alf Håkon Hoel.

Hartvig Christie and Hege Gundersen // NIVA – Norwegian Institute for Water Research

From sea urchin deserts to rich kelp forests

Crabs and climate as drivers of ecosystem shifts in southern Nordland and eastern Finnmark

Imagine if some calamity were to destroy your favourite forest; if the rich environment that harboured animals, birds and insects were to vanish. Something very similar happened a few decades ago in the ocean off the coast of Norway. But with time, the undersea forest is recovering. Scientists from NIVA are watching the process closely.

FORTY YEARS AGO, green sea urchins (*Strongylocentrotus droebachiensis*) appeared at high densities over a 1 500 km stretch of coastline from mid-Norway (63°N) to northern Norway (71°N). Thousands of square kilometres of otherwise highly productive kelp forests were overgrazed and transformed into marine "deserts" dominated by sea urchins. This state of affairs continued for some time, but in recent years the densities of sea urchins have decreased and kelp forests have started to recover. This change, first seen in mid-Norway, has gradually proceeded northwards. More recently, a similar kelp recovery has been reported from easternmost Finnmark. The aim of this project was to record current distribution of sea urchins and kelp in Nordland, Troms and Finnmark, and to reveal important drivers favouring kelp at the cost of sea urchin dominance.

We recorded the distribution of kelp and sea urchins at more than 1 000 stations along the coast (see map), and quantified sea urchin density and size distribution at 55 of these stations.

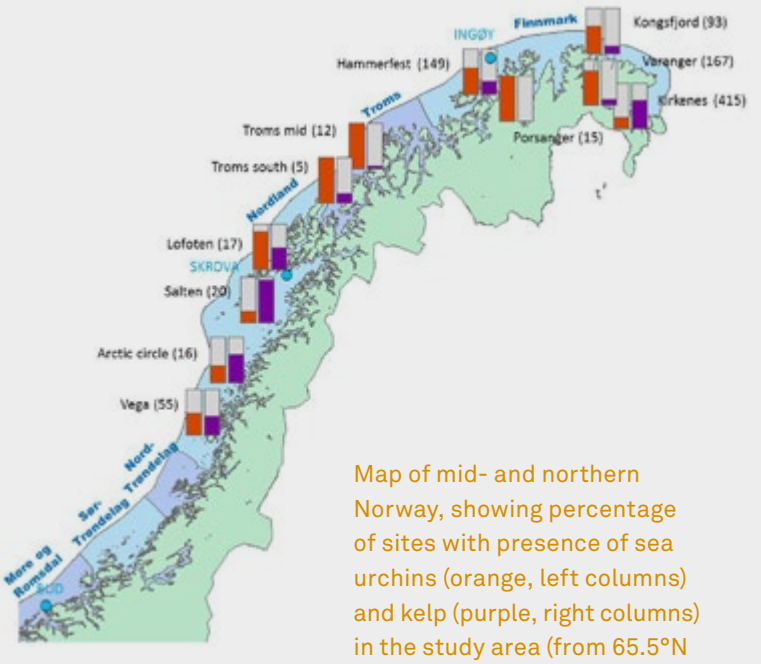
Adult sea urchins were found among stones and on smooth rocky surfaces, usually between 20 and 50 urchins per m^2. However, in areas where sea urchins are declining (see map) kelp recovery was observed, mainly on smooth rocky surfaces, whereas urchins persisted among stones. This strongly indicates that in areas experiencing reduced sea urchin density, the remaining sea urchins hide from predators in refuge habitats. Small sea urchins (10 mm or less) were found at high densities in kelp holdfasts and in maerl beds, but densities in sampled maerl were lower south of Lofoten (190 per m^2) than in Troms and Finnmark (540

Green sea urchins (*Strongylocentrotus droebachiensis*) invade a forest of kelp (*Laminaria hyperborea*) in Hammerfest. (Colour enhanced for clarity.)

Photo: Hartvig Christie

and 680 per m^2). This illustrates reduced recruitment of sea urchins in southern Nordland but not further north; other NIVA projects have related such reduced recruitment and northward recovery of kelp to increasing water temperatures.

The warming of the costal water has affected more species, such as the edible crab (*Cancer pagurus*), which has shifted northwards and increased in fishery landings in Nordland (Helgeland) since the late 1990s (Figure 1). As the edible crab is a predator on sea urchins, the reduction in urchin density is indirectly related to climate change. Predator impact is difficult to quantify, but the importance of crabs as predators is supported by recent observations of the invasive red king crab (*Paralithodes camtschaticus*) feeding on sea urchins up to the littoral zone. The abundance of



Map of mid- and northern Norway, showing percentage of sites with presence of sea urchins (orange, left columns) and kelp (purple, right columns) in the study area (from 65.5°N to the Russian border). The number of stations in each area is shown in parentheses.

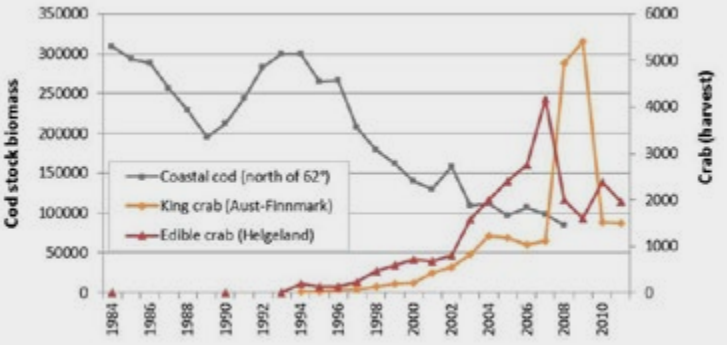


FIGURE 1

Changes in the biomass of coastal cod (*Gadus morhua*) north of 62°N (grey line), and landings of king crab (*Paralithodes camtschaticus*) in eastern Finnmark (yellow line) and edible crab (*Cancer pagurus*) at Helgeland (red line). Biomass and harvest are given in tonnes. Data from Directorate of Fisheries and Havforskningsrapporten, a report from the Institute of Marine Research.

the red king crab has increased in eastern Finnmark, which is also reflected in the landings (Figure 1). The increase in abundance of both crab species correlates in both space and time with the declines in sea urchin density and the distribution of the remaining sea urchins in predator refuge habitats.

Species at higher trophic levels may also indirectly influence the kelp-sea urchin dynamics. The top predator cod (*Gadus morhua*) has been found to feed on both the edible crab and the red king crab. If cod predation exerts significant pressure on crab stocks, a reduction of the coastal cod stocks might have contributed towards the increase in the crab populations. While the pelagic arctic cod stock in the northeast Atlantic is in very good condition, the Norwegian coastal cod stocks north of 62°N have been reduced by more than 50% since 1997, a reduction correlated in time with increasing crab landings (Figure 1).

This study shows a long coastline still dominated by sea urchins at high densities, an expansion of kelp recovery in mid-Norway, and a recent decline of sea urchins in the northeasternmost part of Norway. For both areas where kelp forests are recovering, simplistic models of the ecosystems can be made, combining our data with scenarios of increasing temperature (Figure 2). The models suggest the direction and strength of interactions between the key components that influence the stability of the two alternating states of the ecosystem: kelp forest versus barren, sea urchin-grazed seafloor. However, the importance and strength of some of these interactions is still hard to determine.

The models for both areas include the same biological mechanisms, but at present it is only in south Nordland that some of these mechanisms are influenced by temperature increase. The resilience of recently recovered kelp forests may differ between the southern and northeastern areas, since high temperatures may function as an important factor favouring kelp persistence in Nordland. Kelp recovery has been found to be negative for sea urchins, but kelp forests provide shelter and feeding grounds for juvenile cod

that may eventually increase predation on crabs and reduce future pressure on sea urchins. This may lead to increasing grazing on kelp forests in northeastern Finnmark, whereas in southern areas, high temperatures will disfavour sea urchin recruitment and enhance conditions for edible crabs. The positive or negative interactions and feedback mechanisms illustrated in Figure 2 give indications of how increase or decrease in one factor would influence other factors and the subsequent steps in the chain of reactions. These models may serve as tools for management of the system and indicate the potential effects of possible actions.

These results emanate from the project "Reduced sea urchin grazing – effect of climatic change or predator change?" organised under the Fram Centre Flagship Fjord and Coast. Hartvig Christie at NIVA has been the project leader. Other contributing colleagues at NIVA are Eli Rinde, Camilla With Fagerli, Trine Bekkby, Janne K. Gitmark and Kjell Magnus Norderhaug. The project involves cooperation with Akvaplan-niva (Nina Jørgensen), UiT The Arctic University of Norway (Torstein Pedersen and Knut Sivertsen), and the Institute of Marine Research (Hans Kristian Strand).

FURTHER READING:

Norderhaug KM, Christie H (2009). Sea urchin grazing and kelp re-vegetation in the NE Atlantic. Marine Biology Research 5: 515-528

Fagerli CW, Norderhaug KM, Christie H (2013). Lack of sea urchin settlement may explain kelp forest recovery in overgrazed areas in Norway. Mar Ecol Prog Ser 488: 119-132

Large red king crabs are now common in shallow waters in east Finnmark, where they can be seen feeding on sea urchins and other animals up to and even into the intertidal zone. (Colour enhanced for clarity.)
Photo: Hartvig Christie

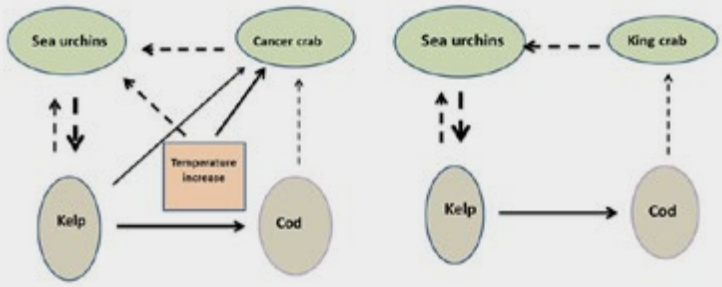


FIGURE 2

Conceptual model of the key components in the kelp–sea urchin system in the southern (left) and the northeastern parts (right) of the study area. Solid line – positive effect, dashed line – negative effect. The bold lines indicate interactions known to be strong.

Deck of RV *Lance* seen from main mast.

Photo: Kim Holmén, Norwegian Polar Institute

Arild Sundfjord // Norwegian Polar Institute

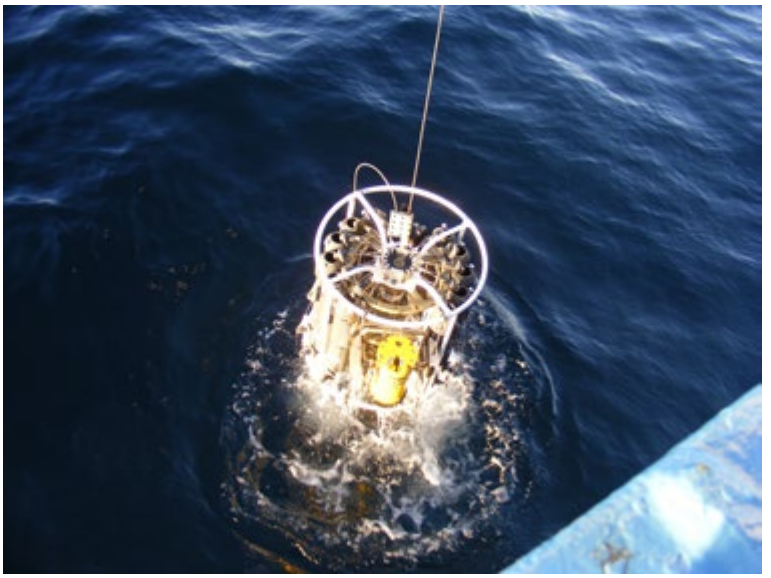
New data on Atlantic inflow to the Arctic Ocean reveal effects on sea ice and marine ecosystems

Water that flows northward from the Atlantic Ocean into the Arctic Basin plays a crucial role in conditions in the Arctic Ocean. The Fram Centre Flagship project A-TWAIN collects unique new data on the Atlantic Water that enters the Arctic Ocean north of Svalbard.

ATLANTIC WATER FLOWS into the Arctic in two branches near Svalbard. One branch follows the outer perimeter of the Yermak Plateau northwest of Svalbard and then turns eastward, flowing as a wide, slow and semi-deep current along the outer, deep part of the continental slope. The other branch is warmer, faster, and is found near the surface, following the upper part of the slope north of Svalbard. This large current system carries an enormous amount of heat and salt into the region - of similar magnitude as the Barents Sea Branch but with higher temperature when it enters the Arctic Ocean proper. It also brings a continuous supply of nutrients for primary production (phytoplankton growth) and transports living organisms of lower-latitude Atlantic origin into the area.

The primary objective of this project, funded by the Fram Centre "Arctic Ocean" flagship, is to understand how heat from the Atlantic Water influences the Arctic Ocean sea ice cover, but also to provide data for understanding the playing field for some of the key actors in the ecosystem, and components of the carbon system. A-TWAIN (Long-term variability and trends in the Atlantic Water inflow region) was established to gain understanding of how the inflowing current system is distributed at different depths along the continental slope, how it responds to local, short-lived atmospheric changes, and how it varies on seasonal and inter-annual timescales.

In the first year, a total of nine instrument moorings were deployed. The moorings all contain current meters plus salinity and temperature sensors, which together allow us to calculate fluxes of heat and salt. Some of the moorings also have sensors for chlorophyll, organic material and the key nutrient nitrate. Three moorings were provided through the Fram Centre Arctic Ocean project funding for A-TWAIN. Two moorings were deployed by the Institute of Oceanology, Polish Academy of Science (IOPAS), and four by Woods Hole Oceanographic Institution (WHOI), USA. The latter were deployed to obtain a first coverage of



Deployment of oceanographic current meter for mooring array.

Photos: Vladimir Pavlov, Norwegian Polar Institute

Deploying and preparing hydrographic instrument and water sampling device.

A-TWAIN

The project "Long-term variability and trends in the Atlantic Water inflow region" (A-TWAIN) is led by Vladimir Pavlov of the Norwegian Polar Institute and Randi Ingvaldsen of the Institute of Marine Research, working with colleagues Marit Reigstad (UiT The Arctic University of Norway), Frank Nilsen (University Centre in Svalbard) and others.

See more at www.whoi.edu/warmingarctic/

For more information please contact vladimir.pavlov@npolar.no

the outer branch of the Atlantic Water current, and had funding for only one year. Three A-TWAIN moorings were redeployed in 2013, along with one from IOPAS. Together these moorings will cover the innermost Atlantic Water branch also in the coming year. We hope to continue this data collection in the future, as it is the only data series covering the actual inflow of Atlantic Water into the Arctic Ocean via Fram Strait - the warmer of the two main pathways.

To complement and fill in the spatial gaps between the mooring locations, we collected a substantial number of vertical profiles of hydrography and currents, and took water samples for analysis of a much broader set of biological and biogeochemical parameters. This was done both during the first deployment cruise in September 2012 and during the recovery and

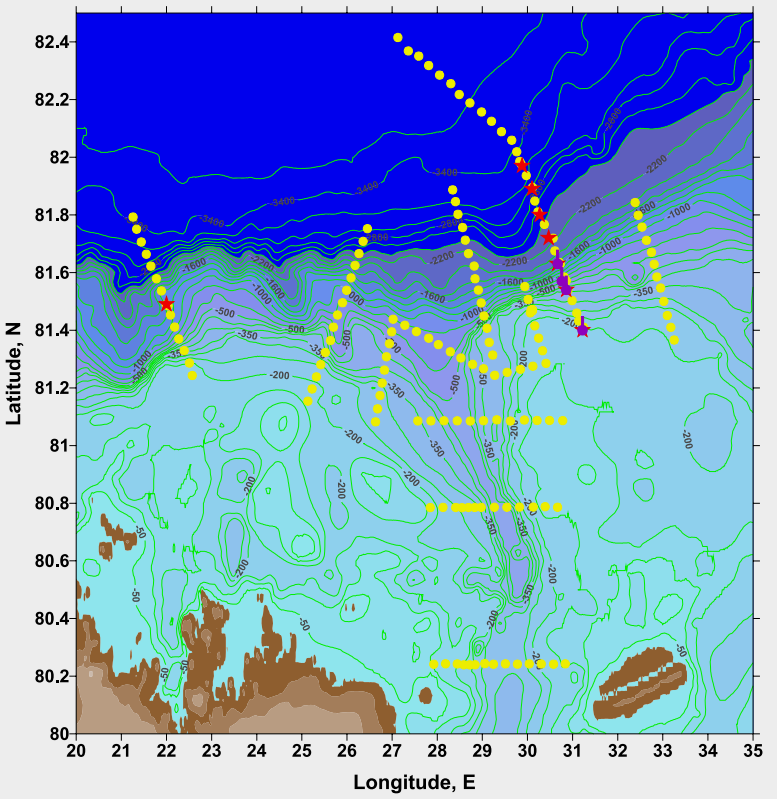
Deployment of plankton sampling net.
Photo: Amy Cooper, Woods Hole Oceanographic Institute

redeployment cruise in autumn 2013, where six institutes participated (UiT The Arctic University of Norway, Institute of Marine Research, Norwegian Polar Institute, University of Bergen, IOPAS, and WHOI).

We are currently processing the data from the first year-long series and from the cruises. The first joint publications from the project should be published in the coming year. Processed and averaged data will be made publicly available in appropriate databases. We believe that the data will be used both for fundamental research, for operational purposes such as tuning forecast models of ice and ocean, and for evaluation and improvement of climate model performance.

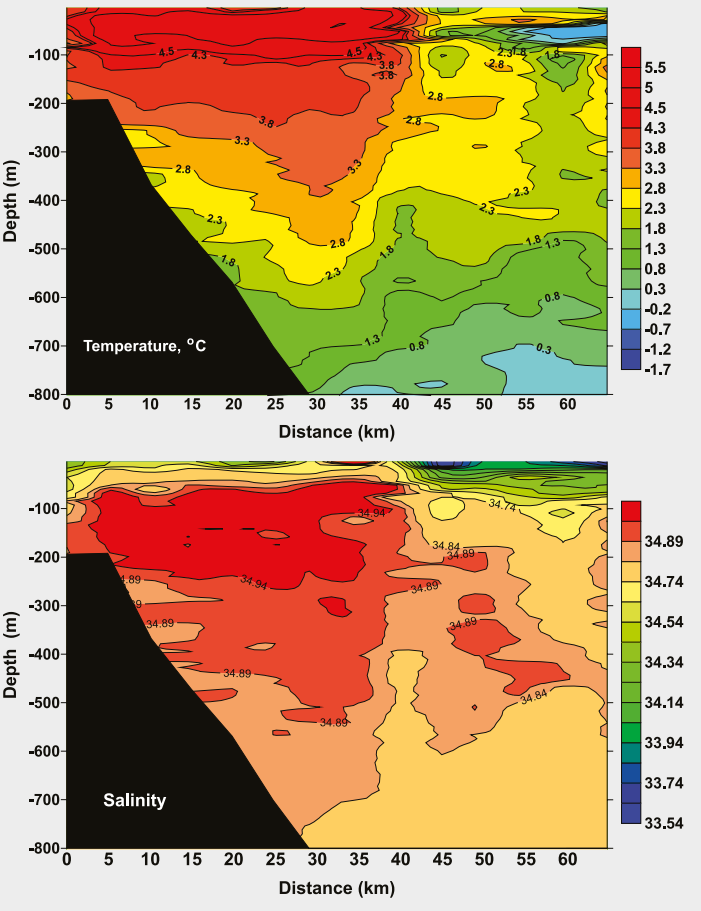
The project was recently presented at the annual meeting of the Forum for Arctic Ocean Modeling and Observational Synthesis, in Woods Hole, USA. The community was enthusiastic about the successful completion of the first year of measurements, and the continuation of the program. Several institutes have since that meeting indicated their intentions of becoming partners by providing instrumentation and personnel for cruises from next year.

The data will be used for evaluating simulation performance of the sea ice-ocean-ecosystem model established within the Fram Centre Arctic Ocean flagship project "Modeling of ice, ocean and ecology of the Arctic Ocean". This consists of a setup that gives 4 km horizontal resolution for the entire Arctic Ocean and Nordic Seas, and an even finer-resolution model of 800 m which covers the Svalbard area including Fram Strait and the mooring area at 30° East. The dataset will also be used in the project Carbon Bridge, led by UiT The Arctic University of Norway and funded by the National Research Council's Polar Program. Carbon Bridge has the A-TWAIN area as its focal point for three cruises in 2014. The initiative Arctic in Rapid Transition, endorsed by the International Arctic Science Committee, will use the A-TWAIN line as focal point for a cruise with RV *Polarstern* in 2015. The data will also be useful for understanding the oceanographic conditions during the RV *Lance* freeze-in drift project which will take place in the first six months of 2015 (see article on page 28). Furthermore we aim to use the data in collaboration with the new Nansen and Amundsen Basin Observing System project, run by the International Arctic Research Center, Fairbanks, USA, and the Arctic and Antarctic Research Institute (AARI), St. Petersburg, Russia, and for the Laptev Sea Systems project (Alfred Wegener Institute/AARI).



Map of the study area

Purple stars – A-TWAIN moorings
Red stars – partner moorings
Yellow dots – hydrography stations



Temperature (top) and salinity (bottom) across the continental slope in the Atlantic Water inflow region north of Svalbard.

Jørgen Berge // UiT The Arctic University of Norway, and University Centre in Svalbard

Head above water?

"Down on the bottom of the deep dark sea / sits a little devil and cries." Thus begins a well-known Norwegian song from the early 1990s. This article isn't about a little devil; it's about a little fish known as the Atlantic spiny lumpsucker. But it *does* sit on the bottom of the deep dark sea, and for the zooplankton *Themisto libellula*, it really *is* a little devil.

THE ATLANTIC SPINY LUMPSUCKER, (*Eumicrotremus spinosus*) is a small but relatively common fish around Svalbard. Anyone who has done some diving in the Svalbard archipelago will probably have had the pleasure of encountering this funny little fish, which can often be found sitting quite motionless in the kelp beds. Rarely more than 10-12 cm long, it is an extremely poor swimmer. If you happen to come across a spiny lumpsucker and want to admire it, just cup it in your hand. If it tries to get away, all you need do is poke it back in your hand and it will stay put. This fish is incredibly sluggish!

During a research cruise organised by the University Centre in Svalbard in the autumn of 2012, we found more than 250 individuals of the species in a single trawl. Despite more than ten years of field work in the fjords around Svalbard, this was something I had never before experienced. So we decided to take a closer look at this unusual accumulation of an otherwise common yet little known fish.

To illustrate how little is actually known about this fish and its closest relatives (two species are found around Svalbard - the Atlantic spiny lumpsucker and the leatherfin lumpsucker): until quite recently it was thought that Svalbard waters harboured more species than these two. However, genetic studies demonstrated that individuals believed to belong to two different species, were actually males and females of the spiny lumpsucker! In any case, we took the opportunity to examine the spiny lumpsucker more closely, hoping to discover more about its biology.

The most interesting thing was what we found in the fish's stomach. All the fish that had food in their stomachs had consumed large quantities of the pelagic amphipod *Themisto libellula*. And more than 90 per cent of those fish had nothing but *Themisto libellula* in their stomachs.

What's so special about that? Well, *T. libellula* is a species that swims freely in ocean waters and is known for its ability to swim long distances. Previous research has shown that this amphipod makes daily vertical migrations, swimming up from great depths to the surface at night and returning to the seabed for the day. Every day. All year round. Large swarms of *T. libellula* can frequently be observed under pack ice in the Arctic Ocean, in areas several thousand metres deep. In other words, this is a species with excellent swimming capability. Surely it should be able to elude the sluggish and poorly camouflaged spiny lumpsucker? Not only did the spiny lumpsuckers have masses of *T. libellula* in their stomachs: all the fish had clearly eaten at about the same time, for their stomach contents all displayed the same degree of decomposition. (OK, there can be a touch of "CSI" about a biologist's working day...) On two successive cruises in the areas around Svalbard, we encountered spiny lumpsuckers. On both occasions, we did tests to see whether the results from the previous autumn could be replicated,

Spiny lumpsucker – the little devil.
Photo: Erling Svendsen

Themisto libellula.
Photo: Jonas Thormar

and both times the results were approximately the same.

The story might well have ended there. We now know that the spiny lumpsuckers living around Svalbard eat *T. libellula*. A lot of *T. libellula*. But that is where the song I mentioned earlier comes in - the fact that we found so much *T. libellula* in the stomachs of the spiny lumpsuckers, and that all the fish had fed at roughly the same time, provides valuable information about the biology not only of the spiny lumpsucker but also of *T. libellula*. The only way the sluggish spiny lumpsucker can catch the much quicker amphipod must be for it to sit on the bottom of the deep dark sea waiting for its food to descend to it.

As mentioned earlier, *T. libellula* is known to undertake major daily migrations year-round, including during the long dark polar night. This daily migration serves as an enormous biological carbon pump: the amphipods feed in the upper layers of the ocean at night and then swim to the bottom to digest their food during the daytime. In this way *T. libellula* carry organically bound carbon down into the sea, where it is released through respiration and digestion. This means the amphipod is in effect extracting a greenhouse gas out of the atmosphere and transporting it down to the bottom of the ocean. But how far down do the amphipods swim, and does it *matter* how deep they go?

In context of carbon transport, it actually matters a great deal whether the migration stops in the middle of the water column or goes right down to the bottom. Thanks to the spiny lumpsucker - the little devil at the bottom of the deep dark sea - we now know that *T. libellula* migrates right down to the seabed, and is thus a powerful and positive contributor toward attaining Norwegian politicians' ambitions to reduce atmospheric levels of the greenhouse gas carbon dioxide. The amphipod also plays an important ecological role in connecting the two otherwise relatively separate food webs in the free ocean waters and on the seabed.

One last thing... Later on in that song there's a line saying "we must look to the moon". That is exactly what *T. libellula* does in the dark polar night: it uses the light of the moon to tell it when to start its daily migrations! This is something we will be studying in detail next winter, when we will try to find out what goes on during the long polar night "down on the bottom of the deep dark sea".

FURTHER READING:

Berge J, Nahrgang J. (2013) The Atlantic spiny lumpsucker *Eumicrotremus spinosus*: life history traits and the seemingly unlikely interaction with the pelagic amphipod *Themisto libellula*. Polish Polar Research 34(3):279–287

See also www.mare-incognitum.no

The author diving in a kelp bed off Svalbard. The spiny lumpsucker got away before the picture was taken.

Photo: Geir Johnsen, Norwegian University of Science and Technology and University Centre in Svalbard

Claudia Halsband // Akvaplan-niva
Dorte Herzke // NILU – Norwegian Institute for Air Research
Geir Wing Gabrielsen // Norwegian Polar Institute

Plastic litter in the ocean – also a problem in the North?

Plastic waste in the oceans is a growing environmental problem. Large amounts of plastic are adrift at sea, and a lot of it ends up on beaches, cluttering our planet's coastlines. Unfortunately, the coasts of Norway and Svalbard are no exception.

