

Nature and Cultural Environments in the Arctic

Greenland, Iceland and Svalbard

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Nordic co-operation

Nordic co-operation, one of the oldest and most wide-ranging regional partnerships in the world, involves Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, Greenland and Åland. Co-operation reinforces the sense of Nordic community while respecting national differences and similarities, makes it possible to uphold Nordic interests in the world at large and promotes positive relations between neighbouring peoples.

Co-operation was formalised in 1952 when the Nordic Council was set up as a forum for parliamentarians and governments. The Helsinki Treaty of 1962 has formed the framework for Nordic partnership ever since. The Nordic Council of Ministers was set up in 1971 as the formal forum for co-operation between the governments of the Nordic countries and the political leadership of the autonomous areas, i.e. the Faroe Islands, Greenland and Åland.

Challenges in the Arctic	6
What should be protected in the Arctic?	8
Vulnerable cultural environments need better protection	12
Wear and tear from traffic necessitate monitoring	16
Research that leaves no trace	20
Proposal: An Arctic education for nature interpreters	24
Education improves environmental awareness	28
Local Agenda 21 in the Arctic	32
Pioneering an Arctic seabird colony database	36
Bottom trawling and scallop dredging in the Arctic: Vulnerable habitats need protection	40

Challenges in the Arctic

The Arctic possesses unique environmental values, but the challenges of protecting and preserving these values are daunting and not met yet. The areas of pristine nature in the World is being diminished at a fast pace, and some of the last, huge, and fairly pristine areas are found in the Arctic.

Furthermore, many old cultural heritage sites exist in this magnificent nature telling us a fascinating story on how man has lived in the Arctic throughout the ages by using the natural resources. The natural and cultural environment of the Arctic represents a great value on its own, and it is also very important for the protection of the biological diversity. The Arctic has attracted a lot of attention recently – not only by the increasing number of tourists – but also in the global science community, and as a reference area for environmental monitoring.

One of the biggest and most urgent environmental challenges is to ensure that the local activities such as exploitation of the resources, tourism, and research are conducted within a sustainable framework. The biodiversity must be preserved, and the pristine areas and cultural heritage sites must not be degraded or destroyed. However, there are other threats to the fragile Arctic

environment and the living conditions of the people such as emissions of greenhouse gasses and pollutants, which originate far away from the polar areas but are transported to the Arctic, where they already are affecting the environment.

The Action Plan

The Nordic Action Plan to Protect the Natural and Cultural Heritage of Arctic - Greenland, Iceland and Svalbard (Nord 1999:29) intends to contribute to the realization of the goals in the Nordic Environmental Strategy and the Arctic Programme for Co-operation. The Action Plan was approved by the Nordic environmental ministers in Iceland on August 23rd 1999.

Geographically the Action Plan was limited to cover Greenland, Iceland and Svalbard and the oceans in between. This was due to the explicit wish to promote cooperation among these Nordic islands in the Arctic.

The purpose of the plan is to compare and evaluate the needs of the different regions and to propose prioritized measures within the fields of biodiversity, protection of landscapes and cultural environments, out-door life, and environmental monitoring.

The protection of cultural heritage sites has not previously been taken into account in other multi-lateral environmental programmes in the Arctic. In this context the intention of the Nordic Action Plan to apply a holistic approach to protect natural and cultural environments in an overall effort may be seen as pioneering.

The Action Plan identifies four key areas for future Nordic cooperation on environmental protection in the Arctic:

- 1) The Arctic as a role model for the international effort to promote sustainable development.
- 2) Improvement of the environmental knowledge base and the environmental monitoring in the Arctic.
- 3) Improvement of the Nordic cooperation on environmental legislation and management in the Arctic.
- 4) To work for an improved public ecoconsciousness and for prevention of environmental crimes in the Arctic.

Realizing the plan

The Nordic Council of Ministers appointed an Arctic Steering Group that was given the responsibility for realizing the recommendations of the Action Plan.

The Steering Group has been in close collaboration with the Working Group for Nature, Out-door Life and Cultural Environment as well as The Nordic Environment Monitoring and Data Group. Nine projects covering a broad range of measures to protect and preserve the cultural and natural environments in Greenland, Iceland and Svalbard have been carried through. This booklet describes the substance of the projects and their results.

The Nordic Action Plan for the Arctic did not include climate change or environmental toxins because these challenges were to be dealt with in their own strategy. On March the 16th 2006 the Nordic environmental ministers adopted this Strategy for Climate Change and Pollution in the Arctic Region.

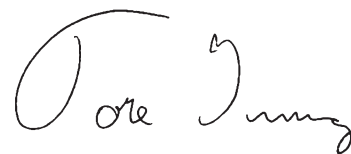
The road to the future

Many challenges for environmental protection in the Arctic can only be met through cooperation between all the Arctic Nations, which have many interests in common concerning future management of the resources and the environment. The projects initiated by the Nordic Council of Ministers - and described in this booklet - are to be seen as a Nordic contribution and supplement to the multilateral collaboration under

the auspices of the Arctic Council and the Barents Co-operation. We do hope that the holistic approach to natural and cultural environments will be adopted and further developed by other international organisations in the Arctic.

The nine projects have strengthened the Nordic cooperation on environmental protection and sustainable use of the natural resources in the Arctic, and they have also improved the general knowledge base. It is the hope of the Nordic Council of Ministers that the networks that have been established between the environmental authorities in Greenland, Iceland and Svalbard will be developed further after the termination of the projects.

The results from the projects includes a number of recommendations for specific initiatives, which will need a follow-up. It would be a success for the Arctic co-operation, if the best proposals for projects and initiatives can be implemented.



Tore Ising
Chairman of The Arctic Steering Group

What should be protected in the Arctic?

Increasing human activity may wear down fragile landscapes and cultural environments in Greenland, Iceland and Svalbard. Therefore we need objective criteria for protection that take into account the interaction between nature, human history and society.

Tourism and outdoor life is expanding in the Arctic and the resulting traffic may damage unique landscapes and cultural environments in Greenland, Ice-

land and Svalbard. The increasing pressure on the vulnerable nature and many cultural heritage sites makes it necessary to develop a set of objective protection criteria for environmental management. These criteria should be based on an overall assessment of the interaction between the landscape, the cultural environments and human activities. A central challenge is to define which values landscapes and cultural environments display, and to determine the importance of different values in order to be able to prioritize.

Geologists use the steep rock walls at Festningsodden, Svalbard, as a geological reference profile and the site is visited frequently by students (photo: Winfried Dallmann).





A tenth of all the icebergs that is calved from the Greenland ice sheet passes through the Ilulissat Icefjord (photo: Jakob Laurrup, GEUS).

The climate, nature, and societies are very different in Greenland, Iceland and Svalbard, and so far this has influenced the environmental priorities of the authorities. In Greenland human life depends on living resources, and environmental protection has focused on wildlife and on conservation of cultural heritage sites. In Iceland people live with frequent volcanic eruptions and earthquakes, and therefore landscapes have always been an important topic. Svalbard has a history as mining colony and hence geological formations have been considered of economical importance, but not worthy of protection in their own right.

A holistic approach

A project group working under the auspices of the Nordic Council of Ministers has developed a set of common protection criteria for landscapes and cultural environments, which can be applied by

the environmental authorities in Greenland, Iceland and Svalbard. These criteria give first priority to landscapes and cultural heritage sites that display a holistic impression of the interplay between nature and history. The chosen sites may either represent something unique or a phenomenon that was typical in the past.

Cultural heritage sites are irreplaceable sources to historical information, and they tell us about of the social, religious and economical life of our ancestors. In a similar way the present landscapes hold clues to the development of planet Earth. Many geological formations in the Arctic yield important information on the geological processes in the past, and studying these natural archives is necessary to be able to predict climate change or natural disasters in the future.

To illuminate management problems related to the protection of landscapes and cultural environments the project group has described a number of locations in Greenland, Iceland and Svalbard.

Life at Ilulissat Icefjord

In 2004 the Ilulissat Icefjord was included in UNESCO's World Heritage List due to its unique nature and extreme beauty. Ilulissat Icefjord is a good example of why the close interplay between nature, the biological resources, and human history necessitate a holistic approach.

In the bottom of the fjord the majestic glacier, Ilulissat Isbræ, calves 35 cubic kilometres of ice each year. The peaks of the gigantic icebergs that drift through the fjord often reach 100 metres above the water surface, and the movements of the large ice masses optimize the conditions for biological production. For mil-

The common criteria for protection

The criteria for protection are based on a holistic approach and they are very similar for landscapes and cultural environments:

Criteria for selection:

- Preservation of the natural heritage with emphasis on geological diversity and a clean environment.
- Cultural heritage sites should be safeguarded with the aim of preserving a representative diversity of historical sites and artefacts on a local, national and international level.
- Basis for knowledge: The importance of landscapes and cultural heritage sites for research, education and communication should be considered.
- Experience and adventure: Aesthetic value, pristine state, rarity, and symbolic value are important assets.