PLASTIC LITTER originating from ships, rivers and coasts can travel long distances before it is deposited again on land. During the journey, marine mammals and birds get entangled in this debris, and some of them ingest bits of plastic together with or instead of food, causing injuries and even death. Seabirds, and especially the northern fulmar (*Fulmarus glacialis*), are highly exposed to plastic litter. Due to their longevity and long periods spent offshore, fulmars can consume considerable amounts of plastic during their lifetime. For example, the number of fulmars caught with plastic in their stomach in the Netherlands increased from 91% in the 1980s to 98% around the year 2000 and has since stabilised at slightly below 95%. Fulmars in Svalbard were less contaminated in the early 1990s, when only 15% of the birds had plastic in their stomachs, but this number has increased to 90% in 2013, as well as the number of plastic particles per bird. Fulmars in the Canadian Arctic and Iceland have also been reported to ingest plastic.

Much of the plastic is invisible to the human eye. Plastic degrades at sea, but very slowly. It is gradually broken down into smaller and smaller pieces, called microplastics. These tiny fragments of plastic can be taken up by many different animals in the ocean - even the smallest organisms, such as plankton. Microplastics can get stuck in the fine hairs, swimming legs and feeding appendages of planktonic crustaceans and other organisms, hampering their movements - and perhaps making them easy prey for predators. When marine organisms mistake plastic fragments for food, the plastic may damage internal organs or prevent nutritious food from being eaten, causing malnutrition or starvation. Plastics may also alter the structure of faecal material and influence how carbon is transported from the water column to the seafloor, where it is used by benthic animals and microorganisms. Plastic can therefore do much harm to marine ecosystems.

Humans are also part of the equation: if microplastics enter the food chain because plankton eat microplastics and young fish eat plankton (or eat plastic directly), the plastic may make its way unseen into the seafood that we eat.

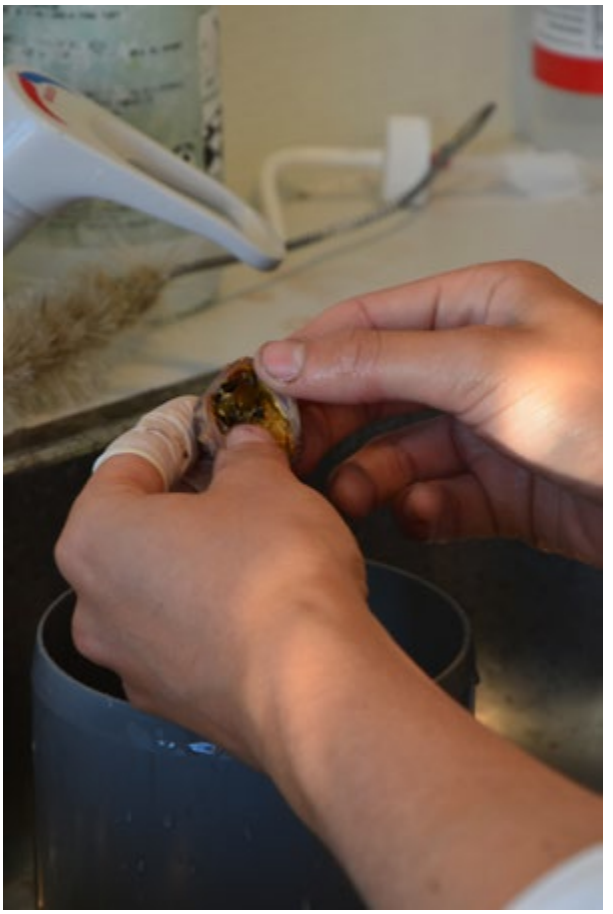
Marine litter consists of different plastic materials which in turn often contain a range of chemical additives (for example softeners such as phthalates). Another problem is that plastic can soak up harm-

Plastic litter on the beach in Skulsfjorden, Tromsø.

Photo: Bo Eide

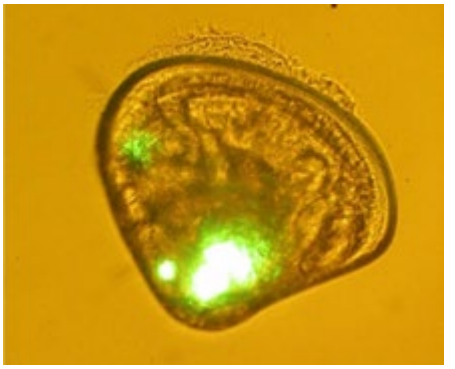
ful chemicals that are dissolved in the surrounding seawater and have entered the marine environment in other ways, for example persistent organic pollutants and other surface-active, hydrophobic chemicals. In addition to the physical harm it can cause to sea life offshore, in the coastal zone and on the seabed, plastic therefore also represents a floating cocktail of toxins, posing a threat to marine organisms and seafood safety (see article on page 37).

Several institutes at the Fram Centre are working on the problem of marine plastic litter. Projects funded by the European Union, the Norwegian Research Council, the Arctic Council and the Svalbard Environmental Protection Fund investigate how the North



Dissection of the stomach of a northern fulmar and plastic fragments found in the stomach of a fulmar captured in Svalbard.

Photos: Alice Trevail



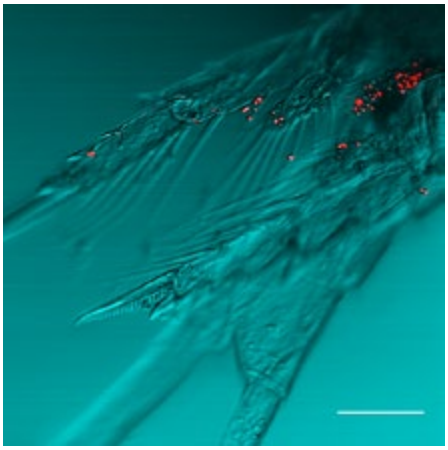
Microplastics in the guts of planktonic organisms: a *Calanus* copepod (top left) and a bivalve larva (bottom left).

Photos: Matthew Cole

Reprinted with permission from Cole M, Lindeque PK, Fileman ES, Halsband C, Goodhead R, Moger J, Galloway T. (2013) Microplastic ingestion by zooplankton. Environmental Science & Technology 47:6646-6655. Copyright 2013 American Chemical Society

and the Arctic are affected by bits of plastic floating in the ocean. Akvaplan-niva and the Norwegian Institute for Water Research look at plankton, fish and benthic organisms and what health issues they may face from microscopic pieces of plastic. The Norwegian Polar Institute examines stomach contents and tissue samples of northern fulmars from Svalbard, Iceland and the Faroe Islands. The Norwegian Institute for Nature Research collects dead seabirds and seabirds caught in nets along the Norwegian coast and examines their stomachs for plastic. NILU - Norwegian Institute for Air Research develops new techniques to determine the chemical composition of the plastic and the harmful pollutants that leak out and get to the organs and tissues of exposed marine animals.

Fram Centre incentive funds helped to integrate these projects within the Fram Centre and develop a new collaboration within the Flagship "Hazardous Pollutants".



Polystyrene beads (red dots) adhering to a copepod swimming leg. Grey scale bar = 50 µm.

Photo: Rhys Goodhead

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Cole M, Lindeque PK, Fileman ES, Halsband C, Goodhead R, Moger J, Galloway T. (2013) Microplastic ingestion by zooplankton. Environmental Science & Technology 47:6646-6655

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Mallory ML. (2008) Marine plastic debris in northern fulmars from the Canadian high Arctic. Marine Pollution Bulletin 56(8):1501-1504

van Franeker JA, Blaize C, Danielsen J, Fairclough K, Gollan J, Guse N, Hansen P-L, Heubeck M, Jensen J-K, Le Guillouj G, Olsen B, Olsen K-O, Pedersen J, Stienen EWM, Turner DM. (2011) Monitoring plastic ingestion by the northern fulmar *Fulmarus glacialis* in the North Sea. Environmental Pollution 159(10):2609-2615

Northern waters seen from the deck of RV *G.O. Sars*, operated by the Institute of Marine Research and the University of Bergen.

Photo: Kjartan Mæstad

Helge M. Markusson // Fram Centre

New research programme on industry and the environment

The research activities conducted under the auspices of the Fram Centre will expand considerably in 2014. In December 2013, the Norwegian Ministry of Climate and Environment gave the green light for the start-up of a sixth research flagship programme: Environmental impacts of industrial activity in the north (MIKON).

Speaking at the Arctic Frontiers conference in Tromsø 21 January, Prime Minister Erna Solberg said, "Such knowledge is needed in order to ensure environmentally responsible development, based on the best environmental solutions that will not have negative impact on ecosystems, cultural heritage or society. The research programme will also seek to promote international cooperation and exchange on these issues."

A total of 15 million NOK has been allocated to the MIKON project in the national budget. In 2014, over half of that sum will be used to finance the ice-drift project with the Norwegian Polar Institute's RV *Lance* (see page 28). In 2015 the budget allocations will go in their entirety to MIKON. This means that measured in money, the research activities will increase significantly in the years to come and that MIKON will be the largest of the Fram Centre's six research flagship programmes.

Will strengthen the knowledge base
MIKON's objective is to do research that will strengthen the knowledge base used by the authorities in efforts to limit the "footprint" of industrial activity in the High North, and ensure that new industrial activity takes place within a responsible environmental framework. The research within the MIKON programme will take into consideration both existing business activities and visions/expectations of future developments.

In the words of Jan-Gunnar Winther, chair of the Fram Centre's committee of institutional directors, "MIKON will increase our expertise and expand our knowledge base concerning the High North – this is Norway's greatest advantage in these northern areas. It will not only benefit Norwegian environmental management and industry in the north, but also have ripple effects on foreign policy."

Cross-disciplinary approach
MIKON will be an interdisciplinary programme. The Ministry of Climate and Environment points out that the environmental consequences of new industrial activity will be complex, and knowledge from a range of disciplines will be relevant, including the natural and social sciences, and cultural history.

MIKON will make use of knowledge from the Fram Centre's five other flagship programmes; natural boundaries between the programmes will be set to prevent duplication of effort.

Ultimately, work done within the framework of MIKON will provide better methods and models for environmental impact assessment, risk analysis and monitoring. However, MIKON will not itself be doing any of these things. Its aim is to provide better tools for others to use.

Harald Steen // Norwegian Polar Institute // Leader of ICE: Centre for Ice, Climate and Ecosystems

Exploring the future Arctic sea ice regime: from year-round to seasonal sea ice cover

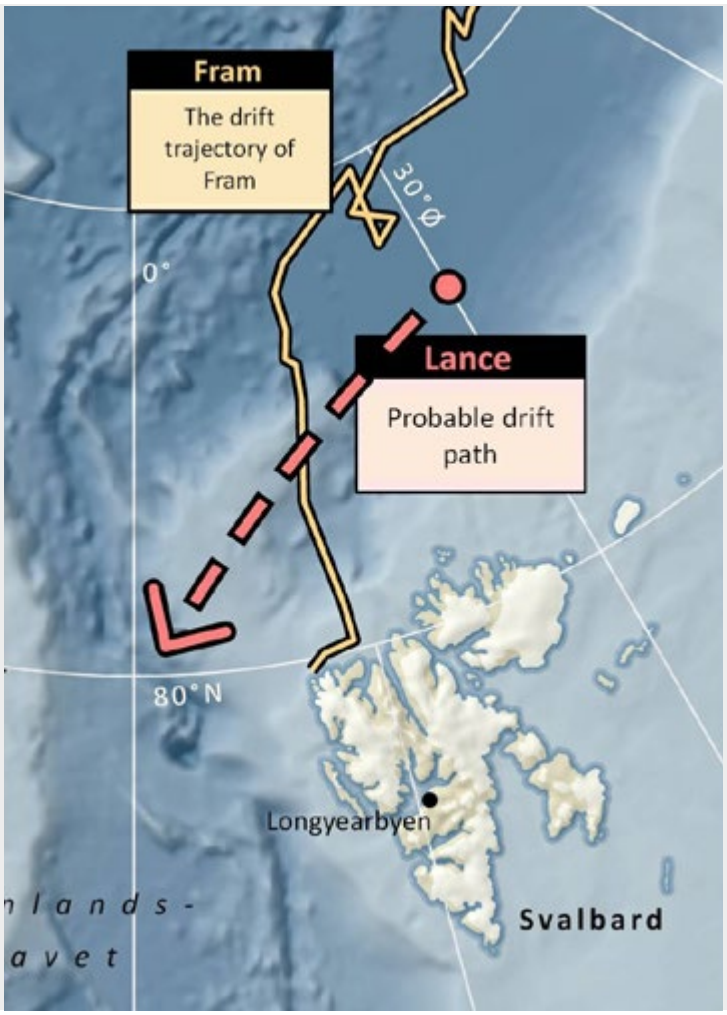
In recent years the ice cover in the Arctic Ocean has been diminishing. Not only is the total ice-covered area smaller than it used to be, but the ice is also thinner. What is happening, and what consequences can be expected?

IN SEPTEMBER 2012 we saw the smallest sea ice extent on record in the Arctic. In addition, we observed that sea ice drifting through Fram Strait was substantially thinner in recent years (less than 2 m thick), than in the early 1990s (about 3 m). This indicates outflow of a larger amount of first-year ice, relative to multiyear ice. The ice measured in the Fram Strait originates from the Norwegian and Russian sector of the Arctic basin. Taken together, this means that over the past 25 years we have not only lost a lot of sea ice cover but also moved from a multiyear sea ice system towards a seasonal system.

"So what?" you may ask. Well, first-year ice is obviously thinner, but it also has different physical properties than multiyear ice. During peak melting season in late July and early August, first-year ice reflects about 10% less of the incoming solar energy than multiyear ice, which means that the ice and the ocean below it receive 16 W/m^2 more energy from the sun. About half of the energy is absorbed in the ice, and the other half penetrates to the ocean below. The extra energy means that the thickness of first-year ice will decrease 13 cm more per month due to melting than multiyear ice. Models predicting the extent of sea ice cover underestimate how big the reduction is. The positive feedback caused by the shift from multiyear ice to first-year ice may explain the discrepancy.

There are also other sources of uncertainty. Warm Atlantic water flows into the Arctic, but we aren't sure how much, or to what extent it mixes with the less saline arctic water in the top layers. This might add another positive feedback loop to the system. If the temperature and volume of the Atlantic inflow increases or if mixing patterns change, this would obviously have a dramatic effect on sea ice.

The energy budget described above stems from a dedicated study done late in the melt season and data from the rest of the year are scanty at best. This lack of data is exacerbated by the fact that the new ice regime is precisely that: new. Thus the climate models are based on data such as those from the SHEBA drift



Ice-bound for science

The yellow line shows the trajectory of a vessel that was intentionally frozen into the ice in the Arctic Ocean and allowed to drift over a century ago. That ship was Fridtjof Nansen's legendary *Fram*. Purpose-built to survive in icy seas, *Fram* played a central role in several of Norway's earliest polar research efforts, and the Fram Centre is proud to bear her name. RV *Lance* will probably drift in a southwesterly direction from the starting position during the winter and spring of 2015. The pink arrow represents an educated guess of how *Lance* will move, based on drift ice trajectories from the last 12 years. The exact path is impossible to predict.

station project (Surface Heat Budget of the Arctic Ocean), carried out in the late 1990s, which focused on multiyear ice, or from Russian Arctic drifting stations. In other words, the current ice situation is not well represented in the models.

To close the knowledge gap, the Norwegian Polar Institute has initiated the "Norwegian Young Sea ICE Cruise". N-ICE2015 will provide a comprehensive dataset on the energy budget of the first-year sea ice system as well as oceanographic and atmospheric data, and will cover the time from when the new ice is formed in winter until it melts. These data will help us understand, model and predict the arctic sea ice system and its effect on the ecosystem, weather and climate. Importantly, the dataset will be made available to the wider scientific community. Basic funding for the N-ICE2015 comes from the Centre for Ice, Climate and Ecosystems (ICE), the Norwegian Polar Institute, the Fram Centre, and the Ministry of Climate and Environment.

In late December 2014 we will let RV *Lance* freeze into the ice north of Nordaustlandet, at 83.25°N 30°E, and let her passively drift with the ice. Judging from historic sea ice drift trajectories, it is likely that RV *Lance* will drift in a southwesterly direction. The actual drift trajectory and speed are impossible to predict, but the ship will probably be freed from the ice in mid spring. If so, RV *Lance* will return to her starting position and start a new drift. Under all circumstances, the ice drift project will end in late June.

During the cruise we will have to tackle many challenges: polar low pressures, total darkness, and extreme temperatures, not to mention isolation. Nonetheless, we will work and sample data around the clock throughout the cruise. In preparation, RV *Lance* is being refurbished. *Lance* was originally a sealing vessel, and many of her old features - specially designed to cope with prolonged stays in the ice - are being reinstated. To maximise her efficiency as a working platform, we will schedule helicopter flights from Svalbard to change personnel. This will allow

RV *Lance* in sea ice during an earlier cruise in winter.

Photo: Jon Aars

scientists to spend only as much time as they need on board, leaving space for other scientists when their own project is finished.

Throughout the cruise we will study oceanographic and meteorological parameters, radiation, the marine ecosystem, the ice itself, ice dynamics and ice mechanics. These data will be the core of our deliverables, and will be made available to the wider community through the Norwegian Polar Institute data service - some data in real time, some after analysis. In combination with the existing multiyear sea ice dataset provided by SHEBA and similar projects, these data will make scientists better equipped to forecast future scenarios of arctic sea ice, ecosystem responses, and feedback on the planet's climate.

In addition to time series data, we will have dedicated campaigns to study processes such as algae bloom under the ice, sea ice thickness over a larger area, and turbulent mixing of the ocean caused by underwater topography and wind. Some of this work will be done using advanced remotely operated underwater vehicles and autonomous unmanned aerial vehicles. While RV *Lance* is in the ice, the area around her will also serve as a ground-truthed reference point for scientists working with remote sensing from satellite images or airplanes.

N-ICE2015 will give us a golden opportunity to do science in an area, and at a time of year, that has seldom been studied before. An endeavour such as this is impossible without collaboration from many national and international groups. Through this joint effort, N-ICE2015 intends to produce a new and comprehensive dataset on the new sea ice regime in the north, enabling us to meet the future well prepared.

N-ICE2015

N-ICE2015 is a collaboration between scientists from many Norwegian and international research institutes. All these institutes will bring equipment and human resources into the project, increasing the value of the initial investment and the cruise.

Norwegian partners

- Norwegian Polar Institute
- University of Bergen
- Norwegian Meteorological Institute
- Norwegian University of Science and Technology
- University Centre in Svalbard
- NORUT – The Northern Research Institute
- UiT The Arctic University of Norway
- University of Oslo

International partners:

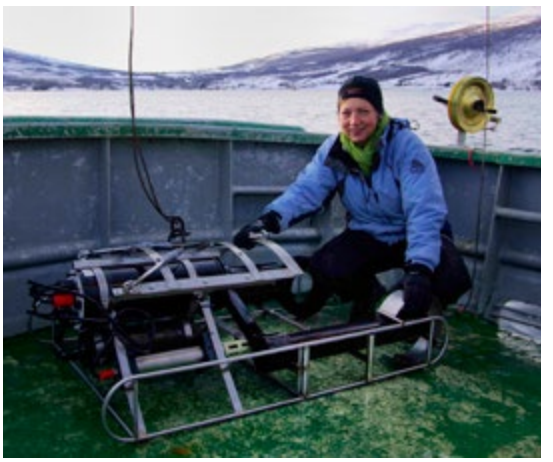
- Arctic and Antarctic Research Institute (Russia)
- Alfred Wegener Institute (Germany)
- British Antarctic Survey
- Ice – Atmosphere – Arctic Ocean Observing System, University Pierre and Marie Curie (France)
- Cold Regions Research and Engineering Laboratory (USA)
- Committee on Earth Observation Satellites (International)
- Earth and Space Research (USA)
- Finnish Meteorological Institute
- Korea Polar Research Institute
- University of Washington – Applied Physics Laboratory (USA)

Fredrika Norrbin // UiT The Arctic University of Norway

A focus on plankton

Some of the world's most important creatures are tiny. Infinitesimal marine organisms make life on earth possible, yet most people have never seen them. Even the scientists who study them rarely get to observe them alive and in their natural habitat. But now there is a way to see marine plankton in action.

ZOOPLANKTON are tiny creatures that populate the seas, much as insects swarm in the air. They feed on even smaller organisms: phytoplankton, which convert sunlight and nutrients to energy, and microplankton that eat particles. Zooplankton are adapted to the seasonal cycle, and are sensitive to temperature. Because they have little motility of their own, they depend on water currents to move from place to place. What makes zooplankton so important to study is that they provide the major pathway of energy to fish and higher organisms. Environmental changes may alter the composition of plankton so that the ecosystem becomes unfavourable to species that humans rely on. Clearly we need detailed knowledge about plankton, for instance if we want to know whether there is enough of the right kind of plankton at the time of year when fish larvae need abundant food.

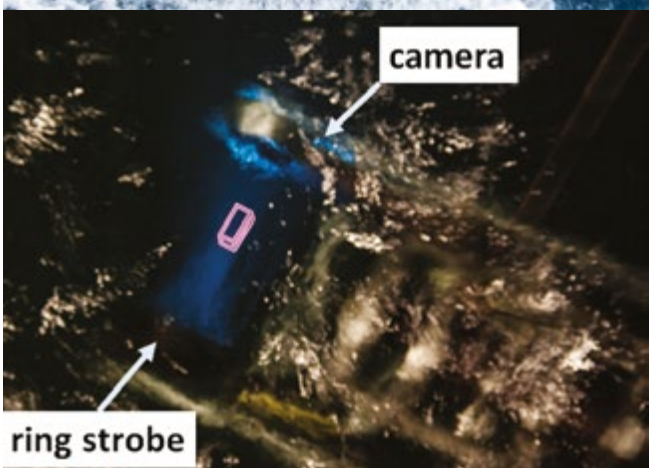


The author on deck with the VPR.
Photo: Fredrika Norrbin

THE VIDEO PLANKTON RECORDER

We use an instrument called the Video Plankton Recorder (VPR) to study the abundance and distribution of common types of zooplankton. The VPR consists of a digital video camera, a strobe light, and sensors for salinity, temperature, chlorophyll fluorescence and turbidity. This device is deployed from a winch and either raised and lowered repeatedly at a single station, or towed behind a ship moving through the water. What is so fascinating about this instrument is that it provides images of undisturbed plankton and particles in the water column, with exact information on the depth of each observation. Some of these animals are too fragile to be caught with plankton nets, so marine biologists rarely see them in a natural state.

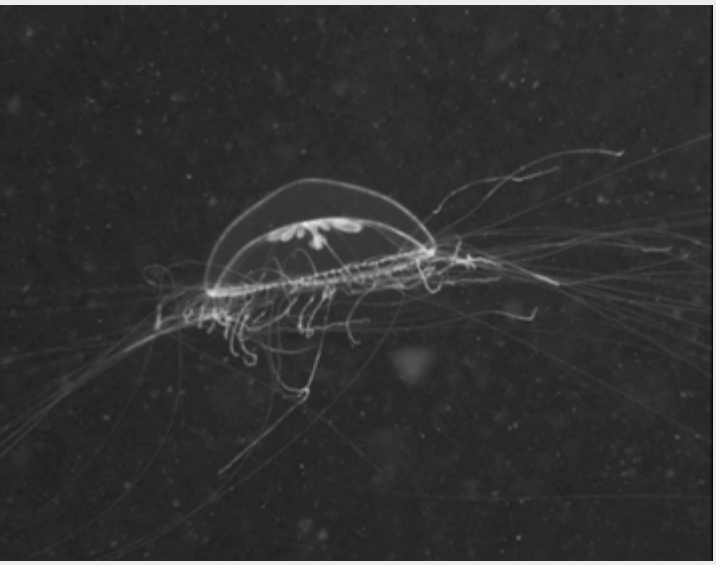
Deployment of the Video Plankton Recorder (VPR).



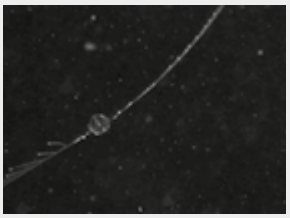
The VPR at the surface, showing the illumination from the Xenon ring strobe. The focus of the 1.4 megapixel B/W camera is midway between the two arms, providing an almost undisturbed sampling area. Twenty images (22 × 32 mm – sampling volume 26 ml) are taken every second.

Photos: Fredrika Norrbin

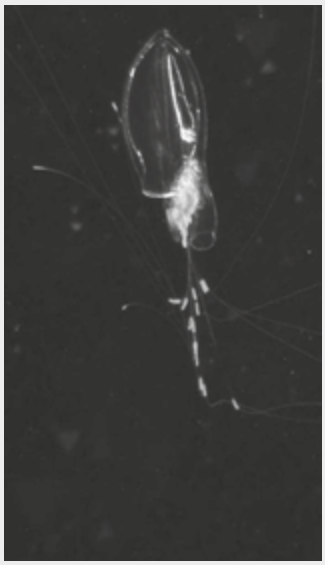
We use the VPR to investigate zooplankton in North Norwegian fjord areas, partly within the Fram Centre Flagship program "Effects of climate change on sea and coastal ecology in the north". The VPR work package is concerned with zooplankton composition and vertical structure. Many models assume that plankton are homogeneously distributed in the water column, but high-resolution studies have shown a large degree of aggregation, and especially layering of the plankton. Although zooplankton are weak swimmers, they can easily adjust their vertical position in the water column. Thus they can choose optimal environmental conditions, and approach or avoid other plankton. Even in rather turbulent coastal waters, plankton form distinct horizontal layers a few metres to tens of metres thick.