Criteria for priorities:

- Vulnerability: Will a landscape or a cultural heritage site be damaged by disturbances or increased traffic?
- Threats: Is immediate action necessary to protect a site? Or should preventive measures be taken, e.g. if more tourists are expected in the future?
- Accessibility: Improved accessibility may increase the risk of damage, but may also improve the utility value of an area. Therefore the pros and cons must be evaluated carefully.
- Utility value: Some cultural heritage sites are of economical value today; an example is historical buildings. Landscapes may also be important for business, e.g. for the tourist industry. Hence commercial exploitation of cultural heritage sites and landscapes necessitate sustainable management.
- Condition: It must be decided whether a cultural heritage site is in a state that makes it worth preserving.

lennia the ice fjord has provided good hunting areas and fishing grounds for the various human societies. The first people to settle in the area were the Stone Age Eskimos of the Saqqaq culture that came down from the north 4000 years ago.

In recent years the town of Ilulissat has been a centre of tourism in Greenland, and the increasing number of visitors may threaten the vulnerable landscape and the numerous cultural heritage sites. Therefore the environmental authorities and the business community now collaborate to develop action plans in order to ensure sustainable use of the ice fjord area.

The historic parliament site of Iceland

Tingvellir is the most famous cultural heritage site in Iceland and many important historical decisions have been taken at the site, where for centuries the ancient

The remains of a stall at Tingvellir (photo: Kristinn Magnússon).





A magnificent view of the sea, the ice and the land in Greenland (photo: John Frikke).

parliament – Alltinget – was assembled to issue laws and pass sentences. Tingvellir was appointed to national park as early as in 1928, and in 2004 the old parliament site was included on UNESCO's World Heritage List.

There are more than 50 ruins at Tingvellir, which is a great tourist attraction. Up till 1998 numerous paths had been made all over the area, and the paths often went right across less visible ruins. Then a substantial restoration work was started to prevent wear and tear and to avoid further damage. The number of paths has been reduced, and a large wooden platform has been built for tourist groups at Lögberg, where the Allting held its sessions according to historians.

The geological time table of Svalbard

On the southern coast on the largest island in the Svalbard archi-

pelago, Spitzbergen, a unique geological profile, Festningen, is located. The almost vertical rock wall facing the sea contains nearly unbroken layers from the beginning of Perm 290 million years ago to the start of the Cretaceous 65 million years ago. The geological archive at Festningen is an important reference profile for geological research. Footprints of the dinosaur *Iguanodon* that lived in the Cretaceous have been found at the site. Festningen is eroded naturally by waves and sea ice.

It is easy to reach Festningen by boat, and this increases the availability for researchers and students and hence the scientific value, but it also increases risk of damage by wear and tear. The locality is conserved, and traffic and other human activities must be conducted in a way that does not damage the environment. When necessary the authorities

can forbid or regulate admittance to especially vulnerable areas. It is strictly forbidden to remove any fossil traces of dinosaurs.

Report: TemaNord 2005:541
 "Vernekriterier for geologiske elementer og kulturminner i Arktis".
<http://www.norden.org/pub/sk/showpub.asp?pubnr=2005:541>.
 Search for the report/the topic at:
www.norden.org/pub

Vulnerable cultural environments need better protection

Cultural heritage sites in the Arctic tell a fascinating tale of the capability of the people to adapt to the cold climate and survive in tough conditions. The cultural environments of the past are now under threat – in some places due to increased activity, in others because people move away from small settlements.

The Arctic nature is tough on cultural heritage sites that are left unattended as they get damaged from frost and erosion, and the fragile vegetation on or nearby ruins may be destroyed by ani-

mals. Consequently, when people abandon small settlements traces of human history may deteriorate quickly.

In other places the cultural environments of the past are under threat due to increased human activity – building of factories, houses and tourist huts, construction of roads and bridle paths, cultivation of fields, use of modern agricultural machinery, and forest planting. In addition many cultural heritage sites are worn by increasing traffic due to tourism, outdoor life and research.

A paleoeskimoic ruin in North-eastern Greenland (photo: Claus Andreasen).





Today the settlement of Qassiarsuk is located at the same site as the farm of Eric the Red. The ruins of the Norse farm and the church are seen in the middle of the picture (photo: Susan Barr).

In spite of the differences in climate, geography and history the main challenges are the same in Greenland, Iceland and Svalbard. To succeed in preserving a representative part of the cultural heritage new initiatives are necessary on the national, regional and local levels. In this context a Nordic expert group has put forward a number of recommendations, and the group has also pointed out cultural environments in each of the three Arctic regions, which are worthy of preservation.

The starting point for the selection of these cultural heritage sites is the interplay between the natural resources and the human history. Dependency on nature is a basic fact of life in the Arctic, and the interaction between man and the

environment is the context that makes it possible to acknowledge, how humans have lived and survived in the North.

Millennia of history in Greenland

The National Park in North-eastern Greenland is the largest protected area in the world, and it contains an outstanding cultural environment that clarifies the tight connection between nature and culture. From prehistoric times there are remains of the oldest paleoeskimo cultures as well as the ancestors of the present Inuit population, the Thule Eskimos, who emigrated from Canada and settled along the coasts of Greenland almost a thousand years ago. From later periods there are traces of Norwegian and Danish hunters

as well as the American presence during World War II.

Admittance to the National Park is only possible with permission from the Greenland Home Rule, which is typically given to scientific expeditions. However, in the future it is likely that the attractions of the National Park will see increased commercial exploitation.

Another unique cultural heritage site in Greenland is Brattahlid near Narsarsuaq, where the first Norse immigrants settled in 985 under the leadership of Eric the Red, and later set sail for America. Today the historical site is surrounded by the settlement of Qassiarsuk, which in some



Three generations of main buildings at the Keldur farm. To the left the most recent house from 1937, in the middle a house from the 18th century, and to the right the medieval longhouse (photo: Þór Hjaltalín).

respects burdens the ruins. Due to the importance of Brattahlíð in Norse history thousands of tourists arrive each year. In 2000 the Greenland Museum and Archive initiated a project to maintain the ruins and to establish paths through the area. Furthermore, platforms have been constructed to prevent traffic on the ruins.

A medieval farm in Iceland

The Keldur farm in Southern Iceland is a unique cultural environment that consists of more than 30 buildings and ruins that were built between 1000-1200 and 1937. The oldest part of the farm is the floor in the medieval longhouse, and a 25 metre long underground tunnel that served as an escape route. The longhouse burned down around 1400-1500 and was later rebuilt. Keldur is mentioned in several medieval

sources, e.g. in the famous Njáls saga. The National Museum bought the farm in 1947, and it was restored from 1997 to 2000. At the moment Keldur is closed to the public.

The coal mines of Svalbard

Ny-Ålesund in Svalbard used to be a mining community with several coal mines. Mining began in 1916 and ceased in 1962 after a serious accident that killed 21 miners. During the operation of the mines several railways, roads, bridges, wharves and barracks were constructed, but after the closure the area was abandoned, and today it is littered with wrenched metal parts, splintered woodwork and remains of buildings and railway tracks. Since 1999 several bridges have been restored, and dangerous waste has been removed. Today the houses are maintained and several of them serve as re-

search bases. The main challenge is preserve the valuable cultural environment while developing the modern research settlement.

Report: TemaNord 2005:552 "Kulturmiljøer i Arktis - Prinsipper for bærekraftig forvaltning"
www.norden.org/pub/sk/showpub.asp?pubnr=2005:552.
 Search for the report/the topic at:
www.norden.org/pub



Remains from coal mining at Svalbard (photo: Susan Barr).

Recommendations for sustainable management

The national level:

- The authorities should evaluate the need for new legislation on preservation of cultural heritage sites, and the concept of cultural environments should be written into the legislation.
- It should be mandatory to investigate the consequences of projects that affect cultural environments.
- All organized tourism that affects cultural environments of high priority should employ qualified guides.

The regional level:

- Area and management plans should be ahead of development in order to create guidelines for the protection and development of cultural environments with respect to the peculiarity of the each site and the original building practices.
- Guidelines should be developed in order to avoid wear and tear by traffic in locations with many or an increasing number of visitors.