Hydromedusa (10 mm in diameter; Porsanger, October)



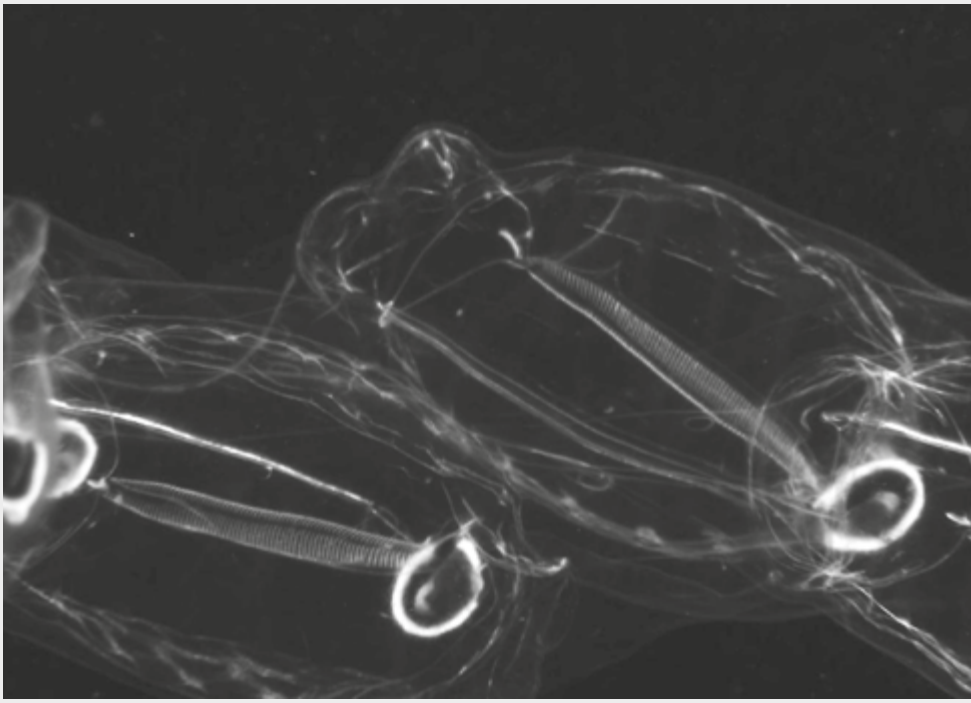
A small comb jelly spreads its tentacles to catch plankton (0.5 mm in diameter; Rijpfjorden, January)



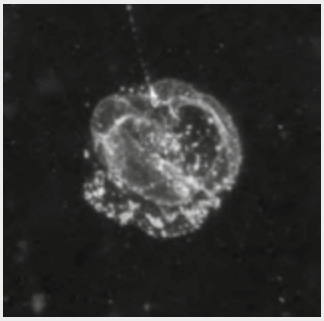
Siphonophore (the main bell is less than 0.5 mm high; Loppahavet , October)

Fragile organisms are often voracious predators competing with fish larvae for copepod prey. Some, like salps and larvaceans, feed on phytoplankton and particles.

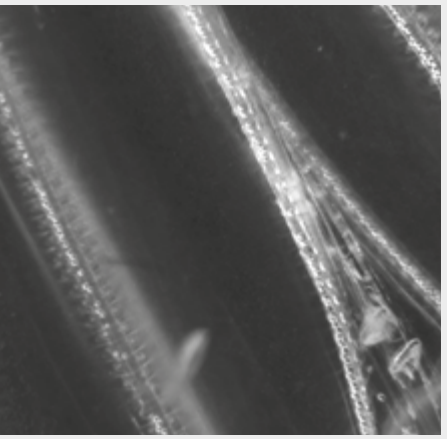
Photos: Fredrika Norrbin



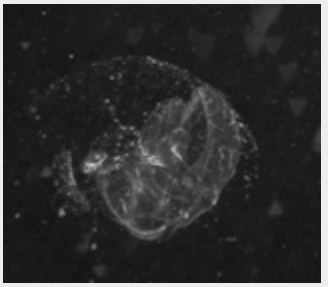
Salps form colonies of barrel-like organisms that filter the water (individual length 20 mm; Loppahavet , October)



Larvacean houses clog up and are shed several times per day, ultimately forming “marine snow” (Billefjorden, January)

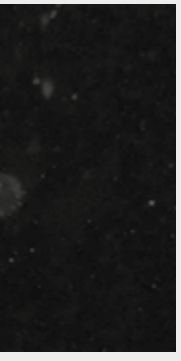


A comb jelly has caught some *Calanus* in its lobes (Porsanger, August)



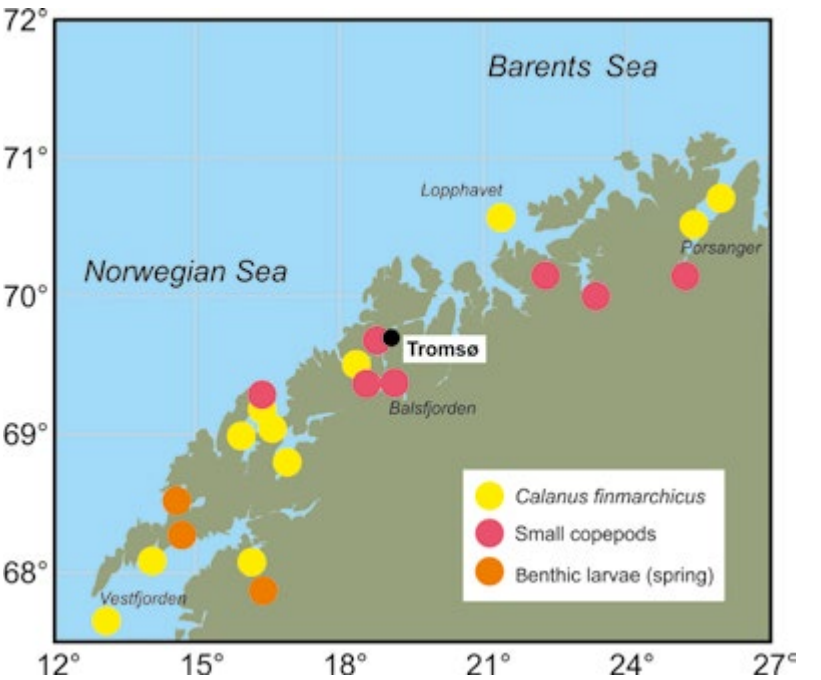
Larvaceans build mucus houses, which are really food-collecting sieves, and sit inside beating their "tail" to create a water current (about 11 mm in diameter; Kongsfjorden, January)

An arrow worm can eat several copepods per day (length = 3 cm; Rijpfjorden, January)

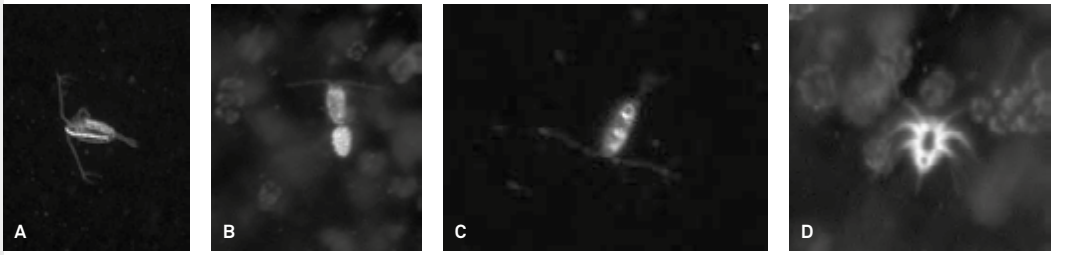


EARLY FINDINGS – INSIGHT FROM IMAGES

From VPR stations taken at various times of the year, a pattern emerges of outer fjords and coastal areas dominated by the copepod *Calanus finmarchicus*, while inner fjord arms are populated by smaller species of copepods and hydromedusas. Although these facts could also have been determined using plankton nets, the VPR provides additional information about depth segregation of species (termed "habitat selection") and the position of invertebrate predators in relation to their prey.

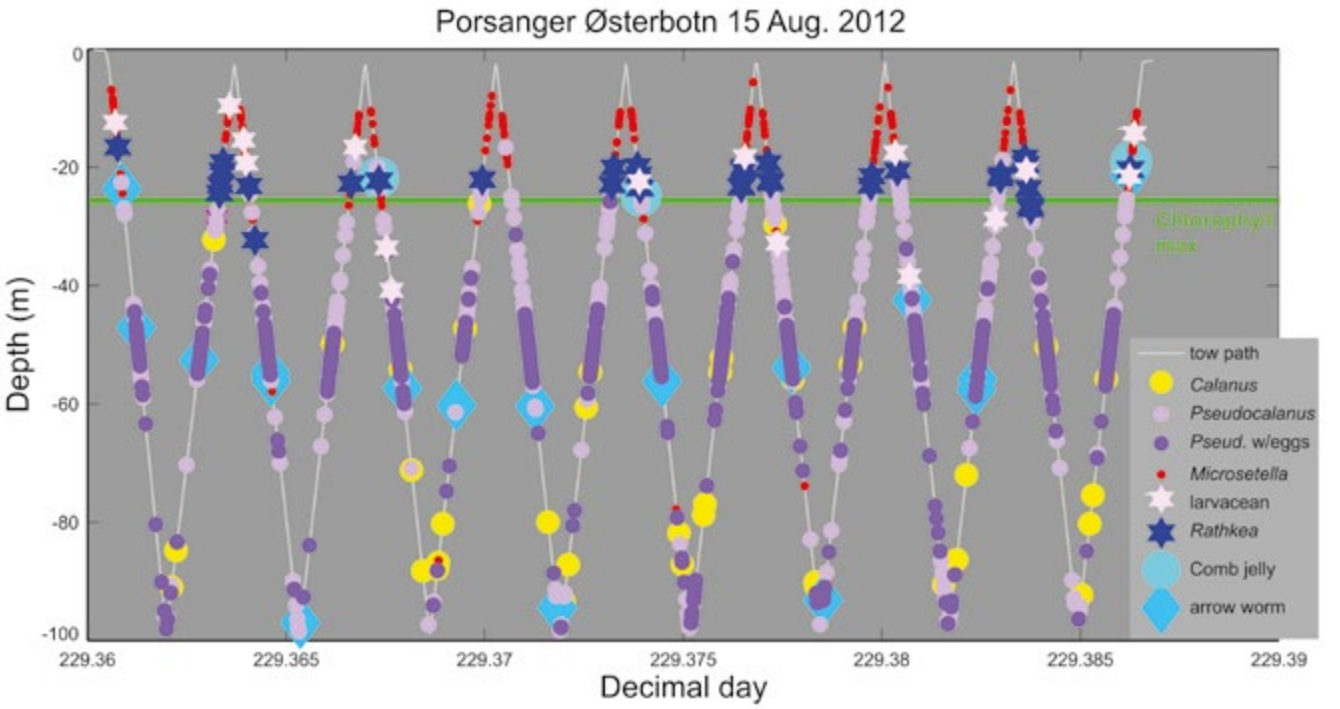


North-Norwegian VPR stations, showing dominance of *Calanus* and smaller plankton, respectively. Larvae of benthic organisms can be very abundant in spring.

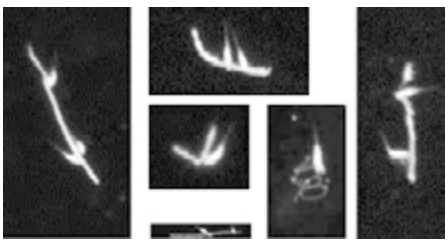


A. *Calanus* (length = 3-4 mm) stores energy in an oil sac. **B.** *Pseudocalanus* (1-1.5 mm) female with egg sac. **C.** *Acartia* (1-1.5 mm) has two little droplets of oil in the body. **D.** Barnacle larvae swarm and feed in the plankton for a few weeks before settling on rocky shores.

Photos: Fredrika Norrbin



Porsanger Østerbotn, individual observations of plankton in a "mini-transect", sampled with the ship adrift. Egg-carrying *Pseudocalanus* females are concentrated around 50 m depth, and predatory species are abundant in the layers both below (arrow worms) and above (comb jellies and the small hydromedusa *Rathkea*) 50 m depth.



Microsetella on marine snow.
Photos: Fredrika Norrbin

We also observed that the tiny copepod *Microsetella* was almost always associated with detritus in the water column. Detritus, or "marine snow", is formed from decaying plankton, and eventually sinks to the bottom, providing food for benthic organisms. Small bacteria and plankton colonise and start to break down the detritus even as it falls through the water.

The VPR lets us visualise many aspects of the lives of plankton, such as environmental preferences and behaviour. The individual observations build up to thousands of data points to be used in statistical analyses of the data. This is valuable information for modellers, and can contribute greatly to predictions related to environmental change.

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Torkjel M. Sandanger // UiT The Arctic University of Norway, Department of Community Medicine, and NILU – Norwegian Institute for Air Research
Pernilla Carlsson // AMAP, Arctic Monitoring and Assessment Programme, and Akvaplan-niva

Seafood and environmental pollutants

We humans have created many chemical compounds to make our lives safer or easier; the insecticide DDT is a prime example. When these compounds escaped into the environment, some of them turned out to be harmful. The worst offenders, like DDT, have been banned. But we needed their beneficial effects, so we replaced them. What effects do these new man-made compounds have?

PERSISTENT ORGANIC POLLUTANTS (POPs) are a group of environmental contaminants that break down very slowly, accumulate in living organisms - and are poisonous. Many of them have now been banned or strictly regulated and are therefore called "traditional" POPs. Some were used as flame retardants (polybrominated diphenyl ethers), some as insecticides (hexachlorocyclohexanes and DDT) and some mainly in hydraulic oils and electronic insulators (PCBs). When the old POPs were phased out, new chemicals were developed to replace them. One class of replacement chemicals, perfluorinated alkylated substances (PFAS), has raised concerns during the last decade after being detected in animals in remote areas, such as marine mammals and birds in the Arctic. The PFAS are used in fire extinguishers, Goretex® and ski wax. Although their effects differ from those of the traditional POPs, they also interfere with cellular processes in humans and animals.

Not only manmade compounds are of concern. Mercury, lead and cadmium are all present naturally in the environment. However, our use of these heavy metals has increased the levels circulating in nature and in the food we eat.

All these pollutants cause concern because of their potential to harm living organisms. Several of the POPs are structurally similar to hormones, which means they can interfere with endocrine systems. Mercury can have detrimental effects on brain development and the immune system. To make matters worse, the pollutants affect health even at low concentrations.

POPs are semi-volatile and persistent. Because of their ability to evaporate and their resistance to breakdown, they can be transported great distances by air and ocean currents. Those that reach the Arctic accumulate primarily in the marine food chain. The highest concentrations of POPs are found in fatty tissues of fish and animals high up in the food chain.

SEAFOOD: A SOURCE OF POPS – AND NUTRIENTS

People who harvest their food from the marine food chain have historically been exposed to higher levels of POPs than the general population. Blubber of marine mammals and fish liver have both been a major source of POPs. At the same time, these foods are extremely nutritious with high concentrations of fat-soluble vitamins (A, D, E) and essential fatty acids. For some communities in the remote Arctic, marine mammals and fish are still a significant source of nutrients. Seagull eggs - also highly contaminated - are not equally problematic; they are cherished as a traditional spring delicacy, but have never been a major component of the diet.

TIME TRENDS

Once POPs were banned and regulated, their concentrations decreased considerably both in the environment and in humans. The decrease since the 1980s is very well illustrated by the figure on the next page. Over a 30-year period, we analysed blood samples taken repeatedly from the same 54 men in Tromsø. For several POPs the concentrations had declined to just 20% of the peak concentrations. The men in our study belong to an older generation, known to consume more seafood than the average population, and are thus expected to have higher concentrations of POPs. But a similar decrease has been observed in other people, as well as in seafood.

DIETARY ADVICE AND POPS

In view of the fact that the concentrations of POPs are much higher in marine food chains than in land-based food chains, much dietary advice has been focused on seafood in Norway. However, now that the POP concentrations are decreasing, a number of these guidelines have been revised. The general precautionary guidelines about fish liver have been removed and replaced with more detailed advice about consumption of fish caught in specific fjords or near sites known to be contaminated. In our opinion, dietary advice to the public often lacks precision. Despite revision, the guidelines may still cause unnecessary concern and make people choose other food than fish, which might be a problem from a public health perspective.

The main route for human exposure to mercury is via seafood. Nevertheless, the amount of mercury in fish is no cause for concern for the general population in Norway.

PUBLIC HEALTH PERSPECTIVE

The main public health challenges in Norway today include obesity, diabetes and cardiovascular diseases, which are all partly linked to unhealthy diets. Norwegians eat less fish than before, and the intake of saturated fats and sugar has increased considerably. Increased intake of fish is known to counteract the negative effects of a number of conditions such as cardiovascular disease. Questioning the safety of seafood can thus have major consequences for public health if it prevents people from eating fish with high nutritional value and low concentrations of POPs.

The concentrations of POPs in fish from the coast of northern Norway are now low. The health benefits of consuming seafood clearly outweigh the potential negative effects of POPs. Granted, some highly polluted “hotspots” remain, where special dietary advice is warranted, and there are precautionary guidelines for consumption of seagull eggs. Nonetheless, the Norwegian Scientific Committee for Food Safety recommends eating fish at least twice a week.

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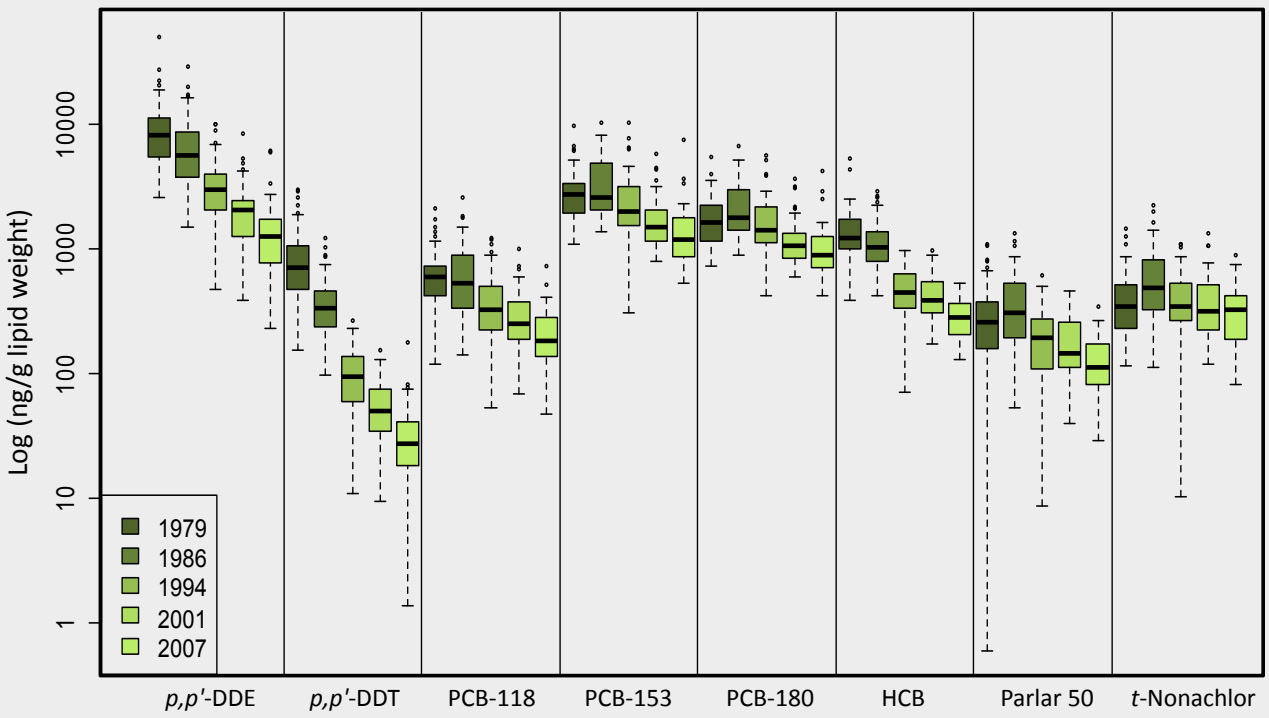
Website of the Norwegian Scientific Community for Food Safety: www.english.vkm.no

Website with consumer information about food, including advice about consumption of various species of fish and other seafood, and from specific areas (in Norwegian): www.matportalen.no.



Decreasing level of POPs

Blood samples were taken repeatedly from 54 men in Tromsø between 1979 and 2007. The men's average birth year was 1937.

These data were previously presented in Nøst et al. Environmental Health Perspectives 2013; 121(11-12): 1292-1298. Used with permission.

NEWS

PINK-FOOTED GOOSE TO NEW HEIGHTS

Annual counts of the pink-footed goose show that populations are continuing to rise. On Sunday, 5 May 2013, a coordinated count was made of the pink-footed goose population at their roosting and feeding grounds in Denmark and Norway.

"The total count was 81 500 individuals, which is a slight increase compared with the spring of 2012 when we counted 80 000 geese," says Ingunn Tombre, researcher at the Norwegian Institute of Nature Research (NINA) at the Fram Centre.

Pink-footed geese overwinter in Denmark, the Netherlands and Belgium, and pass through Norway in the spring and autumn on their way to and from their nesting grounds in Svalbard. Annual counts show that the population has increased from about 30 000 individuals in the 1990s to more than 80 000 today, and there is currently a great deal of interest in the species.

"The increasing numbers of geese are damaging crops in farming areas along their migratory route, as well as the vulnerable tundra vegetation in Svalbard," explains Tombre.

The pink-footed goose population has been chosen as the first European example of an international "adaptive management" plan, the purpose of which is to keep the population stable at around 60 000 individuals.

"We will do this over the next few years by controlled hunting to keep the numbers down. These efforts will be coordinated between Norway and Denmark, which both have regular hunting seasons for the pink-footed goose," says Tombre.

The international plan was established under the Agreement on the Conservation of African-Eurasian Migratory Waterbirds under the Bonn Convention.

Calanus finmarchicus.
Photo: Malin Daase, Norwegian Polar Institute

A female *Pseudocalanus acuspes* carrying eggs.
Photo: Peter Thor, Norwegian Polar Institute

Peter Thor // Norwegian Polar Institute
Howard Browman // Institute of Marine Research
Claudia Halsband // Akvaplan-niva

Ocean acidification – CO_2 effects in Northern waters

At present we are emitting CO_2 at alarming rates. We all know the result is global warming, but what is probably less well-known is what marine chemists have termed "the other CO_2 problem".

ONE THIRD of the CO_2 emitted is absorbed by the world's oceans, where it is transformed into carbonic acid, making the pH of the oceans lower. There are growing concerns that this ocean acidification (OA) will disturb affected marine wildlife in ways we cannot yet predict. The Arctic is an area of particular concern. Colder water absorbs more CO_2 and the acidification is more severe in polar regions, where natural pH and carbonate ion concentrations have always been higher than elsewhere. At the same time, polar regions are blank areas in our knowledge of how OA affects marine life. For example, we do not know much about the seasonal changes of pH and associated ocean chemistry, or how it varies from year to year.

In 2011 the Fram Centre flagship "Ocean acidification and ecosystem effects in northern waters" was established to serve as a platform for research on acidification in the Arctic Ocean. As part of the flagship we initiated studies of OA effects on pelagic copepods in 2012. Marine pelagic copepods constitute the most numerous animal group on earth. These crustaceans comprise 80% of the global zooplankton biomass, and they are the most important food for larvae of many fish species. Also commercial fish stocks depend on copepods, and survival and growth of cod and herring larvae depend strongly on the copepod biomass in their feeding grounds. Consequently, if copepods suffer from OA and their numbers decline during the next decades, this will carry over to fish populations and ultimately to fisheries.

We started our studies of OA effects by looking at populations from the North Sea. Here we found very different effects among species - even closely related ones. Metabolism and egg production rates remain unchanged in *Calanus finmarchicus*, a relatively large copepod (2-4 mm), when subjected to pH levels predicted for the year 2100. This species, which dominates in the North Atlantic, normally produces many eggs (>20 eggs per individual per day) that are spawned freely into the water.

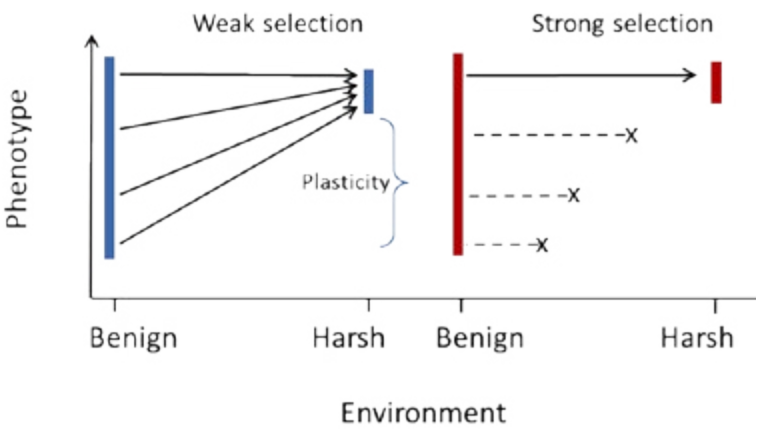
A smaller species, *Pseudocalanus acuspes* (1-2 mm), is apparently more severely affected by OA. This species is found in large numbers in North Atlantic and Arctic waters. We observed a significant decrease in both metabolism and egg production under conditions of OA. The results suggest that egg production will decrease by 30% by the year 2100, and this may have harmful consequences for the populations. *Pseudocalanus acuspes* carries its eggs in a brood sac until they hatch. This is an evolutionary strategy to avoid the fierce predation on eggs in the plankton. It allows

P. acuspes to invest less energy into egg production (<3 eggs per individual per day) and nonetheless attain the same number of surviving larvae as free-spawners such as *C. finmarchicus*. A 30% reduction in egg production may not reduce the number of surviving larvae of free-spawners like *C. finmarchicus* because it could be counteracted by decreased density-dependent predation on eggs. But the effects would be more pronounced in populations of egg-carrying copepods. Egg production rates are low and the supply of new larvae is all the more dependent on constant production of new eggs. So the risk that OA will affect future population sizes of *P. acuspes* negatively is very real.

Previous studies have shown that such effects influence animals higher up in the food chain. In the Baltic Sea, the abundance of a sibling species, *P. elongatus*, has declined due to climate change. This species is the preferred prey for Baltic herring, and due to this decline, the herring have been forced to revert to less favourable copepod species for prey, which has limited herring growth in these waters.

OA is a recent and dramatic environmental change. Nevertheless, it progresses at rates that may be sufficiently slow to allow populations to adapt to the new conditions through selection of the more fit individuals over the course of many generations. Our experiments have shown that copepod populations can respond very quickly to changes in their environment. They can, for example, change their body size by 15% per generation when this trait is manipulated towards larger or smaller individuals. Moreover, individual organisms may be able to acclimatise to the changed environment if their physiology allows. This acclimatisation would lessen the natural selection, because the genetic effects of OA would be alleviated.

The question here is then: Does OA induce adaptation (genetic change) or are the animals able to compensate the physiological stress by acclimatisation (phenotypic change)? We are directing part of our work to address these questions. Our studies on North Sea *P. acuspes* suggest that populations may develop some resilience against OA through selection. Populations



This graph shows the effects of acclimatisation and selection on a given phenotype (for example egg production rate). In a benign environment, the populations contain a diverse range of genotypes giving rise to many different phenotypes (individuals with different egg production rates) under these circumstances. When the environment changes, certain phenotypes prevail because these individuals perform better, either because they can already cope with the new conditions, or because they are able to change their phenotype – a process called "plasticity". In the blue population, selection is weak because all genotypes survive. Every individual can plastically change their phenotype (acclimatisation) and genetic diversity is maintained. In the red population there is no phenotypic plasticity and most individuals disappear. Here the genetic diversity decreases.

that had been subjected to year 2100 levels of OA for two generations did experience the 30% decrease in egg production rate described above, but the effect of OA was twice as severe in control populations kept at present-day pH until the second generation and then transferred to the year 2100 level 3 weeks before measurements. Egg production rates would have plummeted by more than 60% had the population not adapted to OA. This would have had severe consequences for the populations in the North Sea.

The studies will continue and we are now (January 2014) starting a study on arctic *Calanus glacialis* (a sibling species to *C. finmarchicus*) at a cold-water OA laboratory we have established at the research station in Austevoll, run by the Institute of Marine Research. We hope to extend these studies into the second generation of the animals, to be able to address similar evolutionary questions as for *P. acuspes*. In 2015 we will initiate further studies on arctic species at the Marine Lab, Ny-Ålesund, Svalbard.

Note: The oceans are basic (pH between 7.9 and 8.1) and the term ocean acidification is slightly misleading. The anthropogenic emission of CO_2 has not made the oceans acidic (pH under 7), only less basic.

Helge M. Markusson // Fram Centre

New report on ocean acidification

A new report on Arctic Ocean acidification was presented 6 May 2013, during the International Conference on Arctic Ocean Acidification organised by the Arctic Monitoring and Assessment Programme (AMAP) in Bergen.

The Arctic Ocean is absorbing carbon dioxide (CO_2). This leads to acidification – a permanent decline in the pH of the ocean. This change is impacting on marine ecosystems in the Arctic, ecosystems that are already compromised by rising temperatures and melting sea ice.

The report presented in Bergen is the result of a three-year study initiated by AMAP, an Arctic Council working group, and is the first large-scale study of acidification of the Arctic Ocean. The members of the international working group included several researchers affiliated with the Fram Centre's research programme on ocean acidification. In connection with the conference, the Fram Centre also held a reception and presented the Centre's flagship research programme.

IMPORTANT FINDINGS

- The world's oceans are becoming more acidic. Acidification is taking place as a result of the oceans' uptake of large amounts of CO_2 emitted through human activity.
- In the past 200 years, the average acidity of ocean surface waters has increased by about 30 per cent globally.
- The Arctic Ocean is particularly vulnerable. CO_2 is absorbed more quickly in cold water, and the increasing quantities of freshwater entering the Arctic from rivers and melting ice are reducing the ocean's capacity to neutralise the acidification.
- Acidification is particularly prominent in central areas of the Arctic Ocean. Monitoring stations in the region show that, in particular, surface waters are growing more acidic.
- Since arctic marine food chains are relatively simple, the ecosystems are vulnerable to change when key species are affected by external factors.

SVALBARD POSTEN

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Vil starte Arktisk høyskole i Longyearbyen neste høst

Professor Olaf I. Rønning (t.h.) underviser Utdannings- og forskningsminister Gudmund Hernes i flora og fauna i Ny-Ålesund, under Studietur Nord som har vært arrangert denne uka. Men det er ikke bare blomster som har vært diskutert på turen. Hernes ivrer sterkt for en Arktisk høyskole i Longyearbyen allerede fra høsten 1993. Professor ved Universitetet i Trondheim, Olaf I. Rønning, har i flere år arbeidet for dette og kan bli sentral i planleggingen. En slik høyskole vil også kunne bli et tilbud til ungdom i Longyarbyen, i første omgang til de som ønsker å studere realfag, spesielt geologi.

Og Kolle Grøndahl vil gjøre Longyearbyen til forskningsby

Studietur Nord - side 2 - 3 - 4 og 13

VERDENS NORDLIGSTE AVIS

In 1992, UNIS was first-page news in Svalbardposten, the local paper.

Eva Therese Jenssen // University Centre in Svalbard

A fairytale on top of the world

ONCE UPON A TIME in a faraway land of ice and snow... it sounded like a fairytale. Establish a university college at the top of the world? In the tiny "town" of Longyearbyen at a staggering 78 degrees North? Wishful thinking - that's what the academic world thought when the first seeds of the idea were spread in the 1970s. It would cost a fortune! It would be hard to recruit competent scientific staff and students! There were many reasons it could *never* work.

Some 40 years down the road the fairytale has become reality - with a lot of potential. The University Centre in Svalbard (UNIS) just turned 20 and has had an exceptional growth since the modest start back in 1993.

Students heading out for fieldwork near Kapp Linné. *Photo: Mike Retelle*

THE RESULT OF HAPPY CIRCUMSTANCES

The first seeds of the idea of establishing an arctic college in Svalbard were spread - not surprisingly - by a botanist. Professor Olaf I. Rønning had many years' experience in Svalbard. He had acquired substantial expertise and with time he became one of the people scientists and politicians contacted when they had questions about Svalbard.

The idea started forming in the 1970s, but the time was not ripe until the late 1980s, when there was an alarming dip in Norwegian polar research activity. At the same time it was clear that the main settlement in Svalbard needed to be modernised. Ever since its establishment in 1906, Longyearbyen had been very much a company town. From 1916 on, the town had been owned and managed by the Norwegian state-owned company "Store Norske Spitsbergen Kullkompani" (SNSK). The future of coal mining in Svalbard was uncertain, but the Norwegian government needed to maintain a strong settlement to underline Norwegian sovereignty over the Svalbard archipelago, a sovereignty conferred in 1925 on the basis of the Svalbard treaty from 1920.

So, in addition to coal production, what industry might be viable in Svalbard? Olaf Rønning's idea of introducing arctic education and research was suddenly not all that far-fetched. Slowly, the seeds professor Rønning had sown started germinating in the High Arctic soil, but the cultivating conditions were still difficult.

By the early 1990s the process towards establishing an institution of higher education in Longyearbyen had lost momentum. However, that was to change in August 1992. Gudmund Hernes, then Minister of Education and Research, spent a week on a study tour

The Kjell Henriksen Observatory, owned by UNIS, is the northernmost aurora observatory in the world, located 10 km outside Longyearbyen.

Photo: Njål Gulbrandsen, UNIS

in Svalbard. He was introduced to the idea of an arctic college and he liked it so much that he went straight back to Oslo and started working on a plan. He allocated funding for 100 new students and UNIS started up less than a year later - record speed for an academic establishment.

COMPLICATED BIRTH, HEALTHY GROWTH

Rome was not built in a day. Neither was UNIS. It takes more than time to build a research and education institution: it also takes resources. In a challenging climate like the one at 78 degrees North, it takes money - a lot of money. And that money was allocated by minister Hernes.

UNIS was officially established as a foundation in 1993. The founders were Norway's four universities, those in Oslo, Bergen, Trondheim and Tromsø. This move ensured that UNIS would not become a competitor for the mainland institutions, but rather function as the High Arctic extension of the existing universities. This was a unique collaborative effort between the Norwegian universities. In 2002 UNIS was converted into a state-owned limited company, with the Ministry of Education and Research as the sole owner. In 2011 Norway's four "new" universities entered into a cooperation agreement with UNIS, so that the whole Norwegian university sector is now involved.

The establishment of UNIS was officially announced on 6 September 1993. But as is so often the case with fast-moving UNIS, the students had arrived long before then: the institution was up and running already in mid-August 1993. The first 23 students, 9 women and 14 men, followed courses in Arctic Geology and Arctic Geophysics. In the words of Svalbard historian Thor Bjørn Arlov: "UNIS was established before there was a formal resolution and started before it was officially opened."

Indoor classes were held in existing locales in Longyearbyen until 1995, when the first UNIS building was completed. By the beginning of the new millennium

The Svalbard Science Centre. UNIS, the University Centre in Svalbard, occupies the left side of the building complex.

Photo: Eva Therese Jenssen, UNIS

it was clear that UNIS needed more space and in 2006 the new Svalbard Science Centre was officially opened, built as an extension of the old UNIS building.
The educational fields on offer at UNIS have expanded too. Within the first year, UNIS added Arctic Biology and in 1996 the fourth field was introduced: Arctic Technology.

NATURE AS LABORATORY

Fieldwork is the core of courses at UNIS. The philosophy is that the best place to study the Arctic is in the High Arctic, and fieldwork gives the students valuable hands-on experience in arctic science.

Many have asked why UNIS does not expand its course portfolio to include more subjects, such as social sciences and humanities. The answer is simple: UNIS offers field-based courses no other institution can offer. International politics or history can be taught by other universities at a better level than UNIS ever could. However, no one can offer natural science courses with the important field component better than UNIS does. Theory can be learned anywhere in the world. But to gain experience in arctic fieldwork students need to be present in the Arctic. And that is exactly what UNIS offers.

Thus, UNIS did not and still does not offer full degree programs. Rather, the Centre offers specialised courses in arctic natural sciences at Bachelor, Master, and PhD level.

CHALLENGING CONDITIONS

UNIS has gradually developed into a visible and significant institution for arctic studies. Up from a meagre 23 students in 1993, the number of students in 2013 was close to 500. And one of the main strategies is that students and staff should be multinational. About half of the annual student body hails from a country other than Norway. Between 20 and 30 nationalities are represented among the students every year. Sure, most of the students are from Europe and North America, but

Fieldwork is central to all courses at UNIS. These geology students are on their way up to Storvola, Van Keulenfjorden.

Photo: Eva Therese Jenssen, UNIS

Biology students going ashore on a sunny summer day in Magdalenefjorden.

Photo: Steve Coulson, UNIS

over the past few years UNIS has had students from Indonesia, Trinidad and Tobago, and Australia! Needless to say, the official language at UNIS is English.

Teaching and conducting research in the field in Svalbard is actually a monumental undertaking. That is why UNIS has such a focus on safety. With hundreds of students and staff out in the field almost every week of the year, provisions must be in place to ensure their safety. Every spring semester, all new students (and new staff) must go through a mandatory six-day safety course.

LOOK TO THE NORTH!

Looking back over these 20 years, it is clear that UNIS is a success story. Not everyone believed in the idea back in 1993, but UNIS was always a step ahead in the development. So what about the future? In the next few years, UNIS plans to have 600 students annually, and continue to expand educational and research cooperation - both within Norway and internationally.

UNIS is important both for the community in Longyearbyen and for Norway's position in Svalbard. In line with current political analysis, it is clear that the strategic importance of the High Arctic will increase. Climate researchers look to the Arctic for early signs of global warming. The industrial world is looking towards the Arctic for untapped natural resources and new transport routes to Asia and North America.

Norway needs more expertise within the natural sciences to be better prepared for climate change and geopolitical challenges. In UNIS, Norway has an institution that can provide not only the arctic experts of tomorrow, but also maintain a solid Norwegian presence in Svalbard.

UNIS is the foremost platform for scientists within arctic research. Over the past 10 years, UNIS has become a partner in several Centres of Excellence in Norway, such as the Centre for Research-Based Innovation "Sustainable Arctic Marine and Coastal Technology" (SAMCoT), the Birkeland Centre for Space Science, and

Geology students on Nordenskiöldbreen during fieldwork. Safety is always a top priority.

Photo: Endre Før Gjermundsen, UNIS

Svalbard is a natural laboratory where biology and geophysics students can learn how sea ice supports life, and technology students can study how it threatens infrastructure. *Photo: Kjersti Lundmark Daae, UNIS*

most recently a centre of excellence in biology education (bioCEED).

UNIS is unique in the world by virtue of its location, scope and international attention, all of which benefit both scientists and students. In fact, UNIS is so unique that other countries look to Svalbard when planning their own arctic academic institutions. A few years back, the Canadian government published a White Paper on the possibility of opening a college and research facility in the Canadian High Arctic. UNIS was one of the institutions the expert group had investigated - and UNIS was praised in the White Paper. In Greenland, the Technical University of Denmark started up the Arctic Technology Centre in Sisimiut, which will offer training opportunities for young Greenlanders with engineering ambitions. The centre wishes to extend their course portfolio and increase the number of international students - and naturally they look to UNIS for ideas.

Life at UNIS is definitely not all work and no play. These students are competing in the traditional sled race during the festival that marks sun's return to Longyearbyen.

Photo: Eva Therese Jenssen, UNIS

Sigrid Elvenes // Geological Survey of Norway (NGU)

The Porsanger fjord: Revealing seafloor secrets

Maps give us an objective, reality-based picture of the world – at least this is what we believe. We assume that aerial photographs have been taken, or a surveyor has determined exact positions of landmarks and altitude contours, and a cartographer has converted this information into a chart. But what if the terrain is underwater?

ON A ROADMAP of Porsanger, Finnmark, the fjord is shown as a uniform blue surface. There are a few scattered place names: Ryggen, Nordmannsgrunnen... A nautical chart will show you contours and a number of depth points confirming that Ryggen is indeed a sizeable underwater ridge crossing the fjord a little north of the island Lille-Tamsøya, and that Nordmannsgrunnen is the outermost in a series of 40-50 m deep shoals stretching northward mid-fjord from the island of Hamnholmen. This is helpful information that contributes to safety at sea.

Nautical charts will also give you sporadic indications of what type of material the seafloor is made of, typically based on what will stick to a greased leaden weight attached to a line and thrown overboard. Such knowledge is useful, as different seabed types have different properties of importance to anchorage conditions, sediment stability, and bottom fauna. However, the nautical chart shows seabed information for no more than 15 locations across the 1500 square kilometers of the Porsanger fjord. How well does each of these represent the closest one hundred square kilometre of seafloor?

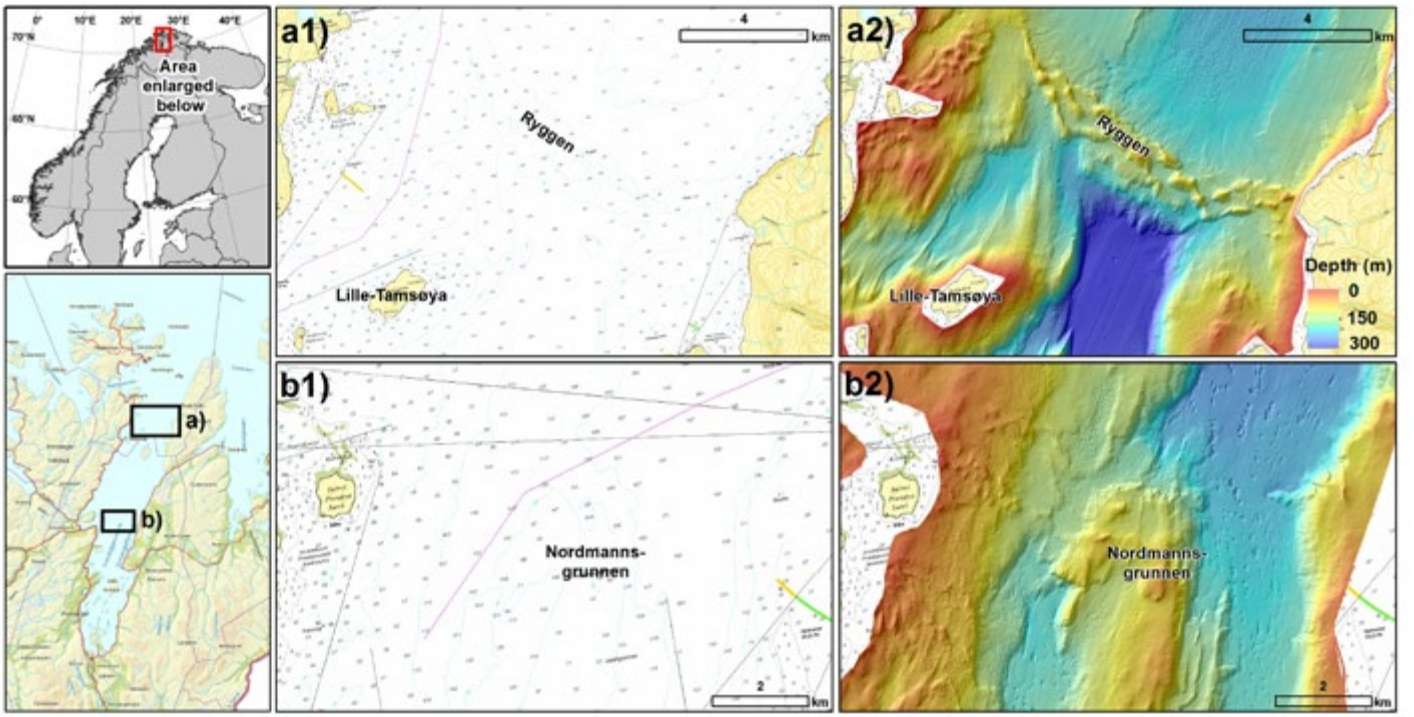
The last few decades have seen great progress in equipment and methods for seabed mapping. Where information on the underwater terrain was previously gathered using single-beam echosounders that took depth soundings directly below a vessel's path, today's mapping vessels are equipped with multibeam echosounders that simultaneously record information from a wide swath of acoustic beams. This allows for far more detailed mapping, as overlapping swaths create a continuous surface of depth soundings.

Multibeam technology reveals seabed topography in great detail, giving us information that was previously hidden beneath the waves and inaccessible. The horizontal resolution of multibeam data is typically in the range of a few metres, but as water depth increases and the swath width widens, the resolution goes down. Modern echosounders also record echo intensity, the backscatter, which is related to seabed type. Soft, muddy bottoms will absorb much of the acoustic signal, while more signal is reflected from gravel and still more from bedrock. This makes backscatter data invaluable for the seabed surveyor who wishes to map the distribution of sediment types.

Grab sampling of seabed sediments.
Photo: NGU

RV *Seisma*, the 17-m research vessel operated by the Geological Survey of Norway.

Photo: Sigrid Elvenes, NGU



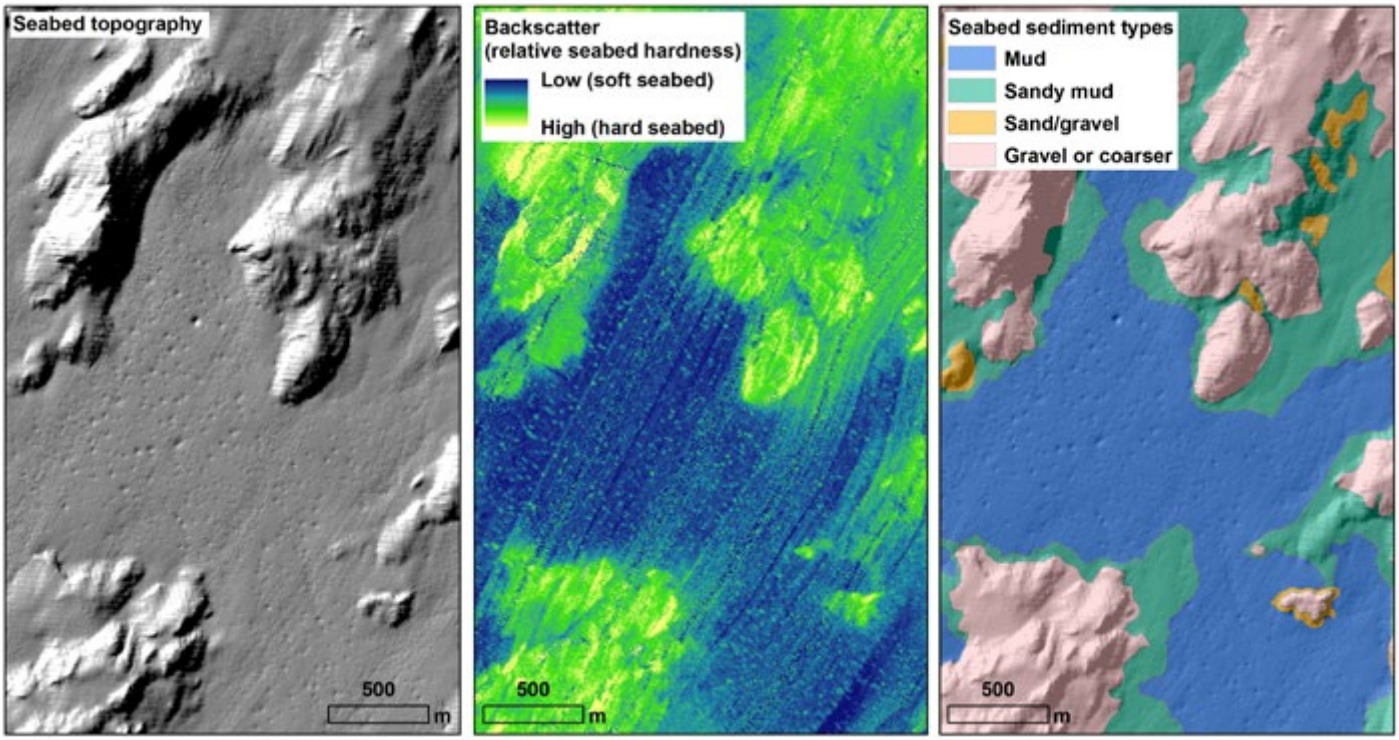
Imaging the seabed through navigational charts (a1, b1) and with multibeam echosounder data (a2, b2).

The Geological Survey of Norway (NGU) started a seafloor mapping project in the Porsanger fjord in 2012. Building from already existing multibeam data from the Norwegian Mapping Authority, fieldwork has been carried out with the 17-m research vessel *Seisma*, equipped with her own multibeam echosounder in addition to an assortment of gear for sediment sampling, video inspection of the seafloor, and acoustic surveying of sediment thickness.

Dropping a grab sampler to the bottom and inspecting the catch when it is back on deck – this is one of the most basic methods for studying marine sediment. It provides an opportunity for quick on-board assessment of sediment composition, but the material can also be bagged and taken back to the lab for analyses. The grab sampler, however, is sensitive to gravel and cobbles that may prevent the jaws from closing properly and result in loss of finer material. Homogeneous sandy and muddy sediments will therefore yield the best grab samples, while coarser or more mixed sediment types are difficult to sample accurately.

As with the traditional greased lead weight method, grab samples are point data that say very little about spatial changes in seabed character. To get a better understanding of the mixed seafloor types that are very common in coastal areas (such as combinations of boulders, gravel and sand), *Seisma* employs a towed winch-operated video camera. The camera is kept close to the seabed and towed at low speed. Video recordings show in great detail what the seafloor is made of, and if changes along the recorded track are sudden or gradual.

To create a full-coverage sediment map, geologists put this exact seafloor information from video lines to good use by combining it with backscatter data. Backscatter values are relative and cannot be directly translated into sediment types, but having an idea of



Knowledge of seabed topography and hardness aids the geologist's interpretation when creating a full-coverage sediment map.

which bottom type (e.g. sandy mud or gravelly sand) is represented by which span of backscatter values in your dataset is a great aid to sediment interpretation. Unfortunately for the geologists working in the Porsanger fjord, full-coverage backscatter data from previous surveys have only been recorded in the fjord's inner part. However, during fieldwork in 2013, *Seisma* was able to collect additional multibeam and backscatter data in a series of cross-fjord transects, providing insight into seafloor properties across the whole fjord.

Better knowledge of the seafloor leads to better understanding of the marine environment, as has been shown through Norway's offshore mapping program MAREANO (www.mareano.no). Anyone planning activities in marine areas - be it aquaculture, pipeline construction on the seafloor, or harbour development - will benefit greatly from detailed information about underwater topography and seabed sediment types.

Coupled with the experiences of fishers and marine biologists, detailed seafloor data make way for reliable mapping of spawning areas and valuable fishing grounds, in turn allowing for better management. Positive experiences have already been reported from coastal municipalities that have access to detailed seafloor maps (e.g. in southern Troms through the Astafjord Project), as well as from fishing vessels that have started to use maps showing seabed sediment and topography. NGU plans to continue mapping the Porsanger fjord seafloor in 2014, with the ultimate aim of producing a full set of detailed seafloor maps that can be made available to the public.

Harp seals with pups.
Photos: Michael Poltermann, Institute of Marine Research.

Measuring blubber thickness.
Photo: Kjell Tormod Nilssen, Institute of Marine Research

Tore Haug, Ulf Lindstrøm, Kjell Tormod Nilssen and Tor Arne Øigård // Institute of Marine Research

Is the harp seal on a diet in the Barents Sea?

Recent measurements of the body condition of harp seals may suggest so. Scientists have discovered that the seals' blubber layer is considerably thinner now than it was twenty years ago. The question is: Why?

THE INSTITUTE OF MARINE RESEARCH has been measuring the blubber thickness of seals caught as part of the commercial seal hunting in the East Ice (the pack ice in the southeastern part of the Barents Sea). The results showed that the animals were in good condition between 1992 and 2001. Similar measurements made in 2006 and 2011 showed a blubber layer that was considerably thinner. As a result, we are now asking ourselves whether harp seals are getting enough food, and whether the changes we have observed can be related to the climate-driven changes observed in the Barents Sea in recent years.

FAVOURITE FOOD IS KRILL

The areas east of Svalbard and in the northern Barents Sea have traditionally been the harp seal's most important feeding grounds in Norwegian waters. The availability of prey with high content of fat (and thus also energy) in the northern waters at this time of year is probably the most important reason why harp seals make their long feeding journey. Every spring they swim from their breeding and moulting areas in the White Sea and the East Ice, to the edge of the sea ice, far up in the north. To survive large seasonal variations in food supply, the harp seals must accumulate energy reserves in the form of blubber in the summer and autumn. While in the north, they thus feed intensively to build up a blubber layer that they can "feed" off in the winter and spring, when nutrient intake is much lower.

Recent studies done by the Institute of Marine Research show that the favourite food of the seals in the northern Barents Sea - especially young seals - is krill. Older seals eat krill too, but also supplement their diet with fish such as arctic cod and capelin. Chemical analysis of the seals' prey shows that it is in fact krill that contains most fat, and thus provides the best energy supply, in the summer. In late summer and early autumn, the seals also feed on other fat-rich pelagic crustaceans, especially amphipods. As autumn progresses, the fish also fatten up, and the seals gradually shift to a diet exclusively of fish.

PACK ICE IMPORTANT

Proximity to pack ice is important during the entire life cycle of the harp seal. Both during the breeding season and subsequent moulting period (from February to May) the seals have to haul out of the sea and onto the ice. They use the large areas of pack ice in the White Sea and the East Ice for breeding and moulting. The pack ice is also important for harp seals in the feeding areas in the north, where they use ice floes as resting places and often feed near the edge of the ice.

In the Barents Sea, the ice sheets are at their annual minimum in the summer and autumn. In recent years, there has been a big increase in the ice-free part of the Barents Sea during this period. In addition, some fish species, especially cod, have expanded their areas of distribution northwards. Such changes may have affected harp seals' possibilities of building up energy reserves in the form of blubber during the summer feeding season.

In recent years, observations made by the Institute of Marine Research on its annual ecosystem research voyages indicate that harp seals no longer feed in areas east of Svalbard, as they did only 10-15 years ago. These areas are now ice-free in the summer and autumn, and are dominated by cod. The reduction in the ice sheet, and possibly also the increased competition with cod, may have forced the seals to migrate further north, perhaps as far as the Arctic Ocean north of Svalbard. Increased energy consumption as a result of a longer migration between south and north may have contributed to the seals being in poorer condition today than in the 1990s. Poor availability of pack ice may also force seals to shed their coats in the water - physiologically speaking a poorer solution, which is also more energy-consuming than moulting in the open air on ice floes.