The local level:

- Local authorities should encourage the local inhabitants to participate in the measures to protect cultural environments.
- If necessary traffic should be prohibited at vulnerable sites.
- It should be mandatory that all visits to particularly vulnerable areas must be announced to the authorities. This could give an overview of the number of visitors, and the visitors could be informed on sustainable conduct.

Wear and tear from traffic necessitate monitoring

Many Arctic landscapes and cultural environments that used to be inaccessible are now easily within reach with modern means of transportation. The increasing traffic may wear down vulnerable environments and this necessitates environmental monitoring.

When a great number of people visit the Arctic to enjoy the nature or the cultural heritage sites the resulting traffic may wear down fragile environments. The plant cover is often thin and fragmented, and the plants grow in a thin

layer of humus. Therefore the vegetation is vulnerable to wear and tear, and the cold climate and the short growing season makes it hard for the plants to recover. If a site is worn for longer periods the plant cover may disappear completely. This often creates erosion that may lead to landslides, especially in areas with steep slopes.

The beautiful and pristine Arctic nature attracts a growing number of tourists, and outdoor life is increasingly popular within the local populations. In Iceland many people spend their vacations in the highlands riding or walking, while trips on dog sledges and snow

Footpath at Sermermiut by Ilulissat Icefjord in Greenland (photo: Joel Berglund).





The vegetation at Gravneset in Svalbard has been worn down by tourists (photo: Kirsti Høgvard).

scooters are popular in Greenland. In Svalbard many cruise ships anchor at the coasts, and sometimes up to a thousand people go ashore at the same time, which burden the fragile vegetation.

The booming outdoor activities put many landscapes and cultural environments at greater risk of being worn down, and at cultural heritage sites souvenir hunters also cause problems.

The increasing pressure on nature and the cultural environments necessitate environmental monitoring to make it possible for the authorities to regulate traffic in order to avoid irreversible damage. But how can the environment be

monitored efficiently at a reasonable price?

To answer that question a Nordic expert group has tested a number of methods for environmental monitoring at ten locations in Greenland, Iceland and Svalbard, and they have developed a new observation scheme with descriptive classes of conditions that has proven very useful.

Field tests

One of the cultural environments in Greenland that has been monitored during the project is the ancient settlement of Sermermiut at Ilulissat Icefjord, where more than 20 ruins are located. The oldest ruins are remains of the Stone Age Saqqaq Eskimos that settled

in the area 4000 years ago, while the most recent ruins date from 1850 when the settlement was abandoned. Each year Sermermiut is visited by 10.000 tourists. Many paths have been trodden all across the area, and the vegetation near the most visible ruin is worn down. The Sermermiut area was monitored by sketching and photographing, and the observation scheme was applied to describe the condition of the ruins. At the moment the possibility of monitoring Sermermiut from satellites is being evaluated.

The Skaftafell National Park in Iceland is a unique landscape with several active volcanoes and the largest glacier of the island, Vatnajökull. The area is nominated

for UNESCO's World Heritage List, and if Skaftafell is included more visitors are expected, and this would increase the traffic load on paths and cultural heritage sites in the area. Therefore it is important to initiate environmental monitoring now in order to be able to spot possible changes such as increased erosion. In the Skaftafell National Park the methods applied were airplane photos, observations schemes, and measurements of cultural heritage sites, while photos were taken of localities at high risk.

In Svalbard a famous old burial ground for whalers, Gravneset, has been monitored by photography on location and by airplane photos. Many tourists visit Gravneset and the vegetation has been completely destroyed in large areas.

The expert group recommends that environmental monitoring should be continued in all the ten areas that have been monitored so far.

Overview and details

Experience from the project show that it is appropriate to monitor the environment at both an overall and a detailed level.

Often it is important to monitor the development at a large number of localities in order to spot general trends. In this context photos taken from the air and satellite pictures are excellent, but also expensive methods. In many cases the use of observation schemes is a good alternative at a reasonable price. The method is cheap in particular when the environmental monitoring is carried out along with other supervision tasks.

Detailed monitoring is recommended at smaller locations with a large number of visitors. In this context photography and especially manipulated 3D pictures is an appropriate method.

A satisfactory environmental monitoring of landscapes and cultural environments in Greenland, Iceland and Svalbard demand increased funding. The Nordic expert group recommends that the authorities initiate a long-term monitoring programme, and meanwhile the methods for monitoring should be further developed and improved.