INCREASED COMPETITION?

Our analyses indicate that krill has a positive effect on the seals' body condition: the more krill, the better condition. It is possible that as cod stocks grow and shift farther north, the fish are increasingly competing with the seals for resources. At any rate, our analyses indicate that the seals' condition becomes poorer when cod stocks increase. Moderate quantities of arctic cod and capelin - which, like krill, are good food for seals - appear to have a positive effect for seals. But if these stocks increase too much, it has a negative impact on seals' condition. Krill may possibly be so important for the seals that any competition for this resource (which is also eaten by cod, arctic cod and capelin) will impact negatively on the seals' ability to store energy.

"JUNK FOOD"

All marine arctic species have a great capacity to take up and store energy in the form of fat during the productive, light months of the year. With an increase in sea temperatures, arctic species will face greater competition with species from more temperate areas, where it is not equally necessary to store energy for the winter. For the seals at the top of the food chain, this may mean a change from food rich in fat to a much leaner diet. Initially, the "junk food" diet that is forced upon them may affect the animals' possibility to build up necessary fat reserves in their blubber, and may subsequently have impact on their ability to produce viable young. It is worth noting that there was a very marked reduction in the number of harp seal pups produced annually in the White Sea in the years after 2003. We cannot exclude the possibility that poorer body condition may have affected the fertility of the female harp seals, and that this in turn has caused a fall in numbers of harp seal pups born in the Barents Sea.

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Elisabeth Isaksson // Norwegian Polar Institute

Estimating surface mass balance variability in Antarctica: examples from Fimbulisen

If all the ice in the Antarctic ice sheet were to melt, the world's oceans would rise about 58 metres. Although nobody expects anything that dramatic to happen, current knowledge doesn't tell us what we might actually expect. The Fimbulisen project should help eliminate some of the uncertainty.

THE ANTARCTIC ICE SHEET is a vast reservoir where water continually accumulates in the form of snow and disperses through melting and calving. Knowledge about the current balance between these processes - the mass budget - is crucial both for understanding the climate system and for estimation of future sea-level change. Despite concerted research efforts, the status of the ice-mass budget of the Antarctic ice sheet is still not entirely certain, partly because vast sections of the ice sheet are not covered by ground-based measurements.

One important parameter for estimating the mass budget is the surface mass balance which, simply put, means surface accumulation (all the snow and ice that falls on the surface), minus losses to wind, evaporation and melting. Antarctica is by definition a desert; it snows very little, only a few centimetres per year over large parts of the interior, since the air is cold and has limited moisture holding capacity. In coastal regions, temperatures are higher and snowfall is much greater - more than a metre each year in some areas. Therefore, changes in these areas can have large impact on the overall mass budget. In a warming climate, increasing snowfall on the Antarctic ice sheet is likely to mitigate 21st century sea level rise.

In the project "Fimbulisen top to bottom" we have made oceanic and glaciological observations at the ice shelf Fimbulisen in Dronning Maud Land throughout three field seasons. An ice shelf is a glacier floating in the ocean; ice shelves make up about 10% of the area in Antarctica. The overall goal of the project is to determine the total mass balance of the ice shelf, and figure out whether it is growing or shrinking.

Surface accumulation represents the positive input to the overall ice shelf mass balance calculations, and is balanced by melting from the underside and by calving at the shelf front. In the Fimbulisen project, glaciologists used three different methods - stakes, snow cores and ground penetrating radar - to determine both the spatial and temporal variability of accumulation and contribute new data about this largely undocumented area. The simplest method for estimating snow accumulation at one spot is to place stakes

Scientists drilling a shallow ice core on Fimbulisen. This work can be thoroughly exhausting so it's good to have many helping hands.

Photo: Helgard Anschütz

Front of an ice shelf in Dronning Maud Land. The ice wall is about 30 metres high.

Photo: Elisabeth Isaksson

in the ice and measure the exposed height above the snow surface over several seasons. To measure snow accumulation over longer time periods, we drill snow cores and study seasonal layering. To evaluate how representative the spot measurements are, single sites can be connected with radar measurements where individual snow-layers can be traced over larger areas.

Our results at Fimbulisen show that large-scale estimates of accumulation derived from satellite measurements generally give an accurate representation of the spatial pattern of accumulation over the ice shelf. However, in the grounding line area, where ice flows out onto the sea and where there are large topographical gradients and strong catabatic winds, there are significant differences. This implies that surface accumulation may be underestimated over areas with high topographical gradients, such as the margins of the East Antarctic Plateau.

Our field data show large interannual variability in accumulation, which means that measurements from a single year do not give reliable estimates. However, longer term data from ice cores can be used to set the data in a longer perspective. An illustrative example of this is that during the winters of 2009 and 2011, satellite measurements showed unusually heavy snowfall in some parts of Dronning Maud Land. The question is then: How representative are such events? And can such events be ascribed to natural variability, or are they the first signs of the increase in snowfall projected to occur due to global warming? Our ice core data suggest that heavy snowfall has occurred in the past and is thus likely part of the natural variability. Model projections describing various future warming scenarios predict essentially no heavy snowfall events in the present (that is, nothing like the ones observed recently), but suggest that such anomalies will become increasingly likely toward the end of the 21st century.

Our results from Fimbulisen emphasise the importance of using a combination of ground-based validation data, regional climate models and remote sensing in order to fill in the gaps in this puzzle and achieve a reliable estimate of surface accumulation for the entire Antarctic ice sheet.

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http://fimbul.npolar.no

Little auks in one of the study colonies, Bjørnøya in Svalbard.

Photo: Hallvard Strøm

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Børge Moe // NINA – Norwegian Institute for Nature Research
Hallvard Strøm // Norwegian Polar Institute

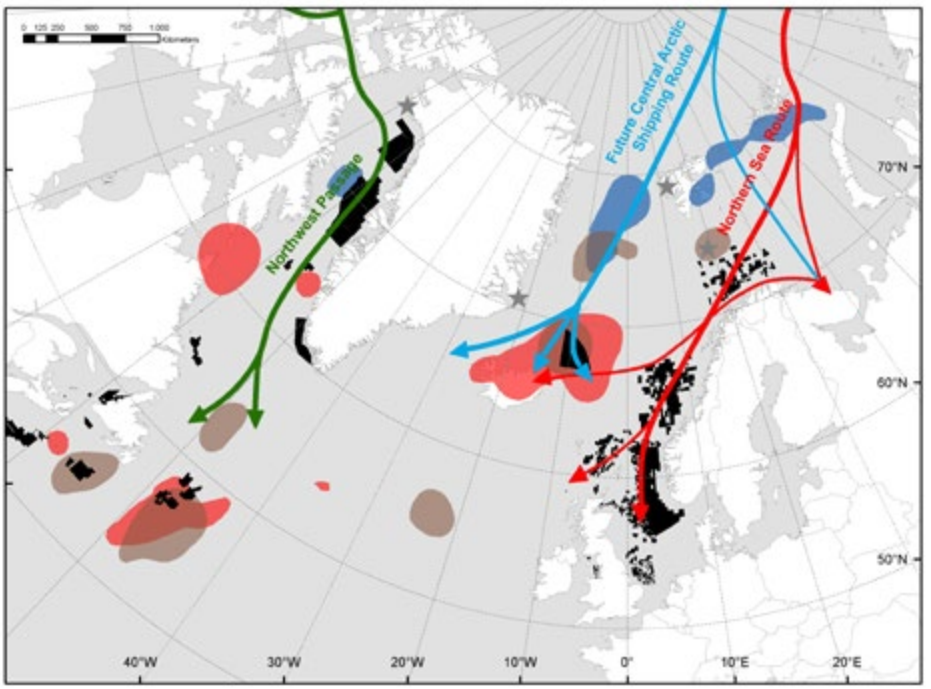
Tracking of little auks revealed large scale distribution and potential threats

The little auk (*Alle alle*) is the most abundant arctic seabird. Dense swarms of this tough little bird circle above the scree slopes where they nest. All summer long the hillsides echo with their laughter-like calls, and when they leave, the silence is tangible. Where have the little auks gone? What risks do they run in the winter?

EVERY YEAR, an estimated 15 million pairs of little auks gather at breeding colonies along the arctic coastlines. Flocks of this small seabird then commute from the colonies to ice-filled waters where they dive for the copepods they must eat to be able to reproduce. During the non-breeding season, however, they may spend more than 6 months away from the breeding grounds, and there is little knowledge about where the different populations migrate and spend the winter. This also applies to many other seabird species. Such information is important because extensive development of human activities in combination with ocean warming is rapidly modifying marine habitats in the Arctic and in North Atlantic regions. To understand the potential impacts on marine biodiversity, we need to determine distributions of potentially vulnerable species and identify sensitive hotspots that might require particular protection. In this study we tracked little auks to provide a large-scale overview of its non-breeding distribution and to document potential threats that human activities might pose to this species.

Field work was conducted in four little auk colonies, located in different parts of the Arctic (Bjørnøya, Spitsbergen, East Greenland and Northwest Greenland). In this way we covered a large part of the breeding range of the species. To track the little auks, we used relatively new technology: geolocators, small light-level sensors weighing just 1.5 grams. We mounted the geolocators on the birds' leg band in July 2010. The loggers archive the data, but contain no transmitters, so to find out where the birds had been, we had to recapture them one year later and download the information from their geolocators.

The tracking data showed that the distribution of little auks is partly determined by the position of the sea ice, and that these birds are closely linked to the sea ice in parts of the year. This underlines the vulnerability of this species to extensive reductions in sea ice extent. The data also revealed unexpected patterns of distribution among breeding populations. Little auks from Spitsbergen and Bjørnøya overlapped in winter, when they were distributed in the Greenland Sea,



Overlap between the non-breeding distributions of tracked little auks and future human activities in the Arctic (oil/gas activities and shipping routes). The map shows little auk distribution in autumn (blue), winter (red) and spring (brown). Black areas represent licensed petroleum exploration blocks, and lines represent main future shipping routes. Stars mark the breeding colonies in Spitsbergen, Bjørnøya, East Greenland and Northwest Greenland where the little auks were fitted with geolocators.

Iceland Sea or Labrador Sea. Before that, however, in the autumn, birds from Bjørnøya migrated to the northern parts of the Barents Sea, while birds from Spitsbergen migrated to the Fram Strait and overlapped with birds from East Greenland. This is the moulting period, when flight feathers are being replaced, and birds are more sensitive to threats because of reduced mobility. Birds from Northwest Greenland spent this period in Baffin Bay. They wintered east of Newfoundland, together with birds from East Greenland. In spring, the birds from Bjørnøya returned to the colony by the end of April and were the first to return. Sea ice conditions are likely to affect the timing of arrivals of the different populations to the waters near the breeding colonies.

The distributions of the little auks overlapped with licensed petroleum exploration blocks and future shipping routes through the Arctic. The ongoing climate change is accompanied by reduced sea ice cover in the Arctic, and human activity in these sectors is expected to increase. It is well known that alcids - the group of diving seabirds to which little auks belong - spend much time at the sea surface and are very vulnerable to oil spills. Hence, accidents and discharges associated with human activities can pose threats to the most numerous arctic seabird species.

This study depended on large-scale cooperation between researchers from several European institutes. The key was to conduct field work on the same species in four different colonies in the Arctic, and then merge the data for joint analysis and publication. By doing so we could draw conclusions about little auks throughout their breeding distribution in the Arctic, instead of a breeding population from a single colony. This study should be used as a model for other tracking studies on arctic seabirds. One limitation of our study is that it covers only one year. Seabirds may use different areas and flyways from year to year as a part of their survival strategy. If we replicate the studies over several years, they will reveal any temporal variability in distribution patterns. Tracking the large-scale distribution of arctic seabirds over several years and learning where they overlap with human threats is of prime importance for marine conservation management.

What's out there

People boating around Svalbard often encounter bearded seals on drifting ice. These large sea mammals are named for their magnificent whiskers, which tend to curl as they dry. Bearded seals are easy to spot where they lie basking in the sun, and since they are also relatively unafraid, it is possible to admire them from a respectful distance. Many other seals take to the sea at the first sign of humans. Bearded seals hauled out on ice floes will keep a wary eye on intruders, but they appear reluctant to go back into the icy water.

Some bearded seals have red fur on their faces. These are individuals that feed on clams, crabs and other small prey in the soft sediment of the seafloor. Iron compounds in the sediment stick to the seal's fur and rust when exposed to air, making the seal a redhead.

The seal in this picture apparently prefers other types of food. And judging from the curl of its whiskers, it has been out of the water for some time.

Photo: Audun Rikardsen

Angelika Renner and Sebastian Gerland // Norwegian Polar Institute
Mari-Ann Moen // UiT The Arctic University of Norway

Towards improved automatic charting of Arctic sea ice

INFORMATION ON SEA ICE with high spatial resolution is of high relevance both for climate science and for socio-economics. Climate-related processes such as atmosphere–ice–ocean interaction can be strongly influenced or even steered by small scale features such as leads and melt ponds. With increased interest in the Arctic from shipping and exploration industries, exact and reliable sea ice charts are in great demand. Safe and efficient shipping requires route planning, which in turn relies on knowledge of where in the ice pack areas of open water or with thin ice cover can be used for travel. Installations such as oil rigs, on the other hand, must monitor potential threats from heavily deformed, thick sea ice.

While simple parameters such as ice extent and concentration can be extracted automatically from satellite observations, additional information about different types of ice (e.g. young or old ice, level or deformed ice) and the thickness associated with that type currently requires manual input from analysts. Often, field data help experts interpret the satellite images. Ultimately, the quality of the ice charts often depends on the experience of the analysts and the amount and nature of field observations. Scientists at UiT The Arctic University of Norway, the Norwegian Polar Institute, and the Norwegian Meteorological Institute have developed and evaluated new algorithms to determine sea ice types from both airborne and satellite observations.

These algorithms aid interpretation by "segmenting" the image. Segmentation means assigning each pixel in an image a value based on its characteristics (brightness, for example). All adjacent pixels with the same value are then grouped together into a segment. This simplifies the image and makes it easier to interpret. In a recent study, one of these algorithms was used to automatically segment a high resolution satellite image of sea ice north of Svalbard, while two ice analysts – working independently and without reference to the algorithm – created ice charts from the same image. Discrepancies between the manually drawn charts demonstrated the need for methods that do not rely on humans. The automatic segmentation algorithm, however, segments the ice based solely on statistics.

During helicopter surveys in the Arctic, we measured sea ice thickness while simultaneously taking photos of the ice surface. Using the photos and the ice thickness observations, we could label the classes in the automatic segmentation. Working towards automatic labeling, we analysed the relationship between the physical properties of each ice type and the statistics of the segments.

The photos acquired during helicopter flights were classified to extract information on how much area was covered by solid sea ice, open water, thin ice, or melt ponds. The results were then combined with the ice thickness as measured from the helicopter. This unique dataset allows us to interpret the ice thickness observations in much greater detail regarding the composition of the ice pack and potential developments. The initial results are promising, and further investigations are under way.

Pauli image of Radarsat 2 satellite scene (25 km × 25 km) with photos of sea ice surfaces, taken from helicopter, corresponding to different points in the Pauli image.

Helicopter starting from RV *Lance* for a transect with the ice thickness sensor and camera.

Photo: Angelika Renner

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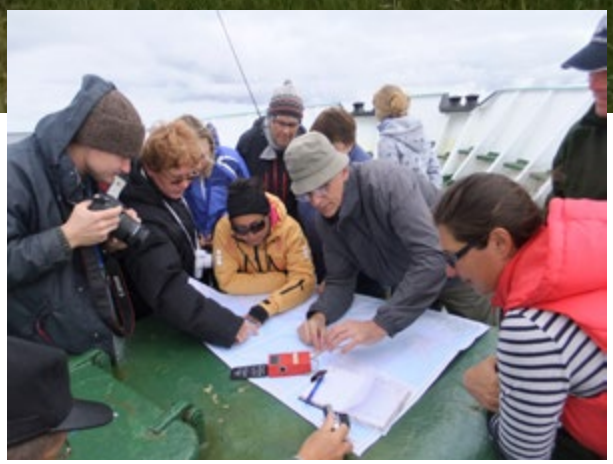
Kolgujev.
Photo: Gunn Sissel Jaklin, Norwegian Polar Institute



Studying the map on deck.
Photo: Gunn Sissel Jaklin, Norwegian Polar Institute

Gunn Sissel Jaklin // Norwegian Polar Institute

Nansen Memorial Expedition – along the Siberian coast

On 6 August 2013 the research vessel *Professor Molchanov* set off from Arkhangelsk in Russia. On board were scientists, historians, bureaucrats, businessmen, media representatives and communications officers, based in Norway and Russia. The aim was to sail parts of the Northern Sea Route 100 years after the Norwegian scientist, polar explorer and humanist Fridtjof Nansen sailed the same waters. Nansen accompanied the Norwegian businessman Jonas Lied, who was keen to prove that the Northern Sea Route was an interesting business opportunity. Today, commercial shipping along the Route is more interesting than ever, due to the warming of the Arctic.

Lied and Nansen were hindered by heavy sea ice and had to adjust their itinerary. A hundred years later the participants of the expedition never saw ice on their journey through the White, Barents, Pechora and Kara Seas, and along Yenisey river.

The journey was organised by UiT The Arctic University of Norway, Arkhangelsk University, and the Norwegian Polar Institute. The vessel acted as a floating seminar venue, and participants gave talks on board during the 11-day journey. This led to an important exchange of knowledge and fruitful discussions.

The first stop was Kolguyev, a small island in the Barents Sea. Even centuries ago, the island was seen as a potential main harbour along the Northern Sea Route, but so far, not much has happened. Most of the island's 500 inhabitants are Nenets people who herd reindeer for a living. Conditions are good for reindeer, but there are too many on the island and the herds will have to be reduced. Kolguyev hosts an oil drilling base, but very little of this economic activity rubs off on the local community, and there is an aura of poverty over the settlement. The authorities have banned the sale of alcohol, as alcoholism is one of the problems the inhabitants face.

Next stop was Dikson, which used to be a buzzing outpost in the Kara Sea, with more than 3000 inhabitants. However, military and other activities have gone down, and people have left. There are now fewer than 1000 people scattered around in the large buildings designed to house three times as many. Not a very encouraging sight, to say the least. However, the inhabitants were welcoming and more than willing to talk to the foreigners who "invaded" their town, possibly because they do see the odd visitor from time to time, usually explorers in the Arctic arriving on small ships or sailboats. Even so, "There have probably been more visitors on the North Pole than here in Dikson," a Russian representative told us. "You have to have a special permit to come here."

Dikson's history is linked to Norwegian polar history. In 1919, polar explorer Roald Amundsen sent away two of his men from *Maud*, which was sailing through the North East Passage. Peter Tessem had been suffering severe headaches and wanted to return home.

Participants Harald Steen (left) and Jan-Gunnar Winther (right) from the Norwegian Polar Institute and Kirsti Strøm Bull from the Norwegian Academy of Sciences, in Dudinka.

Photo: Gunn Sissel Jaklin, Norwegian Polar Institute

Dikson.
Photo: Gunn Sissel Jaklin, Norwegian Polar Institute

Paul Knutsen joined him, and Amundsen – who thought it safe to walk across the ice – sent them along with mail for those waiting at home and parts of a book manuscript. But something went wrong. The body of what appears to have been Tessem was found near Dikson. Knutsen was never found and his fate will probably remain a mystery.

The last stop on our journey was Dudinka on the Yenisey, a harbour town of about 60 000 inhabitants. Dudinka is the maritime gateway to the industrial city of Norilsk – one of the world's most polluted cities.

The aim of the expedition was to explore and promote the possibilities for further co-operation between companies and institutions in the two countries. As a first result, a joint "Floating University" expedition for students is planned for 2014.

Monument to Peter Tessem in Dikson.
Photo: Gunn Sissel Jaklin, Norwegian Polar Institue

NEWS

PREDATORS ARE NOT THE CULPRITS

Too many reindeer on the grazing grounds, poor physical condition of the animals, and adverse weather conditions are the most important causes of loss of animals in the reindeer herding industry. Only a small percentage of the reported losses can be attributed to predators. That is the conclusion of a report from the Norwegian Institute for Nature Research (NINA), which was published in June 2013.

The researchers at NINA have spent a decade examining production and causes of loss in the reindeer industry in Norway.

“A higher slaughter outtake could effectively counteract most of the losses and make reindeer herding more economically efficient,” explains Torkild Tveraa, who has headed the research project. Tveraa is a senior researcher at NINA – a Fram Centre member institution.

NOK 36 MILLION TO RESEARCH THE LAW OF THE SEA

Who owns the seabed beneath the Arctic ice? Does Russia have the right to lay pipelines in Norwegian waters? In 2013, the Kristian Gerhard Jebsen Foundation awarded NOK 36 million to UiT The Arctic University of Norway to establish a research centre that will aim to answer questions like this.

These issues are important for Norway. And yet until now surprisingly little research has been done into the law of the sea. It is an area of legislation explored by relatively few and far-flung research environments in Norway or internationally.

Following assessment by international experts and in tough competition with the law faculties in Oslo and Bergen, UiT was chosen to host the research centre. The new K.G. Jebsen Centre for the Law of the Sea at the university’s Faculty of Law will receive NOK 36 million from the Foundation.

“We commend the Foundation for taking such a long-term perspective on the law of the sea. They have seen us establish Norway’s best expertise in the field over the past ten years and want to invest in our future dedicated research into this area,” says Professor Tore Henriksen, head of the new research centre.

EXTREME WEATHER STRESSFUL FOR NATURE IN THE HIGH NORTH

More extreme weather and fluctuating temperatures in winter are proving stressful for the natural world. Hitherto, researchers have been most focused on the effects of climate change in the summer months, while most of the changes are expected to take place in the winter. In the High North especially, a change in winter climate may have serious consequences for vegetation and animals.

Through the EWWA project (Extreme Winter Warming in the High North and its biological effects in the past, present and future), research scientists – including several from Fram Centre institutions – are seeking to find out how more frequent mild spells followed by cold and ice affect the ecosystem. The project has a special focus on the plants reindeer graze on. The project will run through 2014.

Jenny Baeseman and Heidi Isaksen // CliC Project Office

The Climate and Cryosphere International Project Office at the Fram Centre

The Climate and Cryosphere (CliC) project is one of the core projects of the World Climate Research Programme (WCRP). It focuses on the cryosphere – the parts of the earth where water exists in frozen form. CliC promotes efforts to understand the cryosphere's interactions with the global climate system and to enhance the ability to use parts of the cryosphere to detect climate change. CliC is committed to supporting international cryosphere research, encourages communication between researchers with common interests in cryospheric and climate science, promotes international cooperation, focuses attention on the most important issues related to the cryosphere and highlights the importance of this field of science to policy makers, funding agencies, and the general public. CliC also publishes significant findings regarding the role of the cryosphere in climate, and recommends directions for future study. The CliC International Project Office is hosted by the Norwegian Polar Institute at the Fram Centre.

CliC also provides travel support and assistance to international workshops related to the cryosphere all over the world. CliC provides webcasts and hosts websites where information, presentations, posters, and reports linked to scientific meetings can easily be found before and after the meeting. To further enhance science communication CliC produces "FrostBytes", 30-60 second videos designed to help researchers share their latest findings with a broad audience.

To enhance international cryosphere communication and research collaboration, CliC developed and maintains information resources and tools including:

- Community calendar
- Podcast series on iTunes
- Cryonews for Facebook, Twitter and LinkedIn
- Cryolit RSS feed with recent publications about the cryosphere
- Project catalogue
- Directory of specialists
- Historical sea ice archive

In 2013, CliC supported five workshops at the Fram Centre, all funded in part by the Research Council of Norway. The Norway–China Research Collaboration in Sea Ice, Snow, and Climate workshop helped to enhance and extend collaborations between researchers in Norway and China. The Norway Sea Ice workshop focused on sharing information on Norwegian sea ice research projects, enhancing collaborations, and addressing research needs. The Sea Ice Modelling and Observing workshop brought together researchers from both the Arctic and Antarctic to discuss current knowledge gaps and discuss and plan internationally coordinated research projects focusing on tying the sea ice modelling and observing communities together. The Antarctic Ice Rises workshop brought together this research community for the first time to share current knowledge about ice rises. As a result, a new network was formed to continue efforts to understand the stability of Antarctic Ice Sheet. The final workshop set the plan for the

WCRP's Cryosphere Grand Science Challenge. These workshops helped bring almost 200 international cryosphere researchers to Tromsø from 65 institutions in 23 countries. In addition, CliC supported 15 other workshops and events around the world.

The WCPR Cryosphere in a Changing Climate Grand Challenge will be one of the main foci for CliC in the coming years. We plan targeted activities to address the following topics:

- Magnitude, timing and form of greenhouse gas release from permafrost carbon reservoir to the atmosphere in a warming world
- Current and future mass loss of global glaciers and ice caps
- Freshwater volume and availability from the cryosphere
- Ice sheet snowpack melt, storage, and runoff
- Impact of changing sea ice on high-latitude climate systems
- Internal variability of sea ice up to multi-decadal time scale
- Impact of snow changes on water resources
- The role of snow as an active component of the global climate system

In addition to the Grand Challenge activities, CliC is working with other international partners on an Arctic Freshwater Synthesis, which will review the state of freshwater regimes in the Arctic including river fluxes, permafrost thaw, and freshwater inputs to the Arctic Ocean, and will provide recommendations to policy makers on developing adaptation strategies. The Polar Coordinated Regional Downscaling Experiment (PolarCORDEX) was initiated to reduce uncertainties in modelling regional climate in the Arctic and Antarctic. Ice Watch, a mechanism for the standardisation of research observations on sea ice, and the Arctic Shipborne Sea Ice Standardization Tool (ASSIST) Data Network were also launched this year. Several other targeted activities are being planned and both the scientific and stakeholder communities are encouraged to propose initiatives.

For more information on CliC and international cryosphere research, visit the new CliC website: www.climate-cryosphere.org

NEWS

SVALBARD'S LARGEST LAKE NAMED

Over 100 names were submitted when the Norwegian Polar Institute invited suggestions for a name for Svalbard's largest lake – which was nameless. In May 2013, it was given the name Trebrevatnet (which means Three Glacier Lake).

The lake lies north of Ekmanfjorden. Gradually, a large body of water has formed below the glaciers Orsabreen, Holmströmbreen and Morabreen. These glaciers have been retreating for some time and meltwater has accumulated behind a dam of moraine. Since 1990 the lake has grown from 2.3 to 17.3 square kilometres. Trebrevatnet is thus currently Svalbard's largest lake, snatching that distinction from the previous record holder, Brånevatnet in Nordaustlandet, which has an area of about 9 square kilometres. For comparison, Adventfjorden is about 23 square kilometres.

Because of climate change, the new lake may not last long.

"The ice has been retreating since the 1920s, and with global warming, the melting rate is accelerating. In a few decades' time the ice core that holds together the moraine that is currently damming the lake may have melted, and Trebrevatnet may disappear," explains geologist Winfried Dallmann at the Norwegian Polar Institute.

Ellen Øseth // Norwegian Polar Institute

Environmental monitoring of Svalbard and Jan Mayen

Why do brooding glaucous gulls die on the nest? What does an absence of sea ice mean for polar bears? How is the climate changing and what consequences will that have for the ecosystems in the Norwegian Arctic? The MOSJ programme is an integrated system for environmental monitoring in Svalbard, Jan Mayen and the surrounding seas. MOSJ (which stands for Environmental monitoring of Svalbard and Jan Mayen) gathers and presents data on climate, fauna, flora, cultural heritage and impacts such as traffic, pollution and hunting.

Adaptive monitoring has been a priority for the Fram Centre, especially in the Terrestrial Flagship programme. A MOSJ environmental status report, due out in mid-2014, recommends that MOSJ take a more adaptive approach. In recent years, MOSJ has carried out high-quality environmental status assessments that contribute towards improving the monitoring system and measuring whether the Norwegian government's environmental goals are being attained.

MOSJ was set up in 1999; it is run by the Norwegian Polar Institute, and is the most comprehensive monitoring system the Arctic. It is based on indicators for the status of the natural environment, and for activities and processes with impact on that status. The system neither funds nor carries out the actual monitoring work, but collates relevant information from thematic monitoring programmes covering the area. Many institutions, most of which are affiliated with the Fram Centre, deliver data on the indicators in MOSJ, which are then presented on the MOSJ website (www.mosj.npolar.no). At regular intervals, thematic reviews are made of the environmental status in MOSJ. The overarching trends are summarised, and the status evaluated against the government's goals. On this basis, recommendations are given concerning the need for environmental management measures.

Not all data and monitoring series are incorporated into the MOSJ programme. The environmental status reviews provide information about which indicators should be included in the various thematic areas in order to establish whether environmental goals are being attained.

Knowledge about terrestrial and marine environments of Svalbard is limited, and even less is known about Jan Mayen's. Research is done on a broad scale in Svalbard, and through the years, several long time series have been established; these will be crucial for assessing the state of the environment. A major challenge will be to obtain long-term funding for the time series, to guarantee sufficient duration and continuity. Research plays an important role in MOSJ, as research results, recorded data and statistics are the foundation for the thematic monitoring programmes on which MOSJ is based.

In 2013, status assessments were done on two of the thematic areas: the marine environment and the terrestrial environment. The reports – to be published in mid-2014 – will contain useful information on the state of the environment, as well as recommendations for improving MOSJ. The reports will be authored by some of the foremost experts in the fields and will be peer-reviewed prior to publication. A strong scientific foundation is essential to the

Top predators like the glaucous gull are subject to several environmental pressures simultaneously. Climate change causes stress, which releases accumulated ecotoxins, weakens the birds' reproductive capacity and increases mortality.

Photo: Geir Wing Gabrielsen, Norwegian Polar Institute

The reproductive success of the polar bear is dependent on sea ice. Without sufficient sea ice, the females cannot reach the winter lairs where they give birth. MOSJ reveals the correlation between the sea ice cover in autumn and polar bear reproductive rates.

Photo: Magnus Andersen, Norwegian Polar Institute

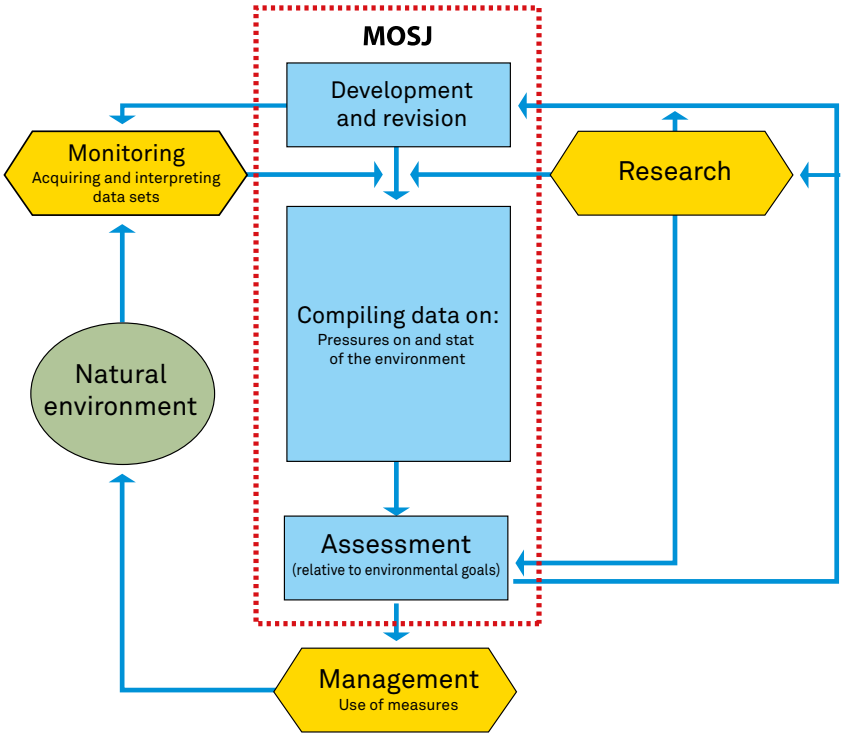
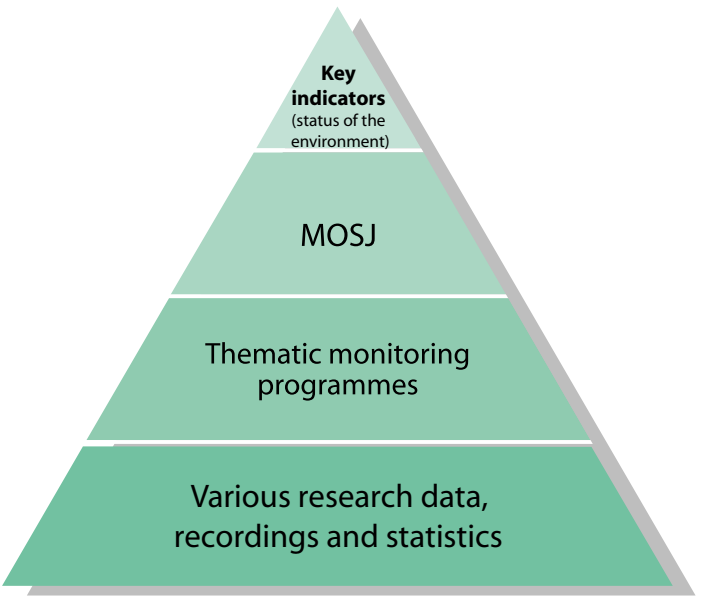


Diagram showing MOSJ activities. Core MOSJ activities in blue within the red outline. Yellow boxes denote activities outside the system that either supply or receive information. There is significant interplay and interaction between several of the elements, so reality is less static than the diagram might suggest.

Graph: Jan Roald, Norwegian Polar Institute

success of MOSJ. Researchers affiliated with the Fram Centre have been central to the environmental assessments carried out in recent years. The system must continue to evolve, both because the environment is changing and because methods and current knowledge are continually advancing. Consequently, considerable effort will be put into improving the content, structure, and usability of the MOSJ website.

MOSJ will celebrate its 15th anniversary in 2014. Since it was first established, MOSJ has developed into an important channel for information about the environment in the Norwegian Arctic. With escalating climate change and increased human activity in the area, there is an ever greater need for information. MOSJ delivers an overall picture of the environmental impact of these changes, both measured directly in the physical environment of Svalbard and Jan Mayen, and as revealed by migratory species or permanent residents in the area. Moreover, the results from several different indicators can be interpreted simultaneously. This is essential to holistic, ecosystem-based management.



MOSJ in relation to other monitoring and research. The width of the triangle indicates the extent to which various data-gathering activities are included. The uppermost levels rely on those below: for example, monitoring relies on research.

Graph: Jan Roald, Norwegian Polar Institute

Yngve Antonsen and Heidi Rapp Nilsen // Norut Northern Research Institute

Climate communication and action

Researchers have demonstrated that the consequences of climate change will be serious. Despite this, surveys show that less than half of all Norwegians are worried about greenhouse gas emissions. In August 2013, Norut, the University of the Arctic, UiT The Arctic University of Norway, and CICERO (the Center for International Climate and Environmental Research – Oslo) held a joint "World Café" event aimed at generating ideas for how to improve communication between researchers, decision-makers and ordinary citizens to reduce the gap in awareness and achieve concrete action.

The World Café concept is based on informal conversations around a coffee table – something most of us have taken part in at one time or another. This provides a relaxed framework for discussion, with time for reflection. Many cultures have a long tradition of using dialogue to discuss complex questions. There are several versions of the method known as the World Café process, which was originally developed by Voldtofte and Brown. Most have the same basic elements, one of the central premises being that everyone is equal and has an equal right to take part in the dialogue. Participants gather in groups, a host at each table welcomes them, and then they discuss a pre-assigned topic. Any ideas that are put forward are noted down on a large sheet of paper. After a specific time, the groups break up and everyone finds a seat at a new table, so that new groups are formed and each participant gets a new question to discuss. The host stays at the same table throughout the process. As each new group is formed, the host gives a brief summary of the earlier discussions at that table. When everyone has changed tables a few times, there is a plenary session where table hosts present the ideas that emerged from their table's discussion.

The World Café at the Fram Centre gathered 35 invited participants from the spheres of education, voluntary organisations, the arts and culture, local government and the church. There were five tables with three discussion sessions at each. The subjects discussed were:

- What connection is there between what Norway does internationally and nationally to reduce our contributions to climate change, and people's attitude to how serious this is?
- How do people perceive information and the debate on climate change in Norway?
- How can the consequences of climate change be communicated so that more people will understand the seriousness of the problem?
- What does acting in a climate-friendly way entail? How can we influence people to act in a climate-friendly fashion and help reduce greenhouse gases?
- How important is climate in relation to other considerations in planning the society of the future?

VIEWS AND CHALLENGES

The questions cover the same problem areas so some of the ideas and responses overlap. The summary below is therefore not organised according to the questions discussed at each table, but rather in relation to what the participants perceived to be the most important issues.

ABOUT CLIMATE POLICY

The World Café participants believe it is essential to change Norwegian climate policy. In their view, too much of the discussion focuses on measures to be taken in other countries. This obscures the fact that

the people of Norway must take responsibility themselves. With carbon trading and other measures taking place abroad, the moral and practical responsibility is left to others, which means that Norwegians do not fully appreciate how serious the problem is. Carbon trading makes it difficult to see the connections between actions and their effects, and there is also scepticism as to whether carbon trading actually works. The politicians must set specific emission standards for each sector – standards that will mean reducing emissions within Norway itself.

ABOUT THE KNOWLEDGE BASE

Ninety-seven per cent of climate researchers believe that climate change is caused by humans. This figure was neither disputed nor discussed. On the contrary: it was taken as a natural starting point for the dialogue around the tables. An important point for many participants was that information on climate change goes over people's heads because it is presented in too complex a form. The knowledge doesn't "hit home" and is often presented as though it doesn't concern the individual. Even when people understand that climate change is a threat, they overlook the fact that it demands a change in behaviour. People need more concrete examples of what climate change will actually mean in everyday life and in the way policy is framed, for instance in discussions about public transport.

Proposals for concrete action

- *Competition and positive challenges.* We can measure emissions connected with what people do, and provide incentives for reducing CO_2 emissions by getting people to compete with themselves or others. Reducing emissions should be fun, positive and inspiring, not a matter of coercion. Long-term solutions require development of attitudes and values that commit people to act responsibly.
- *Local solutions – local development.* We must work at community level and make use of local resources. Demonstrating how climate change affects local conditions will help clarify the links to how resources are utilised – and how they could be used to reduce emissions.

Photo: Yngve Antonsen

- *Role models.* Famous people who get involved in climate issues can serve as role models, not least for young people, who may imitate the behaviour of celebrities.
- *Involve young people.* Involving and educating young people plays an important part in raising awareness of climate change, particularly in the longer term. Climate change must be included both in teacher training and in the school curriculum.
- *Culture workers as agents of change and partners in scientific outreach.* We can encourage actors, singers, and artists to get involved in framing messages that will inspire exchange of ideas on climate policy and possible measures.

We thank everyone who took part in the World Café for their constructive contributions and for making the event such a success. We have already put the results to good use as part of two different applications to the new Climate Research programme of the Research Council of Norway.

John Richard Hansen and Nina Mari Jørgensen // Norwegian Polar Institute

Norwegian–Russian cooperation for environmental and resource management in the Barents Sea

We have to go back to 2002 to find the roots of the current environmental management plans for Norwegian seas. That was when the Bondevik government presented the White Paper "Rent og rikt hav" (Clean and bountiful sea) which heralded the start of the work on the management plan for the Barents Sea and the Lofoten Islands. An important step was the creation of a steering group composed of relevant sectoral authorities with responsibility for environmental protection, fisheries and coastal affairs, oil and energy, and foreign policy. While the structure of industry in the Barents Sea was changing as a result of increased petroleum activity, work was going on which led to Norway's first holistic environmental management plan in 2006. The plan was updated in 2011, eight years after its inception.

Developing the environmental management plan was a challenging and time-consuming exercise. This was no surprise, as the 2002 White Paper had identified clear challenges in terms of managing marine resources, marine environment, risks and societal aspects. The time had come for meticulous coordination of the sectors and the introduction of "ecosystem-based management". Obviously the plan did not evolve right there at the negotiating table. Information was needed first: extensive basic environmental and resource studies, descriptions of industries, livelihoods and communities. Also essential were far-reaching studies of the effects of the petroleum activity, fisheries and aquaculture, shipping and other external pressures, as well as assessment of environmental goals, management objectives and knowledge requirements.

The Barents Sea is shared between two nations, and its resources and environmental challenges transcend borders. This means that a holistic, ecosystem-based management programme must involve the entire marine area if it is to be effective, targeted and successful in the long term. The Russian authorities have been kept well informed about the development of the management plan in Norway – not least through the Joint Norwegian–Russian Commission on Environmental Cooperation. As part of the Commission's three-year work programme, the Norwegian Polar Institute has played a central role in marine cooperation and in helping the Russian authorities develop a conceptual framework for managing their sector of the Barents Sea. Norway's experience of the process, and Norwegian research, have given the Russian authorities a foundation on which to base much of their work.

Norway faced huge challenges in developing sectoral cooperation and a shared understanding of the management of the Barents Sea. Our Russian counterparts are encountering challenges just as great,

if not greater. It is evident that resource utilisation in the Russian part of the Barents Sea is sectoral in character and could be better coordinated. Not least, federal laws need to be adapted, and regional and local authorities need deeper understanding of holistic environmental management.

In this sea of problems, the Norwegian parties in the well-functioning Joint Commission have focused on getting the ball rolling, despite the lack of a formal basis for action in Russia, and have pointed out the advantages of launching efforts to increase the knowledge base while awaiting formal decisions. Initially, the focus has been on arriving at a common understanding of the situation in the environment, and agreeing on a joint set of indicators for environmental monitoring in the Barents Sea. Not least, there has been major emphasis on joint dissemination of environmental knowledge through creation of the web portal *barentsportal.no.*

BarentsPortal presents a joint Norwegian–Russian view of the environmental status of the entire Barents Sea, and environmental challenges in the region. Knowledge-intensive organisations in both countries have participated in this work, including the Knipovich Polar Research Institute of Marine Fisheries and Oceanography, the Russian marine geology giant Sevmorgeo, and on the Norwegian side the Institute of Marine Research and the Norwegian Polar Institute. The environmental status report relies on a knowledge base from 2009 with key chapters updated in subsequent years. The portal is in two languages, and all content will soon be available in both English and Russian.

Environmental monitoring will be a key element in an environmental management plan for the Barents Sea as a joint marine area. When the bilateral 5-year project ends in 2015, it is expected have produced a list of environmental indicators to be included in a joint Norwegian–Russian monitoring programme for the Barents Sea. The next two years will focus on identifying gaps in the current Russian and Norwegian resource and environmental monitoring, and determining how these gaps may be eliminated. In addition, initiatives will be taken toward development of joint monitoring methods and monitoring activities.

A holistic and ecosystem-based management programme for the Barents Sea will comprise area-based management where the properties of the areas determine activities and measures. It is also the aim to protect the most valuable and vulnerable areas against negative impacts; to reduce the influx of environmental toxins; to strengthen fisheries management; to ensure control of environmental development in the area through more coordinated and systematic environmental monitoring; and to strengthen the knowledge base through better mapping and an expanded research programme. Successful Norwegian–Russian cooperation in environmental management is a tool both to leverage resources and to maintain environmental assets throughout the Barents Sea.

NEWS

AWARDED HONORARY DOCTORATES

Foreign ministers Jonas Gahr Støre (Norway) and Sergei Lavrov (Russia) were awarded honorary doctorates by the University of Tromsø in March 2013. The University's governing board conferred the doctorates in recognition of many years' work to reach agreement on the maritime delimitation between Norway and Russia.

ARCTIC COLLABORATION

Research on Russian verbs, ice extent in the Barents Sea, and films from visual culture studies: these are some of the areas in which the University of Tromsø has collaborated with Lomonosov Moscow State University. A new collaboration agreement was signed at the Third International Arctic Forum in September 2013.

Ingrid Jensvoll // UiT The Arctic University of Norway

Capturing predators in pictures: research-based education with wildlife cameras

Through the project TUNDRA schoolnet, pupils living on the tundra study arctic predators and get hands-on experience with climate-ecological research.

THROUGHOUT THE YEAR pupils and teachers have studied predators, eager to get answers to their research questions: *Which predators live in the vicinity of the local community? When are they active? What is the most common predator?* The research-based activity is a part of TUNDRA schoolnet, a circumpolar school project in Norway, Russia and Alaska.

In order to study predators, the schools have received two wildlife cameras from the project. To lure predators, the students place bait in front of the camera. The wildlife cameras are set up close to the school, and when deploying them, pupils and teachers look for tracks in the snow, to get a hint of what they can expect to capture on the camera. Two weeks later the cameras are retrieved, often fully loaded with pictures. The teachers report huge excitement among the pupils when they get the first glimpse of what they have captured with the cameras. This year, schools from all the three countries managed to capture pictures of the arctic fox - the only arctic predator species found everywhere in the circumpolar tundra. However, whereas it is considered an endangered species in Norway it is quite abundant in both Alaska and Arctic Russia.

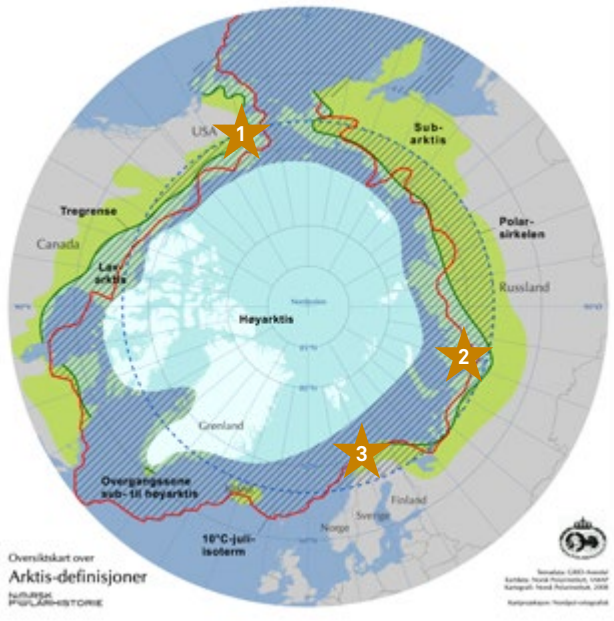
Pupils from Vardø, Daniela de la Cerda, Celine Christensen Olsen, Bjørn Sverre Henriksen, Adina Eriksen Eines and Madelen Josefsen, studying the picture of an arctic fox.

Photo: Håvard S. Mækelæ

The project has its own web page, where the students can enter their own observations and compare results with other schools in the tundra region. The web page also contains suitable educational material for students and teachers in the project.

The teachers are essential to successful implementation of the project. TUNDRA schoolnet arranges yearly seminars aimed to give teachers competence and confidence to include the research-based activities in their teaching. The seminars are also an important step towards strengthening collaboration between schools.

The selected topics for TUNDRA schoolnet activities are in particular motivated by the challenges of climate change. Communities in the tundra region will experience changes impacting their natural environment, more rapidly and extensively than elsewhere. It is therefore important to impart knowledge about such impacts, in order to make them understood both locally and globally. Predators inhabiting the tundra are at the top of the food web, and therefore more likely to be among the most vulnerable species. For instance, the current rarity of the arctic fox in Norway is related to fewer lemmings as available prey and stronger competition from red foxes. Monitoring predators gives opportunities to discover early changes due to climate change in arctic ecosystems.



Arctic foxes, an omnipresent terrestrial predator in the Arctic, were photo-captured close to three of the project schools in the winter of 2013:
1) Atqasuk, Alaska; 2) Seyakha, Russia; 3) Vardø, Norway.

While the Arctic fox is close to extinction in Vardø, probably owing to climate change, it is still common at the sites in Alaska and Russia.

TUNDRA SCHOOLNET

TUNDRA schoolnet is a research-based project for schools at the upper primary level in Norway, Russia and Alaska.The main objectives of TUNDRA schoolnet are:

- Promote awareness of and curiosity for the arctic tundra ecosystem, through research-based education
- Establish a circumpolar network for students and teachers, to create a common understanding of climate-related challenges in the North

The scientific content in TUNDRA schoolnet centres around three activities that give insight into species composition and important ecosystem processes in the arctic tundra:

- See the predators!
- Timing of bud burst
- Small rodent year?

TUNDRA schoolnet has originated from two research projects: Climate Ecological Observatory for Arctic Tundra (COAT) and TUNDRA. COAT is a long-term monitoring project developed by researchers at the Fram Centre. TUNDRA is an international project funded by the Norwegian Research Council / Miljø 2015.

The project has received funding from the Fram Centre and Sparebank1 Nord-Norge.

Hilde Elise Heldal // Institute of Marine Research
Ingrid Kvalvik and Themis Altintzoglou // Nofima
Maaike Knol // UiT The Arctic University of Norway, Norwegian College of Fishery Science
Inger Margrethe Eikelmann // Norwegian Radiation Protection Authority

New and expanding industries in the north – assessment, management and communication of risk

Northern sea areas are considered vulnerable to pollution due to harsh weather and climate conditions and low biological diversity. What risks do new and expanding industries such as shipping and oil and gas exploitation pose to the fishing industry in the Barents Sea? This question formed the basis for the seminar "Risk management, new industries and fisheries in the north" held at the Fram Centre 17-18 September 2013. Representatives from different governmental sectors and Norwegian research institutes participated.

The aim of the seminar was to uncover differences and similarities in the risk analysis and management related to the different industries and sources of pollution. The seminar focused on three issues: 1) Risk assessment, integrated management and common standards of risk; 2) Public risk management, emergency procedures and inter-agency cooperation; and 3) Risk communication to the market and consumers. This article briefly summarises the discussions at the seminar.

RISK ASSESSMENT AND INTEGRATED MANAGEMENT

When risk assessments are carried out for policy-making, risk is often defined as the product of the probability of an event – for example the statistical likelihood that a particular accident takes place – and its consequences. When considering risk from a political or social science perspective, however, it may also include considerations of economic activity, cost–benefit analysis and investment level of emergency response systems. There are also risks connected to the side effects of normal operations. Here, we cannot use the traditional risk equation, as we do not speak of probability.

In the fisheries, nuclear and transport sectors, risk assessments are performed as modelling of damage under different scenarios. The petroleum sector, however, often emphasises the probability, i.e. the likelihood that a certain event will happen within a certain time-frame. This can lead to quite different pictures, one of which focuses on the low probability of an accident, while the other emphasises the potential damage under a given set of criteria (from best-case to worst-case scenario).

The integrated management plan for the Barents Sea provides a framework for managing all human activities to ensure the continued health, productivity and functioning of the ecosystem. A challenge, however, is to achieve an understanding of the cumulative

Photo: Institute of Marine Research

Photo: Frank Gregersen, Nofima

impacts of all human activities. To deal with this, a risk management group was established to inform authorities about risk management in the Barents Sea.

PUBLIC RISK MANAGEMENT AND EMERGENCY PROCEDURES

Transparent, objective and efficient information exchange between relevant actors will not solve the problem of diverging interests and perspective, but it might increase the accuracy of conclusions related to the risk at hand.

A common understanding of risk and risk acceptance – both between sector authorities and between countries – is important because handling all the aspects of a crisis requires extensive cooperation, good warning procedures and exchange of information.

The Norwegian Nuclear Preparedness Organisation continually assesses national and international nuclear and radiological hazards. To foster good functioning, seminars are held every year, with lectures and discussions on relevant themes. Practical exercises move beyond structural procedures and establish personal relations and internalise procedures and routines. In case of a crisis these experiences will be critical for effective crisis management. The same can be seen among other risk management institutions, like the Norwegian Coastal Administration. Experiences from "everyday practice" can decide how well the routines work in cases of emergency. International and national agreements on early notification and information exchange are crucial in emergency situations.

RISK COMMUNICATION TO THE MARKET AND CONSUMERS

In case of an accident, communication of risk to the public is very important. Both Norwegian consumers and the fish export industry are susceptible to real as well as perceived harm and the food safety aspects related to contaminated fish. Risk is perceived differently by each person and is influenced by content, source, media and type of information. Successful risk communication is well prepared, transparent, balanced, understood and trusted. People will pay less attention to over-dramatic media if they receive reliable, informative and educative risk communication first. Accuracy, transparency and confidence in knowledge ensure trust and reliability in communication to the general public.

Jo Jorem Aarseth and Helge M. Markusson // Fram Centre

Fram Centre prizes awarded

At the Fram Centre prize award ceremony. From the left: Sandra Hamel, UiT The Arctic University of Norway, who won this year's Scientific Research Prize, Kit Kovacs, Norwegian Polar Institute, accepting the prize on behalf of Geir Wing Gabrielsen (who was in Svalbard on Fram Day), and Are Johnsen and Jo Jorem Aarseth, both from the Fram Centre.
Photo: Helge M. Markusson, Fram Centre

Sandra Hamel and Geir Wing Gabrielsen were awarded this year's Fram Centre prizes.

THE FRAM CENTRE PRIZE FOR SCIENTIFIC RESEARCH FOR 2013:

Sandra Hamel, postdoctoral research fellow
UiT The Arctic University of Norway

The Scientific Research prize went to a researcher who, despite her tender age, has produced a large number of scholarly publications of very high quality, first and foremost articles published in international journals.