Report: TemaNord 2003:530
"Miljøovervåkning av ferdselsslitasje – Grønland, Island og Svalbard"
<http://www.norden.org/pub/sk/showpub.asp?pubnr=2003:530>.
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At Skaftafell erosion from traffic is minimized by the construction of footpaths (photos: Chas Goemans).

Methods for environmental monitoring

Photos taken on location, airplane photos, and satellite pictures are common methods for monitoring the environment.

When photos of an area are taken with regular intervals the pictures can be compared to spot changes in the environmental condition. Today it is possible to manipulate the photos to create 3D pictures of the locality.

Photos taken from airplanes or helicopters are well suited to monitor larger areas and pictures in the infrared show changes in the vegetation. In recent years it has become possible to employ unmanned micro helicopters that can be equipped with different types of sensors, and this has created a range of new possibilities.

Satellite pictures are excellent for mapping and monitoring of landscapes and vegetation at a very large scale, and new satellites are able to deliver photos with a high resolution down to 5 metres. Such photos can be used to spot e.g. vehicle tracks.

Research that leaves no trace

The Arctic is an extremely important region for research into climate, geology, natural resources, and the environment. Science influences attitudes and it is essential that the field work is carried out in a sustainable manner.

Scientists working in Greenland, Iceland and Svalbard often carry out their field work in remote and pristine areas, which are difficult to reach, possess outstanding natural values, are very vulnerable, and hence are protected by high environmental standards. The large distances, the rough climate, and the absence of roads and other infrastructure necessitate the use of heavy logistics such as helicopters, off-road vehicles and large ships. Such heavy gear burdens the environment more from emissions and wear and tear than lighter logistics that suffice in easier accessible areas.

Research has a profound effect on the attitudes of both students and the general public, and therefore scientists should be very much aware of their environmental responsibilities. It is also important for the validity of the results that the field work does not alter the

environmental state of the areas, where the research is conducted.

A Nordic expert group has now identified a number of challenges that researchers, their institutions, and the environmental authorities must face to ensure that sustainability becomes an integrated part of research in these areas. By taking these challenges seriously it should be possible to reduce the environmental impacts of research and educational activities in the field.

Planning can reduce the impacts

Prior to starting a research project an environmental impact assessment should be carried out as an integrated part of the overall planning. The impacts from heavy logistics can be minimized if different project are coordinated and if data are shared between research groups. In this context project databases should be established for the entire region. The research infrastructure should be concentrated in designated locations in order to minimize the area affected by field work.

Legislation and information

The environmental legislation often contains a complex set of regulations for the areas, where the scientists work. Therefore it



A field camp is placed on stony ground in order to avoid damage on vegetation (photo: John Frikke).

Transport by truck leaves tracks in the landscape. Below the tracks are covered (photos: Snorri Páll Snoraason).



is important that the authorities provide researchers and students with relevant and user-friendly information in order to ensure, that they know the rules. The environmental authorities should also develop better and more rational routines for granting permits for research in pristine areas.

Knowledge of the environment

The demands for conducting field work in a sustainable manner depend on how vulnerable the affected environment is. For many areas this is not known, and if the knowledge exists, researchers may not know where to find it. Therefore it is necessary to establish databases with comprehensive and relevant information on the environmental conditions as well as possible impacts in the areas, where research is carried out.

The field work

During the field work the environmental impacts can be minimized by good practices, and by using the best available technologies it is often possible to reduce the wear and tear from traffic. All transports should pass through the least vulnerable areas and be carried out at times, when the resulting impacts are minimal. When research projects involve the handling of animals it is im-

Arctic research in a global context

The international interest in Arctic research is on the rise, especially in fields such as ecology, climate, geology and environmental research.

The ecosystems in the Arctic are simple and relatively unaffected by human activities and hence very well suited for basic ecological and biological studies. Meanwhile, physical processes such as the exchange of energy between the seas, the ice and the atmosphere are of utmost importance to the global climate. Concerning geosciences the rocks in Svalbard and Greenland represent all the geological periods of Planet Earth, and the geological structures are easy accessible due to the thin soil layers and the thin plant cover. In environmental science the Arctic is important for understanding long distance transport of environmental toxins and pollution.

In Greenland the gigantic, three kilometres thick ice sheet is a unique natural phenomenon in the northern hemisphere. Deep ice cores drilled through the ice sheet has provided us with the most detailed data so far of the Earth's climate and atmospheric chemistry over the last 130.000 years.

Iceland is a young volcanic island of great importance in the study of plate tectonics and volcanism, and the geology provides outstanding opportunities for the development of geothermic energy. Furthermore, the soil erosion is extreme, and the Icelandic research into erosion processes is world class.

From a biological point of view Svalbard is one of the richest land areas in the high Arctic, and the seas surrounding the ice margin are among most productive in the world. Svalbard is one of the best locations to study auroras and also very well suited for receiving data from satellites in polar orbits. The geological formations on Svalbard mirror the geological structures in the surrounding seas, and this is of interest in the context of oil exploration.

portant to investigate, if there are alternative methods or locations, and equally important to consider which season the animals will be least affected. Finally, sustainable handling of waste and efforts to minimize emissions are always important challenges.

Report: TemaNord 2005:547 "Forskning uten spor" <http://www.norden.org/pub/sk/showpub.asp?pubnr=2005:547>. Search for the report/the topic at: www.norden.org/pub



A satellite transmitter is attached to a walrus by hand (photo: Mario Acquarone).

A harpoon tip with a satellite transmitter (photo: Jørgen Sørholm).



Proposal: An Arctic education for nature interpreters

Nature interpreters can do a lot to raise public eco-consciousness and also to minimize the impacts on nature and cultural heritage sites from the growing tourist industry in the Arctic. But their task is demanding, and therefore a new Nordic education for nature interpreters, rangers and guides is proposed.

Nature interpreters act as connectors between the environmental authorities, the local population and the tourists, and they enable people to fully experience nature by communicating knowledge of

natural history, culture, environmental protection and sustainable development. In many places nature interpreters also supervise valuable landscapes and cultural heritage sites and take care of their maintenance.

Iceland has employed rangers for three decades in the national parks and other protected areas where nature interpretation has become one of their main working methods. In recent years a growing number of guides that uses nature interpretation in their work have been employed by the tourists industry as the customers get more and more environmentally conscious. The main tasks of the

Glaciers can be studied close-up from rubber dinghies at Scoresbysund in Greenland (photo: John Frikke).





Nature interpretation at Tingvellir in Iceland (photo: John Frikke).

Icelandic rangers are communication and supervision, but they also help with security matters in case of accidents in the conserved areas. Their education is a 120 hours long course provided by the Nature Conservation Division of the Environment and Food Agency of Iceland.

In Greenland a single ranger has worked for three years in Nuuk, and his main task has been nature interpretation such as educational projects for children and teachers in the primary school. Most of the projects were successful, in particular those where the children were physically active in nature while they learned. Therefore this arrangement now continues on

a permanent basis, and by 2006 seven municipalities in Greenland are expected to employ nature interpreters. The nature interpreter working in Nuuk has completed the Danish education provided by the Forest and Nature Agency. The course takes 504 hours.

Svalbard employs no rangers so far but has good experience with a course for Guides, where sustainable conduct and nature interpretation is an important issue as is security and competence in the field. In 2006 the visiting centre “The gate to Svalbard” opens its doors to the public, and interpretation of nature and cultural heritage sites will be an important topic at the exhibition.

Despite of the differences in Iceland, Greenland and Svalbard there are also similar trends and needs, and recently a Nordic project group has identified three areas where nature interpretation should be further developed in an Arctic context.

High level education

The project group recommends establishing a Nordic education for nature interpreters, guides, rangers and outfitters from Iceland, Greenland and Svalbard as well as the other Arctic parts of the Nordic countries. The new education should complement the national educations and put knowledge of the Arctic nature, environment and history into a global context.

The level must be high, and both researchers and practitioners should be employed as teachers.

Before the end of 2007 a concrete proposal for the content of the education, the structure and the financing should be worked out and put forward to the Nordic Council of Ministers.

Information on the Internet

The group also recommends establishing a web-based information portal for nature interpreters in the Arctic, where the national

A group of tourists are enjoying rugged rock formations in Iceland (photo: Jens Muff Hansen/Naturplan).



A handbook for nature interpreters

What is good nature interpretation in the Arctic? And how do you communicate with the audience in a lively and fascinating way? Now nature interpreters, guides and rangers will be able to find inspiration in a draft for a new handbook "Nature is your job", which can be downloaded from www.norden.org.