In addition, the prize winner has been very active in international collaboration, given presentations at international conferences, and published a wide variety of reports both in Norway and abroad. She has already received several distinctions, and secured considerable amounts of research funding from various sources.
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THE FRAM CENTRE PRIZE FOR SCIENTIFIC DISSEMINATION FOR 2013:

Geir Wing Gabrielsen, senior research scientist
Norwegian Polar Institute

The Scientific Dissemination prize went to a research scientist who communicates a large body of scientific knowledge very skilfully, who thinks along new lines and uses multiple channels to reach a variety of audiences. The prize winner satisfies all the criteria for the award. His own research field is closely associated with one of the Fram Centre Flagship programmes. The winner is an active, creative and innovative disseminator, who masters traditional communication channels, lecturing and giving interviews in TV, radio and the press, and who himself takes the initiative to communicate.

In addition, he uses new and exciting communication channels to reach out to completely new audiences – including some that are often overlooked. This innovation demands effort over and above what might be expected.
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The prizes were presented on Fram Day, 8 November 2013. This is the second time these prizes have been awarded. Each prize consists of a cash sum of NOK 25 000 and a work of art. Sixteen people had been nominated for this year's prizes.

Ann Kristin Balto // Norwegian Polar Institute
Photo: Adolf Hoel // Norwegian Polar Institute

Faroese captains on shore leave in Longyearbyen

The Norwegian Polar Institute's photo archive contains around 90 000 polar images, half of which are available online: http://photoweb.npolar.no

It is 1936. Four Faroese skippers have gone ashore. We see them sauntering down the main street in Longyearbyen with newly purchased maps from *Norges Svalbard- og Ishavsundersøkelser* (the organisation that arranged Norway's scientific excursions in the Arctic in the early 1900s and later became the Norwegian Polar Institute). Today, the only remnants of the buildings in this picture are the timbers on which they stood.

Longyearbyen is the administrative centre of Svalbard. It has now become a modern town with local administration, a broad service sector, museums, shops and cafes, but Longyearbyen began as a "company town" with coal mining as the only industry. In the early 1900s several companies vied to annex the mineral resources in the area. Ultimately, it was John Munro Longyear who came out on top. His Arctic Coal Company launched large-scale coal extraction and built up the settlement that would later bear his name: Longyear City.

World War II reached all the way north to the arctic mining community in Svalbard. Both sides in the conflict needed weather stations in the Svalbard archipelago. In 1941 the entire population of Longyearbyen was evacuated, and the town stood empty. But the Allies maintained a small force in Barentsburg, which led to the Germans launching "Operation Zitronella", sending the battleships *Tirpitz* and *Scharnhorst* to Svalbard. The ships attacked on 8 September 1943 and both Longyearbyen and Barentsburg were set on fire. Longyearbyen was rebuilt after World War II - but not this street, where the jaunty Faroese skippers went walking in 1936.

Projects in the Fram Centre Flagships for 2013

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	E-MAIL PROJECT LEADER
Impact of harbour seal predation on Tana salmon	Martin Svenning	NINA, NIKU, IMR	martin.svenning@nina.no
Anadromous arctic charr in northern Norway – migration, habitat use and effects of climate change	Guttorm Christensen	ApN, NIVA, VI, UiT	kari.norheim@vetinst.no guttorm.christensen@akvaplan.niva.no
Atlantic salmon; an interdisciplinary approach, combining natural and social science, to improve the management of salmon sea-fisheries in northern coastal areas	Martin Svenning	NINA, NIKU, UiT, IMR	martin.svenning@nina.no
Drift of fish larvae, fish–stock interactions and their effect on seabird dynamics	Kjell Einar Erikstad	NINA, IMR	kjell.e.erikstad@nina.no
Seabird habitat use and migration strategies	Børge Moe	NINA, NPI	borge.moe@nina.no
A coastal, ice-associated arctic whale in a changing climate	Christian Lydersen	NPI, UiT, NVH	christian.lydersen@npolar.no

Structure, function and change in arctic and boreal fjord ecosystems

Habitat structure and ecosystem function of eel grass (*Zostera marina*) meadows in the high north in relation to human traditional use and exploitation	Hartvig Christie	ApN, NIVA, UiT, IMR, Norut	hartvig.christie@niva.no
Marine base maps for the Porsanger fjord	Aivo Lepland	NGU	Aivo.Lepland@NGU.NO
Benthic biodiversity and ecosystem function in Svalbard and North Norway	Sabine Cochrane	ApN, NINA	sc@akvaplan.niva.no
Reduced sea urchin grazing–effect of climate change or predator change?	Hartvig Christie	NIVA, ApN, IMR, UiT	hartvig.christie@niva.no
Ecosystem structure and use of marine resources from bivalve and fish bone proxies: A combined natural and social science perspective	Michael Carroll	ApN, NIKU	mlc@akvaplan.niva.no
Trophic interactions in pelagic ecosystems	Tove M. Gabrielsen	UNIS, NPI, ApN	tove.gabrielsen@unis.no
Pelagic ecosystems in ice-covered and ice-free fjords under climate change	Claudia Halsband	ApN, UiT, UNIS	clh@akvaplan.niva.no

Sea ice in the Arctic Ocean, Technology and Systems of Agreements

Sea ice, ecosystems and models

RESEARCH AREAS/PROJECT TITLES	PROJECT LEADER	PARTICIPATING INSTITUTIONS	E-MAIL PROJECT LEADER
CASPER: Characterization of arctic sea ice properties from remote sensing observations	Torbjørn Eltoft	UiT, NPI, Norut, Met.no, Kongsberg	torbjorn.eltoft@uit.no
ATWAIN: Long-term variability and trends in the Atlantic water inflow region	Vladimir Pavlov Randi Ingvaldsen	NPI, IMR, UNIS, UiT	vladimir.pavlov@npolar.no randi.ingvaldsen@imr.no
Modeling of ice, ocean and ecology of the Arctic Ocean	Ole-Anders Nøst	ApN, IMR, NPI, SINTEF, Met.no	oan@akvaplan.niva.no

Driving forces and development of new industry

Arctic futures: Future of the Arctic in light of socio-economic and political aspects of climate change	Peter Arbo	UiT, Norut, NPI, Nofima	peter.arbo@uit.no
Key factors for increased use of the Northern Shipping Route	Eirik Mikkelsen	Norut, FNI, ApN	Eirik.Mikkelsen@norut.no

Environmental impact of shipping

Introduction of marine invasive species–ballast water and biofouling	Anders Jelmert	IMR, UiT, NIVA	anders.jelmert@imr.no
FEARICE: Fate, Effect and Risk modeling of accidental oil spill in the sea ice ecosystem	Lionel Camus	ApN, Norut, NPI, SINTEF, UNIS	lionel.camus@akvaplan.niva.no

Regimes for sustainable management

A-LEX: Regulating Arctic Shipping–Political, technological and environmental challenges	Tore Henriksen	UiT, MarinTek, ApN	tore.henriksen@uit.no

Sea ice in the Arctic Ocean, Technology and Systems of Agreements

Sea ice, ecosystems and models

RESEARCH AREAS/PROJECT TITLES	PROJECT LEADER	PARTICIPATING INSTITUTIONS	E-MAIL PROJECT LEADER
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Regimes for sustainable management

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

Understanding the physical and chemical mechanisms controlling ocean acidification in arctic waters – past, present and future

RESEARCH AREAS/PROJECT TITLES	PROJECT LEADER	PARTICIPATING INSTITUTIONS	E-MAIL PROJECT LEADER
Establishing the current status of ocean acidification in the Norwegian Arctic (OA^{state})	Agneta Fransson Kai Sørensen	NPI, NIVA, IMR, UNIS	agneta.fransson@npolar.no kai.sorensen@niva.no
The role of sea ice processes on CO_2 exchange and calcium carbonate saturation levels (SICCA)	Agneta Fransson Melissa Chierici	NPI, IMR, NIVA, UNIS	agneta.fransson@npolar.no Melissa.Chierici@imr.no

Ocean acidification effects on key components of the arctic marine ecosystem

Effects of OA and temperature on viral stages of arctic vs. boreal zooplankton species	Haakon Hop Howard Browman	NPI, IMR, ApN	haakon.hop@npolar.no howardb@imr.no
Effects of ocean acidification on the reproduction of the reef building cold water coral *Lophelia pertusa*: Effects from OA on important cold-water coral reef inhabitants – how to measure health	Johanna Järnegren	NINA, SINTEF, UiT	johanna.jarnegren@nina.no

Socio-economics of ocean acidification

Economic value and ocean acidification	Claire Armstrong Eirik Mikkelsen	UiT, NIVA, Norut, NINA	claire.armstrong@uit.no Eirik.Mikkelsen@norut.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	E-MAIL PROJECT LEADER
NCoE-Tundra: Herbivore effects on tundra overgrowth, management and environmental gains	Jane Uhd Jepsen	NINA, UiT	jane.jepsen@nina.no

Ecosystem effects of extreme climate events and changing seasons

WINNIT – effects of extreme weather and long distance pollution on plant societies	Jarle W. Bjerke	NINA, Bioforsk, UiT	jarle.werner.bjerke@nina.no
EWWA: Winter climate and effects of extreme warm weather on vegetation in northern ecosystems	Jarle W. Bjerke	NINA, Norut, Bioforsk, UiT	jarle.werner.bjerke@nina.no
Climate changes and archaeological deposits	Elin R. Myrvoll	NIKU, Bioforsk, UiT	elin.myrvoll@niku.no

Capacity for adaptation in indigenous people and local societies

Adaptive capacity – climate adaptation in agriculture in North-Norway	Helene Amundsen	CICERO, UiT	helene.amundsen@cicero.uio.no
Local communities – changes in user strategies among indigenous peoples	Astrid Ogilvie	CICERO, NIKU, NINA, Norut	astrid.ogilvie@cicero.uio.no
Sami reindeer – social processes	Marius Warg Næss	CICERO, NINA	m.w.nass@cicero.uio.no

Adaptive management of ecosystem services

GOOSEHUNT: Reducing damage to agriculture by migratory geese by means of population control by hunting	Ingunn Tombre	NINA, NIKU	ingunn.tombre@nina.no
MIGRAPOP Adaptive management of migratory populations: North-Norway, Svalbard and the European continent	Ingunn Tombre	NINA, NIKU, Bioforsk	ingunn.tombre@nina.no
TundrES – local users' preferences	Vera Hausner	UiT, NINA, NIKU	vera.hausner@uit.no

Observation systems for climate effects

COAT: Climate-ecological-Observatory-for- Arctic-Tundra	Rolf Ims	UiT, NINA, NPI, UNIS, Met.no	rolf.ims@uit.no
Remote water quality – observation systems in northern limnic ecosystems	Karl Øystein Gjelland	NINA, UiT, Bioforsk, ApN	karl.gjelland@nina.no

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

The effects of contaminants and climate change on human health, indigenous peoples and arctic communities

RESEARCH AREAS/PROJECT TITLES	PROJECT LEADER	PARTICIPATING INSTITUTIONS	E-MAIL PROJECT LEADER
Mixtures and metabolic syndrome	Torkjel Sandanger	UiT, NILU	Torkjel.Sandanger@nilu.no
Development of HPC methodology	Nicholas Warner	NILU, UiT	Nicholas.Warner@nilu.no
ARCRISK – Time trends and modeling	Torkjel Sandanger	NILU, UiT	Torkjel.Sandanger@nilu.no
Indoor air quality in polar regions. The case of Tromsø	Sandra Huber	NILU, UiT, NRPA, Norut	shu@nilu.no

The impact of climate change on transport and fate of contaminants in the Arctic

Emission, exposure and effects of cyclic siloxanes	Nicholas Warner	NILU, ApN, UiT	Nicholas.Warner@nilu.no
COPOL II – Importance of primary and secondary sources for POP concentrations in Kongsfjorden	Geir W. Gabrielsen	ApN, NPI, NILU	gabrielsen@npolar.no
COPOL – Methylmercury in arctic marine food webs	Anders Ruus	ApN, NIVA, NPI, NILU	anders.ruus@niva.no
Impacts of environmental contaminants and natural stressors on northern raptors	Jan O. Bustnes	NINA, NILU, UiT	Jan.Bustnes@nina.no
Effects of contaminant exposure on energetics	Heli Routti	NPI, NILU, UiT, NVH, SINTEF	heli.routti@npolar.no
Is the arctic charr population in Lake Ellasjøen, Bjørnøya, affected by chronic exposure to contaminants?	Anita Evenset	ApN, NILU, UiT	Anita.Evenset@akvaplan.niva.no
Influence of pollution and climate variation in rivers and coastal waters indicated by freshwater and marine bivalves	Michael Carroll	ApN, Bioforsk, NINA	michael.carroll@akvaplan.niva.no
Reproductive health in a heavily polluted subarctic environment	Oddmund Kleven	NINA, NRPA, UiT, NGU	oddmund.kleven@nina.no
Multi-stress relationships in seabird populations: interactions between natural stressors and environmental contaminants	Jan O. Bustnes	NINA, NPI, NVH, ApN, NILU	Jan.Bustnes@nina.no
Effects of organophosphorous flame retardants in benthic and pelagic arctic fish species	Lisa B. Helgason/ Ingeborg Hallanger	UiT, NILU, NIVA	lisa.b.helgason@uit.no ingeborg.g.hallanger@uit.no
Hydrophilic pollutants and metabolites in arctic biota samples	Dorte Herzke	NILU, NPI, NINA, ApN	dorte.herzke@nilu.no

Pollution from petroleum activities and shipping in the north – Effects on arctic ecosystems and communities

The combined effects of radionuclides, metals and organic contaminants in produced water on early life stages of *Calanus finmarchicus*	Louise K. Jensen	NRPA, UiT, NIVA, SINTEF	louise.kiel.jensen@nrpa.no
Impact of thermal stress and toxicant exposure in polar cod investigated by in vitro techniques and genome-wide transcriptome analyses	Øivind Andersen/ Perrine Geraudie	Nofima, ApN, UiT	oivind.andersen@nofima.no pge@akvaplan.niva.no
"Oil in ice" – Fate, effect, and risk modelling of accidental oil spill in sea ice ecosystem	Lionel Camus	ApN, Norut, NPI, SINTEF UNIS	lionel.camus@akvaplan.niva.no

Risk communication and participatory governance on local, national and international level

Contaminants, food and health security in border regions	Eldbjørg Heimstad	NILU, Norut, UiT, ApN, NRPA	esh@nilu.no

Many of these projects also involve a significant amount of international cooperation

ABBREVIATIONS

ApN: Akvaplan-NIVA Inc.; **AWI:** Alfred Wegener Institute; **Bioforsk:** Norwegian Institute for Agricultural and Environmental Research; **CICERO:** Center for International Climate and Environmental Research – Oslo; **DnV:** Norwegian Veritas; **FNI:** Fridtjof Nansen Institute; **IMR:** Institute of Marine Research; **HiFi:** Finnmark University College; **Kongsberg:** Kongsberg Satellite Services; **Kystverket:** Norwegian Coastal Administration; **MarinTek:** The Norwegian Marine Technology Research Institute; **Met.no:** The Norwegian Meteorological Institute; **MMBI:** Murmansk Marine Biological Institute; **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; **NPI:** 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; **TØI:** The Institute of Transport Economics; **UiB:** University of Bergen; **UiT:** UiT The Arctic University of Norway; **UNIS:** The University Centre in Svalbard; **VI:** Norwegian Veterinary Institute

Recent doctorates

Magnus Andersen

Polar bears (*Ursus maritimus*) in the Barents Sea Area: Population biology and linkages to sea ice change, human disturbance and pollution

The Barents Sea population of polar bears has been protected since 1956 in Russia and since 1973 in Norway. This thesis focuses on key population biology issues, current threats, and the effect of multiple stressors, ending with some thoughts on future research, monitoring and management. The initial threat to polar bears in the region was overharvest. When hunting was banned, the population grew to about 2650 in 2004. Population recovery probably led to a wider distribution of maternity denning in the Svalbard Archipelago. In recent decades, new anthropogenic threats have emerged, including pollutants and increasing human presence and activity. Contaminants are bioaccumulated through the trophic levels in the marine food web. Females with small cubs use land-fast sea ice for hunting, and are vulnerable to human disturbance. Changes in sea ice conditions reduce access to denning areas in eastern Svalbard, and less land-fast ice close to denning areas in spring could reduce the survival of cubs. Information about toxic compounds in High Arctic systems has resulted in better control and some international bans, and contaminant burdens are declining in polar bears. But new harmful substances are reaching the Arctic. Radionuclides stored in Russian Territories are also a potential threat. Protecting important habitats with local restrictions on motorized traffic may reduce the negative impact of human activity. How polar bears will be affected by climate change is uncertain, but negative effects have been documented.

Link to the thesis: http://munin.uit.no/handle/10037/5069

UiT The Arctic University of Norway
Faculty of Biosciences, Fisheries and Economics
Department of Arctic and Marine Biology

16 March 2013

Lasse Asmyhr

Hunters' behavioural responses to changes in bag size and willow grouse density – implications for management and interpretation of harvest data

Providing guidelines and tools for wildlife management is an important aspect of ecological research. Wildlife managers often collect hunters' bag records and use them to assess wildlife population and reproductive success. This thesis studied how reliable willow grouse bag records are as indicators of population size and demographic structure. Bag size appears to depend more on the hunter's effort than grouse population density and breeding. Young birds and male birds are overrepresented in the harvest, and reproductively successful adults were most vulnerable. The hunter's experience strongly influences hunting success, and can be transferred between hunting areas. Less than one third of hunters return to the same area each year, but good hunting success contributes to returns. The thesis concludes that bag size and harvest age ratios are unreliable as indicators of willow grouse abundance and breeding success, and must be used cautiously. Hunters appear to select key demographic components, such as adults with good reproductive success. This suggests that hunter behaviour should be taken into account when willow grouse harvest levels are set, and also implies that regulation of hunter effort could help maintain sustainable harvest.

Link to the thesis: http://munin.uit.no/handle/10037/4663

UiT The Arctic University of Norway
Faculty of Biosciences, Fisheries and Economics
Department of Arctic and Marine Biology

19 December 2013

Nicole Jeanne Baeten

Mass movements on the continental slope offshore Lofoten, Northern Norway

Swath bathymetry, side-scan sonar, sub-bottom profiler and seismic data from the continental slope offshore the Lofoten Islands, northern Norway reveal smaller-scale mass movements in water depths between 1100 and 2500 m. These mass movements have volumes of 0.061 to 8.7 km^3 and are interpreted as translational slides involving spreading and multi-phase retrogression. The spatial variation in failure style is inferred to have been caused by the activation of different glideplanes (12.5-130 mbsf) within the thicker and more mounded contouritic deposits in the north-east of the study area. Data from a sediment core show that the shallowest style of mass movement (12.5 mbsf), was initiated within contouritic sediments characterized by high sensitivities and water contents. This unit overlies a plumite interval characterized by dilative behavior with pore pressure decrease with increasing shear strain and high undrained shear strength. As such, it is the difference in geotechnical properties which indicates that the interface between these units acts as the basal glide plane, with deformation in the weaker overlying unit. The mass movements in the study area are inferred to have been triggered by undercutting and removal of support at the foot of the slope due to large-scale mass movements that have occurred immediately south of the study area, such as the Trænadjupet or Nyk slides. Furthermore, a network of 2D seismic data reveals the presence of several paleo-canyons. The data illustrate that canyon formation is more extensive than previously thought. These paleo-canyons are buried by an extensive contourite drift interpreted to be a continuation of the Lofoten Drift. The distribution of the drift indicates changes in the depth and strength of paleo-currents. Mass movements only occur in the upper part of the sequence, most likely after the onset of the Pleistocene.

Link to the thesis: http://munin.uit.no/handle/10037/5506

UiT The Arctic University of Norway
Faculty of Natural Science and Technology
Department of Geology

20 September 2013

Stine Barlindhaug

Cultural sites, traditional knowledge and participatory mapping: Long-term land use in a Sámi community in coastal Norway

Knowledge held by people who have been involved in intimate and direct engagement with their land is often valuable for our understanding of past land use. This study used an interdisciplinary approach to explore the possible benefits of emphasizing local knowledge, local participation and new possibilities in digital media, in archaeological work. Two areas in Finnmark, North Norway were studied, and compared with one in British Colombia, Canada. Norway's "nation building" and focus on a single Norwegian heritage meant that the Sami past was of little interest to archaeology until around 1980. At the same time, several legal changes increased the demand for knowledge of Sami land use and cultural history. Despite this shift, additional basic data are needed to meet Norway's obligations and aims. This thesis made use of participatory geographic information systems (GIS) for archaeological research and explored ways to combine archaeology, participatory work and the flexibility in GIS to increase and share spatial knowledge, to the benefit of cultural heritage management, researchers and local communities. It shows how an interdisciplinary approach can lead to more effective archaeological surveying and consequently more sustainable cultural heritage management. The approach has potential to facilitate inter-thematic needs through the software's flexibility. It can help transfer knowledge between a mature population with intimate land use knowledge and younger generations. If one combines documented visible features and transcribed georeferenced traditional knowledge into a GIS, the extent and intensity of land use emerges as more complete and comprehensible. The project shows the value of involving local knowledge, and how oral traditions and traditional knowledge can help archaeologists contextualize and comprehend their findings in a given landscape.

Link to the thesis: http://munin.uit.no/bitstream/handle/10037/5405/thesis.pdf?sequence=2

UiT The Arctic University of Norway
Faculty of Humanities, Social Sciences and Education
Department of Archaeology and Social Anthropology

18 September 2013

Ingrid Agathe Bay-Larsen

Bureaucrats and boundaries. The changing intersection between experts, local communities and environmental administration in nature protection

Loss of biodiversity and fragmentation of habitats are two persistent environmental problems. One challenge to solving them is that the local level bears the cost of restrictions and regulations, whereas benefits are realized at national and global levels. Another challenge is the divide between scientific expertise and the concepts and capacities of stakeholders. Environmental problems are thus resolved in the intersection between multiple scales, actors, agencies and competencies. An ongoing shift from environmental governing to governance places more emphasis on sectors, stakeholders and knowledge across multiple scales; it relies less on legal instruments, formal rules and trust in other institutions' expert knowledge. This has implications for how the environmental administration maintains legitimacy for its decisions. This thesis shows that: 1) regional and national administrative levels respond differently to challenges of accountability and competence; 2) environmental administration struggles to address the inherent limitations in expert knowledge, particularly the complexity of environmental problems and scientific uncertainties; and 3) those who contest environmental protection apply various power resources to challenge the comprehension of environmental problems upon which environmental policy rests. The ideals of deliberative environmental governance quickly face political, juridical and scientific complexities in the administrative reality. Diverging strategies at administrative levels, and lack of strategies to cope with the limitations of science, may further marginalize environmental protection. Administrative strategies must be amended to solve environmental problems, and to ensure that the limitations of scientific expertise are not used strategically to contest environmental programs.

Link to the thesis: http://munin.uit.no/bitstream/handle/10037/5071/thesis.pdf?sequence=2

UiT The Arctic University of Norway
Faculty of Biosciences, Fisheries and Economics
Norwegian College of Fishery Science

8 March 2013

Pernilla Carlsson

Selective processes for bioaccumulative up-take of persistent organic pollutants (POPs) in Arctic food webs

Some pollutants are buried deep into the soil, snow and ice, but are transported into the sea with meltwater. How much of these contaminants end up in the ocean and how does this influence uptake of pollutants in the Arctic marine food web? The overall aim of this thesis was to elucidate selective environmental uptake processes in Arctic food webs that lead to the bioaccumulation of persistent organic pollutants (POP) in food items by Arctic indigenous people. Another aim was to understand the principles behind climate change-related influences on contaminant transport. Svalbard and Nuuk, Greenland were chosen as study areas since they represent Arctic conditions, e.g. glaciers, different marine water masses, long-range transport of POPs and few local sources of POPs. In addition, Greenland has a large population of indigenous people who consume traditional food on a daily basis. Legacy pesticides were analysed in water samples from a Greenlandic fjord. The pesticide distribution indicated that glaciers and snow caps around the fjord are secondary sources of contaminants for the coastal marine environment. Chlordanes were identified as potential indicator compounds for meltwater runoff.

Link to the thesis: http://munin.uit.no/bitstream/handle/10037/5651/thesis.pdf?sequence=12

UiT The Arctic University of Norway
Faculty of Health Sciences
Department of Pharmacy

Joint supervision with the Department of Arctic Technology, University Centre in Svalbard, NILU – Norwegian Institute of Air Research, and the Norwegian University of Life Sciences

21 November 2013

Louis Delmas

Spontaneous avalanche release in Svalbard: Influence of climate parameters on snow mechanical properties

This thesis studied the influence of climate parameters on snow in order to better predict spontaneous snow avalanche releases in the Longyearbyen area. With the development of the city of Longyearbyen in Svalbard, people and infrastructures have become increasingly exposed to snow avalanches. Svalbard's cold, dry and windy climate produces a dense snowpack with frequent avalanches. Current consensus in the scientific community is that climate change, with predicted higher temperatures and more precipitation, will probably affect the size and number of avalanches released in the Arctic. The intricate relationship between snowpack temperatures, layering, and the mechanical properties of snow needs to be investigated to improve understanding of the release mechanisms of spontaneous avalanches. Temperature influences both the weak layer development and slab mechanical properties, and therefore plays a key role in the formation of unstable snow profiles. Snow temperature profiles have been monitored to investigate the global role of temperature on the snowpack development and its stability. Three avalanches occurred close to the instrumented site. This led to the development of avalanche release scenarios in light of the temperature field evolution.

Norwegian University of Science and Technology
Faculty of Engineering Science and Technology
Department of Civil and Transport Engineering

Joint supervision with the Department of Arctic Technology, University Centre in Svalbard

9 October 2013

Markus Eckerstorfer

Snow avalanches in central Svalbard: A field study of meteorological and topographical triggering factors and geomorphological significance

Snow avalanches are common in Svalbard. They influence geomorphology, creating avalanche fans and rock glaciers, and constitute a geohazard, threatening both infrastructure and human lives, particularly around Svalbard's main settlement, Longyearbyen. This thesis is based on field monitoring of avalanches in the Longyearbyen area. The most common type of avalanche in central Svalbard is cornice fall avalanches owing to the plateau mountain topography, lack of vegetation and constant prevailing wind direction. Snow cornices efficiently pluck material from plateau edges and transport it downslope. Two wet avalanche cycles were also observed during the thesis work. They were meteorologically triggered, and extreme in terms of releases, sizes and run-outs. The study concludes that atmospheric low-pressure passage time and intensity determine these events, rather than general climatic warming. Part of the thesis work aimed clarify the snow climate of central Svalbard and to increase understanding of how snowpack characteristics such as depth, layering and temperature influence interactions between snow and permafrost. Such knowledge allows development of observation routines and computer models for warning systems – and may ultimately save lives.

Link to the thesis: https://www.duo.uio.no/handle/10852/34832

University of Oslo
Faculty of Mathematics and Natural Sciences
Department of Geosciences

Joint supervision with the Department of Arctic Geology, University Centre in Svalbard

16 January 2013

Endre Før Gjermundsen

Quaternary glacial history of northern Spitsbergen, Svalbard; cosmogenic nuclide constraints on configuration, chronology and ice dynamics

The ice cover over Svalbard during the last ice age (about 30 000 to 11 700 years ago) has been a focus of discussions about ice thickness, extent and melting rate. This thesis, which builds on newly collected data from previously unexplored high-altitude inland areas of Spitsbergen, shows that the inner parts of the glacial cover started melting several thousand years earlier than previously assumed, about 25 000-20 000 years ago. The melting period was longer and the ice cover did not withdraw from the outermost inland areas until as late as 15 000 years ago. The glacier melting in the northernmost fjords lasted for several millennia between 25 000 and 11 000 years ago. The research also revealed that the alpine peaks in northwestern Spitsbergen are surprisingly old, and have survived the last glacial cycles without much modification. On the contrary: the last glaciation cycles have protected and conserved the high-lying alpine topography. The results also indicate that the mountain peaks in northwestern Spitsbergen have spent more time ice-covered than ice-free during the past one million years. Extended field campaigns in spectacular, but remote and inhospitable areas of Spitsbergen have resulted in a unique collection of data collection. Samples have been collected from large boulders in the lowlands, from high mountain ridges, and from bedrock all over northern Spitsbergen, for exposure dating. Exposure dating measurements tell us when the ice melted away from the rock or mountain, in other words, when that specific area became ice free.

University of Oslo
Faculty of Mathematics and Natural Sciences
Department of Geosciences

Joint supervision with the Department of Arctic Geology, University Centre in Svalbard

8 March 2013

Linda Hanssen

Human biomonitoring of perfluoroalkyl substances and cyclic volatile methyisiloxanes. Concentrations in plasma, serum and whole blood from pregnant, delivering or post-menopausal women, and cord blood

Humans are exposed to many ecotoxins through our food and products intended to simplify our lives. Surveying exposure is a first step toward reducing it. Three populations of child-bearing women in South Africa, Uzbekistan and the Russian Arctic were tested for perfluoroalkyl compounds. Little was known about the toxins in these regions. Blood from the mother and the umbilical cord was tested. The amounts varied, but were highest in the Russian Arctic, followed by South Africa and Uzbekistan. Seen in relation to historic emission data and production bans, the sampling year and region are important factors in exposure. Presence of these compounds showed that the fetus was exposed. Studies based on plasma do not give complete information, as whole blood contains up to six times as much of some perfluoroalkyl compounds. For the first time, cyclic siloxanes were detected in blood of average women (pregnant women in Northern Norway and postmenopausal Norwegian women). Many skin care products contain these, and our research showed that they are present in blood. We saw no correlation between use of the products and siloxane levels in blood, but siloxane-containing products are continual source. Perfluoroalkyl compounds and siloxanes are but a few of over 200 chemicals that can be detected in blood. At present it is unknown what effects long-term exposure to these chemicals might have on the body.

Link to the thesis: http://munin.uit.no/bitstream/handle/10037/5772/thesis.pdf?sequence=2

UiT The Arctic University of Norway
Faculty of Health Sciences
Department of Community Medicine

Joint supervision with NILU – Norwegian Institute of Air Research

25 October 2013

Øistein Breiland Harsem

Oil and gas activity in the high north – Economic opportunities and political dependencies

The aim of this thesis is to analyze what drives Arctic oil and gas activity, and the political effects of the oil and gas industry in the High North. Based on existing political economy theories, four different articles explore these questions by using different methodological approaches. The main findings are that while the potential for a large increase in arctic oil and gas output is significant, only certain arctic provinces may become more attractive. An arctic oil and gas bonanza is unlikely. Further, the arctic energy resources are to a large extent embedded in the Russian–European energy relationship, which is best characterized by interdependence. Natural gas can be used as a political instrument under specific conditions, but future developments may increase diversification of natural gas and decrease the potential of using natural gas for political purposes.

Link to the thesis: http://hdl.handle.net/10037/5161

UiT The Arctic University of Norway
Faculty of Biosciences, Fisheries and Economics
Norwegian College of Fishery Science

Partially funded by the Fram Centre

7 June 2013

Jenny Jensen

The seasonal migratory behaviour of sympatric anadromous arctic charr and brown trout

This thesis used acoustic and archival telemetry to study fish migrations within and between freshwater and marine habitats. The main novel finding is that both arctic charr and brown trout originating from rivers without access to lakes can be found in marine waters also during winter. The physical properties of the freshwater habitat may be the main factor controlling in which habitat fish reside during the winter. The fish that left the river during winter were mainly recorded in the estuary, but also in the sea up to 20 km away from the river outlet. There was large individual variation in migratory behavior, and individual fish were documented to reside in pure marine waters for periods lasting from a few hours to several months. A study of the migratory behaviour of arctic charr and brown trout in summer showed that the species were segregated horizontally, using different areas. Arctic charr preferred colder coastal areas than brown trout. If the migratory behaviour is controlled by temperature, it may be strongly influenced in a potential global climate warming scenario. The thesis also showed that migratory fish may have spread the Atlantic salmon parasite *Gyrodactylus salaris* between watercourses, and that harvesting may remove a much larger proportion of the population of arctic charr than of brown trout.

Link to the thesis: http://munin.uit.no/handle/10037/5427

UiT The Arctic University of Norway
Faculty of Biosciences, Fisheries and Economics
Department of Arctic and Marine Biology

20 September 2013

Ingjerd Sunde Krogseth

From emissions to exposure – environmental behavior of volatile methyl siloxanes and short-chain chlorinated paraffins

There is growing concern the chemicals we emit can be persistent in the environment, be transported to remote areas, and bioaccumulate in animals and humans. While some such chemicals are regulated, many are not. To decide whether regulation is warranted, we need information about these compounds' levels and behavior in the environment. This thesis focused on two classes of substances: short-chain chlorinated paraffins (SCCPs) and volatile methyl siloxanes (VMSs).

Two air sampling methods for VMSs were developed, which both perform well. The active air sampling method was used to study of the occurrence and seasonality of VMSs in arctic air. Decamethylcyclopentasiloxane (D5) and dodecamethylcyclohexasiloxane (D6) were detected, confirming their long-range transport to the Arctic. The active air sampling method was then used to calibrate the passive air sampling method. The calibration study, and passive air samplers in the city of Toronto (Canada), led to the first extensive evaluation of the temporal and spatial variability of atmospheric VMSs levels in an urban area. We now understand how D5 behaves in the atmosphere, also at high latitudes. We used an integrated environmental fate and bioaccumulation multimedia model to study the behavior of SCCPs in the Nordic environment. Model predictions based on the physical-chemical properties and realistic emission scenarios of SCCPs closely matched the environmental levels measured in the Nordic countries, giving us confidence in our mechanistic understanding of SCCPs and in the model. Overall, this thesis has contributed methods and understanding that can be used for decision-making concerning regulation of VMSs and SCCPs as well as similar compounds and compound groups.

Norwegian University of Life Sciences
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Department of Chemistry, Biotechnology and Food Science

Joint supervision with NILU – Norwegian Institute of Air Research, and the University of Oslo

16 December 2013

Rahman Mankettikkara

Hydrophysical characteristics of the northern Norwegian coast and fjords

Northern Norwegian fjords probably play an important role in climate. Nonetheless, thorough physical oceanographical examinations of them are rare. This thesis compiles, organizes and systematizes large data sets, and analyses them for long- and short-term trends. The complete database (1920-2012) is now freely accessible in digital form (http://purl.org/hmd). We found significant hydrophysical differences between fjords, and between inner and outer fjords. Surface temperatures peaked in July-August; temperatures at depth were highest in November-December. Balsfjorden has the widest range of temperature and salinity, followed by Altafjorden. The ranges in Malangen are narrower, and Porsangerfjord is considerably colder and has the narrowest salinity range. Water exchange is lowest in Altafjorden, followed by Malangen and Balsfjorden. Porsangerfjorden receives the most heat and water through advection. Outer and coastal stations are affected by Atlantic Water, whereas inner stations are not. No significant heating or cooling trends were seen between 1920 and 2012. Main warm periods in winter were 1929-1930, 1990-1992 and 2000 at all stations. Outer Malangen and Inner Balsfjorden were also warm in 1938. These fjords had another warm period in 2005 followed by a constant cooling trend until 2012. Altafjorden and Porsangerfjorden had a warm period in 2007, then started cooling. We discovered the correlation between interannual variability of temperature in Inner Balsfjorden and North Atlantic Ocean index. Changes in North Atlantic Ocean index cause a temperature shift in the fjord, sometimes after a long delay.

Link to the thesis: http://munin.uit.no/handle/10037/5426

UiT The Arctic University of Norway
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12 September 2013

Nina Mikkelsen

Predation on the demersal fish eggs of capelin *Mallotus villosus* and lumpsucker *Cyclopterus lumpus* in relation to recruitment

This project investigated the mortality of demersal (bottom-dwelling) fish eggs caused by predation. The prey species studied were Barents Sea capelin and lumpsucker; the predators were capelin, which sometimes cannibalise their own eggs, and the invasive red king crab. Both capelin and lumpsucker are commercially important in Norwegian fisheries, but capelin is also an important forage fish for other species. Male lumpsuckers guard their eggs, but could not protect them from red king crabs, which feed on these eggs. Red king crab stomachs were analysed, and about 8% contained lumpsucker eggs. Capelin eggs were found in 10 and 23%, and capelin in 82 and 22% of the red king crab stomachs in different years. Post-spawn capelin were found more often in crab stomachs than capelin eggs, so hatchlings might have served as an alternative. Lumpsucker eggs stayed longer in the red king crab's stomach than capelin eggs. Red king crabs consumed 0.04% and 2.23% of the capelin eggs available in the two years studied, and mortality due to egg cannibalism by capelin was estimated at over 1-2% of the total egg production in 2003. This study showed that mortality of capelin eggs owing to cannibalism and predation by red king crabs may influence total egg mortality, but probably does not hamper capelin recruitment. Lumpsucker recruitment, on the other hand, may be hampered by red king crabs, which chase away the egg-guarding males and damage and feed on the eggs.

Link to the thesis: http://hdl.handle.net/10037/5428

UiT The Arctic University of Norway
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9 October 2013

Lise Helen Ofstad

Anglerfish *Lophius piscatorius* L. in Faroese waters. Life history, ecological importance and stock status

Anglerfish is now one of the most economically important demersal fish in the Faroese fishery. This study aimed to increase knowledge of anglerfish biology, evaluate the sustainability of anglerfish fishery and investigate trophic interactions between anglerfish and other commercially important fish. Anglerfish grow very quickly in their first year of life. Males mature when smaller and younger than females. The spawning season is long and peaks from February to April, and there are at least two local spawning areas. Large anglerfish showed a seasonal offshore-onshore migration. They migrated to shallow depths in summer to feed and to deeper waters in winter, presumably to spawn. Anglerfish move vertically in water column, and were most active during winter and at night; light intensity seemed to trigger the migrations. The fish generally preferred temperatures between 6.5 and 11°C. Anglerfish in Faroese waters preyed on a variety of food items: Norway pout, blue whiting, cod and haddock. Annual consumption of cod, haddock and saithe corresponded to 33, 19 and 2% of the landings and to 75, 20 and 2% of biomass losses due to natural mortality, respectively. Loss of anglerfish due to cannibalism was estimated to nearly 15% of the annual natural mortality. Anglerfish in Faroese waters may be regarded as a separate stock. The stock biomass ranged between 9000 and 19000 t with a peak in 2004–2005. The stock was slightly growth overfished, but little or no evidence of recruitment overfishing was found. Stock assessments should be performed annually.

Link to the thesis: http://munin.uit.no/handle/10037/5070

UiT The Arctic University of Norway
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16 April 2013

Anupama Rajan

Geophysical characterizations of fluid flow and gas-hydrate systems of the NW-Svalbard and SW-Barents Sea margins

The objectives of this thesis were: (1) to establish a potential link between serpentinization beneath a young sedimented ocean ridge and carbon release and gas hydrate formation directly above it, (2) to understand the coexistence of free gas and gas-hydrate and to image the geophysical evidence for a geologically controlled gas hydrate, fluid migration pathway and seabed expulsion system, (3) to image the active fluid flow migration path-networks from deep hydrocarbon sources and to assess the distribution of shallow gas accumulation, and (4) to determine in detail the seismic velocity structure of the regions close to the landward limit of hydrate stability zone. Methods used included integrating 3D seismic imaging, 1D velocity modeling to 2D seismic imaging and bathymetric and oceanographic data mapping. The work focused on fluid flow and gas-hydrate systems of the NW-Svalbard and SW-Barents Sea margins. The most important results are: (1) new evidence for carbon release from the deep-seated source rock through the sediments above diapirism and methane capture in the inferred areas of serpentinization at the Knipovich Ridge, (2) new geophysical evidence for gas migration and geologically controlled gas hydrate system offshore NW-Svalbard, where there are several glacigenic debris flow units, which are spatially confined and influence gas migration pathways, thus showing the location of gas leakage zones at the seafloor and (3) first findings of the formation of "tilted" bottom-simulating reflectors in the SW-Barents Sea. They have formed due to variations in fluid flux along regions of deep-seated fault complexes causing a change in heat flow. The data also provides new evidence for the connection of deep hydrocarbon and shallow gas hydrate, where existing fault complexes apparently act as pathways for the upward migration of fluids.

Link to the thesis: http://munin.uit.no/bitstream/handle/10037/5149/thesis.pdf?sequence=2

UiT The Arctic University of Norway
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Department of Geology

6 February 2013

Silje Ramsvatn

Investigating coastal ecosystem structure and dynamics using Ecopath mass-balance modelling and stable isotope data

This thesis used the Ecopath mass balance model to study a costal marine ecosystem. One aim was to determine if data on stable isotopes in organisms correctly depicts their diet and can be used as input in the model. The study was done in a northern fjord ecosystem at 70°N. Ullsfjord is larger, more open towards the western Barents Sea and highly influenced by Atlantic water. Sørfjord is smaller, shallower, colder in winter and has fewer different species of birds, fish and semi-pelagic crustaceans. We did extensive fieldwork, collecting data on species' biomass and diet. We show that stable isotopes can be used to detect niche shifts. For example, in Ullsfjord the feeding habits of young haddock differed from those of larger haddock and cod. Several common fish species in Ullsfjord had overlapping carbon isotope signature at sizes between 25 and 45 cm, indicating they may be feeding on similar prey. We investigated ecosystem structure and flow in these two fjords using data from 1993-96 and Ecopath models. Sørfjord was dominated by cod as a top predator and keystone species; Ullsfjord, with greater species diversity, had a more web-like structure, with several lower trophic level groups as keystone species. Lastly, we used a MixSIR mixing model to estimate possible prey contributions from the stable isotope signatures and used these results and gut content analysis results in the Ecopath model. We conclude that use of stable isotopes and mixing models shows promise as a way of getting information on species' diet – especially on lower trophic levels – and as an addition to gut content analysis on higher trophic levels.

Link to the thesis: http://munin.uit.no/handle/10037/5424

UiT The Arctic University of Norway
Faculty of Biosciences, Fisheries and Economics
Department of Arctic and Marine Biology

13 June 2013

Tone Kristin Reiertsen

Seabirds, climate and prey. A population study of two seabird species

Many seabird populations have declined dramatically over recent decades, and it is important to understand the underlying causes and mechanisms. This doctoral project examined how climate and prey abundance influenced demography and population dynamics of the black-legged kittiwake and the common guillemot, breeding on Hornøya in NE Norway. First we sought links between environmental conditions in non-breeding areas and survival of adult breeding kittiwakes. The winter stock of *Thecosomata* (also called sea butterflies), in the Grand Banks/Labrador Sea and that of capelin in Barents Sea in the pre-breeding season together explained up to 52% of the yearly variation in adult survival. For guillemots in the Barents Sea, availability of 0-group cod was more important previously believed. Next we probed which demographic trait drives population dynamics of kittiwakes, and found that both variability in breeding success and adult survival rate contributed to the steep population decline. Reduced breeding success (and hence declining recruitment) had highest impact. Finally we studied micro-evolutionary processes and found that adult survival of the bridled and non-bridled morphs of the common guillemot responded differently to yearly variability in sea surface temperatures. Colour dimorphism might serve as a genetic marker in guillemots, and visualize the direction of selection and micro-evolutionary processes driven by climate. These studies contribute to the understanding of the population dynamics of two seabird species on the Norwegian Red List, and points to future studies and conservation targets of both species.

Link to the thesis: http://munin.uit.no/handle/10037/5158

UiT The Arctic University of Norway
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Department of Arctic and Marine Biology

30 May 2013

Polina Safronova

Distribution, depositional environment and post-depositional deformation of Cenozoic gravity-induced deposits along the western Barents Sea continental margin

The Arctic is one of the areas in the world where little geological work has been done. The Norwegian continental margin in the Barents Sea is now being explored – and is of both scientific and economic interest. The purpose of this thesis work was to get a better understanding of internal and external characteristics, distribution in time and space, sedimentation conditions and deformation of the Cenozoic sandy layers at depth, and underwater landslides along the western continental margin of the Barents Sea. To this end, seismic data and information from sediment cores were used. Understanding sedimentary processes in the deep ocean is important for the oil and gas industry, for the safety of off-shore infrastructure (cables, pipelines and rigs), and to assess natural geohazards that may threaten people in coastal areas. The results show that huge slides can occur along the northwestern continental margin of the Barents Sea. As an example, one of these slides set in motion more sediment than the Storegga slide in the Norwegian Sea, which is known as the world's largest recent underwater slide.

Link to the thesis: http://munin.uit.no/handle/10037/5486

UiT The Arctic University of Norway
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Department of Geology

1 October 2013

Tino Schott

Determinants and effects of moth population dynamics in altitudinal gradients in northern Fennoscandia

This project studied Geometer moths in coastal birch forests in northern Norway, with special focus on the role of moth larvae in the food chain. Lethal parasites (parasitoids) and invertebrate predators had previously been suggested to keep the moth population down. The study showed that parasites did not curtail large-scale outbreaks of moths, but could have impact locally. Analysis of the parasitoid population and its distribution revealed no clear correlation with that of moth larvae. Moth outbreaks often occur near the tree line, so the researchers tested whether invertebrate predators became less common with increasing altitude, such that more larvae survive above the tree line. However, no such correlation was found. They also examined whether two birds that prey on moth larvae – great tit and pied flycatcher – choose their breeding sites based on availability of larvae or on other factors. Timing was found to be the main determinant: the birds nest wherever spring comes first. Great tits laid eggs two weeks earlier than pied flycatchers, and were more likely to lose their clutch. Overall, the thesis shows that Geometer moth larvae are an important resource for many species in northern Norway, but that climatic factors, rather than other species, regulate the moth population.

Link to the thesis: http://munin.uit.no/handle/10037/5159

UiT The Arctic University of Norway
Faculty of Biosciences, Fisheries and Economics
Department of Arctic and Marine Biology

Joint supervision with the Norwegian Institute for Nature Research

21 May 2013

Philipp Semenchuk

The influence of snow cover and cold-season temperatures on growing-season processes – Ecosystem respiration, nutrients, plant growth and phenology in the High Arctic

This thesis examines the increasing snow cover thickness during the arctic winter and makes projections for the future. More snow means warmer soil during winter and later melt-out in spring. Both changes are important for arctic terrestrial ecosystems, since warmer soils will emit more CO_2 and also increase the availability of nutrients for plant growth. With later melt-out, plants have less time to grow and take up carbon, which might make the Arctic a net source of CO_2. However, access to more nutrients might counteract that effect. We used snow fences to increase snow depth and test how arctic ecosystems might react. Extra snow led to higher soil temperatures all winter, but also made winter longer by delaying melt-out. Winter emission of CO_2 from soil is a natural process for which microorganisms are mainly responsible (ecosystem respiration). We found that more CO_2 was emitted from areas with deeper snow, because microbial activity is higher at higher temperatures – even in frozen soil. Surprisingly, CO_2 emissions during summer were lower in these areas after a few years of increased snow depth, probably because the microorganisms had used up their substrates or "food" during the warm winters. This high microbial activity during winter simultaneously produced more nutrients for plants. Therefore, some plant species grew larger in areas with deep snow even though they had less time to grow because of delayed melt-out. This extra uptake of carbon could counteract the increased CO_2 emissions during winter.

Link to the thesis: http://munin.uit.no/handle/10037/5498

UiT The Arctic University of Norway
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Department of Arctic and Marine Biology

28 October 2013

Aleksey Shestov

The role of the thermodynamic consolidation of ice ridge keels in the seabed gouging process

Many engineering challenges are currently posed by the Arctic and the sea ice found there. Currents, winds and thermal processes lead to formation of ice ridges. Ice blocks formed when ice breaks are lifted above and pressed below the level ice. The underwater part is called an ice ridge keel. These can potentially damage subsea installations in the Arctic. This thesis investigated the thermodynamic consolidation of ice ridge keels and developed a mathematical model for ice ridge dynamics. It is known that gouges can be formed in the seabed in winter, possibly by movement of ice ridge keels. Pipelines, power and communication cables are clearly at risk. These structures are usually buried in the seabed soil for protection, but the expense is considerable. The issue for industry is to balance between safety and profit. The thesis focused on physical and mechanical properties of ridge keels and the processes that make them strong enough to pose a threat. Keel consolidation differs depending on season and water salinity, but one important finding is that a keel can become considerably stronger when winter cold consolidates a layer within it. A mathematical model was developed for the ice ridge dynamics associated with seabed gouging and ice–seabed interactions. The model was used to create a geographic information systems module to predict the trajectories and gouge depths in Baydaratskaya Bay. In addition, a physical mechanism was developed for the thermodynamic consolidation of the ice ridge keels below the consolidated layer formed by atmospheric cooling; this mechanism was studied by laboratory experiments, analytically, and numerically.

Norwegian University of Science and Technology
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Department of Civil and Transport Engineering

Joint supervision with the Department of Arctic Technology, University Centre in Svalbard

3 October 2013

Ole Nicolai Staurland Aarbakke

Pseudocalanus (Copepoda: Calanoida) of the North Atlantic Ocean: Species composition, environmental preferences and phylogeography

The seven species of the genus *Pseudocalanus* (Copepoda: Calanoida) are difficult to identify because of very small interspecific, and comparatively large intraspecific, divergence of morphologic and morphometric traits. Thus, despite the fact that *Pseudocalanus* spp. are among the most abundant metazoans in the world, our knowledge of them at the species level is limited. The main objective of this thesis was to lay the groundwork for future studies of *Pseudocalanus* spp. in the Northeast Atlantic Ocean and Euro-Arctic by determining which species are present. Through a combined DNA barcoding and traditional identification approach, this work reveals the presence of at least four species of *Pseudocalanus*, one of which was previously not believed to occur in the East Atlantic Ocean. Furthermore, the thesis reveals differences in environmental preferences and distributions of *Pseudocalanus elongatus*, *P. minutus*, *P. moultoni* and *P. acuspes* in the Northeast Atlantic Ocean and Euro-Arctic, and discusses implications of these differences in relation to rising sea temperatures. Finally, this work examines the phylogeography and demographic history of *Pseudocalanus minutus*, *P. moultoni*, *P. elongatus*, *P. acuspes* and *P. newmani* in the North Atlantic Ocean and based on these results suggests an evolutionary hypothesis for the divergence of *Pseudocalanus* spp. into one oceanic and one coastal clade. Hopefully, this thesis has achieved its main goal of providing a basis from which the biology and ecology of these fascinating copepod species can be further explored.

Link to the thesis: http://munin.uit.no/handle/10037/5424

UiT The Arctic University of Norway
Faculty of Biosciences, Fisheries and Economics
Department of Arctic and Marine Biology

25 June 2013

Ivar Stokkeland // Chief Librarian, Norwegian Polar Institute

New books published in 2013

Seven 2013 tidbits from the library

Russian Climate Politics: When Science Meets Policy
Elana Wilson Rowe. Palgrave. viii, 120 pp.
ISBN 9781137310514
Interplay between climate research and politics is an exciting field. Here's an opportunity to learn how climate policy has developed in Vladimir Putin's Russia. The author, fluent in English, Norwegian and Russian, has in part based her book on anonymised interviews with Russian scientists and experts. She analyses Russian participation in the processes surrounding ACIA and IPCC.

Shipwreck at Cape Flora: The Expeditions of Benjamin Leigh Smith, England's Forgotten Arctic Explorer
P.J. Capelotti. University of Calgary Press. xxix, 269 pp. (Northern Lights series: 16). ISBN 978 1 55238 705 4
High time to turn the spotlight on Benjamin Leigh Smith, who led five expeditions to Svalbard, Jan Mayen and Franz Josef Land between 1871 and 1882. Arctic historian and anthropologist P.J. Capelotti does a thorough job of describing Leigh Smith's life, expeditions and the time he lived in. Leigh Smith never wrote a book about his experiences. He was recognised as a good leader, but disliked being in the limelight.

Carbon capture and storage in Europe
Halle. v, 86 pp. (EASAC Policy Report; 20)
ISBN 978 3 8047 3180 6
There has been a great deal of talk about carbon capture and storage. Here, at last, is an independent, international report that analyses the field. What challenges remain before the carbon capture dream can be realised? How expensive will it be? Or is it unrealistic to think that carbon capture and storage can help reduce climate change?

Antarctica: Global Science from a Frozen Continent
edited by David W.H. Walton. Cambridge University Press. xiii, 342 pp. ISBN 978 1 107 00392 7
Here is an excellent update on the status of international research in the Antarctic, viewed in the continent's exceptional historical and political context. Richly illustrated and thoroughly international, the anthology is a good introduction for researchers and "amateurs" alike.

Science, Geopolitics and Culture in the Polar Region: Norden Beyond Borders
edited by Sverker Sörlin. Farnham: Ashgate. xiv, 443 pp. (The Nordic experience: 2) ISBN 978 1 4724 0969 0
Compiled by a "dream team" of Arctic historians, this anthology sheds new light on recent history in the region. Stian Bones writes about Norwegian Arctic research cooperation with the Soviet Union. Sörlin writes about the Swedish glaciologist Hans W. Ahlmann, an important figure in Norwegian Arctic history. And there is much, much more – this book is chock-full of treasures.

Ocean acidification and climate change: advances in ecology and evolution
Theme issue compiled and edited by Jasmin A. Godbold and Piero Calosi. (Philosophical Transactions of The Royal Society. B, Biological Sciences; Vol. 368, no. 1627). ISBN 978 1 78252 027 6
The oceans are not only getting warmer, but also more acidic. These ten articles emphasise the need for a shift from the current "single stressor" focus to studies on the combined effects of multiple environmental and anthropogenic drivers to establish their overall impact on organisms and ecosystems.

Svalbard Life
Paul Wassmann & Rudi Caeyers. Trondheim: Akademika. 348 pp. ISBN 978 82 321 0211 2 (NOK 375)
Lastly, we recommend a beautiful (and reasonably priced) coffee-table book. Wassmann's texts cover Svalbard's history, its natural environment and the present day. Caeyers' skill with design and illustrations guarantees the visual quality of the work. A particular gem is the chapter devoted to the artists who have been active in Svalbard. The book explores and presents material that has never previously been gathered in a single volume.

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