An important advice is to connect information on facts to the audience's feelings, sensations and experiences of nature. And there are other useful tips. One is to be so well prepared and know one's area so well that it is easy to be spontaneous. If an eagle suddenly flies across the sky, the moment should be caught and the experience should be used right away, even if the nature interpreter had planned to talk about something else. Another piece of advice is not just to communicate dry facts but to tell stories and initiate discussions. The handbook contains facts, stories and legends that can be applied to enlighten nature interpretation.

experiences with nature interpretation can be registered and communicated. It should also be evaluated if a permanent forum for exchange of Arctic experiences should be established.

An Arctic Nature Day

The last recommendation is the institution of an Arctic Nature Day that should illuminate the ecological interaction between the Arctic and the temperate parts of Scandinavia. This could be communicated through themes such as man and nature, pollution, food chains, climate, water, and geology. An interesting possibility is that school classes in the Nordic countries cooperate on projects that culminate on the Nature Day. The Arctic Nature Day should be

held at the vernal equinox because the Sun and the return of spring are so important for life in the Arctic.

Report: *in press* "Din arbetsplats är naturen. En handbok om naturvägledning för naturvårdare och guider i Arktis." Search for the report/the topic at: www.norden.org/pub



At Phippsøya in Svalbard it is possible to get close to walrus (photo: Marie Lier/Naturplan).

Tourists walking through a valley at Kap Stewart in Greenland (photo: John Frikke).



Education improves environmental awareness

Teaching children about the Arctic environment and the interplay between man and nature is a good investment if the kids grow up to be more ecoconscious than previous generations. Important lessons have been learned from an interregional pilot project.

Three schools in Greenland, two in Iceland and one in Svalbard have participated in a pilot project called “Environmental education in the Arctic”. The objectives were to promote cooperation in the

region and to make children aware of the importance of protecting nature and cultural heritage sites.

The concept “the environment” was defined as “the interaction between man and nature at all times” and the topic “Whales and whaling” was chosen as the starting point for multidisciplinary education involving subjects such as nature, environment, biology, history, social studies, and arts.

11 teachers and 200 pupils participated in the pilot project. Everybody was enthusiastic, and many of the multidisciplinary classes

Children from Kangillinnuit have a taste of seal meat (photo: Isaavaraq Petrussen)





Environmental education in a school class in Iceland (photo: John Frikke).

were successful on the national level. However, the schools were not able to establish the intended interregional communication in order to help the pupils acknowledge the differences and similarities of the whaling history in Greenland, Iceland and Svalbard.

After having evaluated the pilot project the working group has put forward a number of recommendations aiming at improving the interregional collaboration in future educational projects in the Arctic. Before contacting the schools a detailed manual must be written describing the objectives, content, rights, and financial means. To ensure the professionalism and to

reduce the extra work of the teachers a comprehensive educational material should be provided, and money should be available for a start-up seminar, where teachers can meet, make personal contacts, and find partners in the other regions. Money should also be allocated to ensure that the schools are not burdened by extraordinary expenses from participating in Nordic projects, and also to pay the teachers compensation for their additional work.

Future projects should cover two school years, and the first year should be used solely to organise the project and to establish contacts between the teachers.

The projects should include a larger number of schools than the pilot project and high schools as well. Participating schools and classes should work towards a common goal, e.g. an informative home page on the Internet. This will strengthen the interregional collaboration and illuminate the Nordic dimension.

Report: TemaNord 2003:538
 "Miljøundervisning i Arktis"
www.norden.org/pub/sk/showpub.asp?pubnr=2003:538.
 Search for the report/the topic at:
www.norden.org/pub



Remains of a furnace that was used for boiling train oil off whale blubber at Smeerenburg in Svalbard (photo: Marie Lier/Naturplan).

The history of whaling

In the 16th century whalers from Europe and America began whaling around Iceland, Greenland and Svalbard. In the seas surrounding Iceland the populations of first the large baleen whales and later the smaller species were diminished in the following centuries. All commercial whaling was prohibited in 1986.

In Greenland the whaling period culminated in the 16th century, when the large scale European whaling made a stark contrast to the Inuit way of whaling from sea kayaks. Beluga whale and narwhale are still important natural resources in North-western Greenland.

The whaling around Svalbard yielded large catches in the beginning, and in the first period train oil was boiled off from whale blubber on land, and many furnaces and mess tins were left on the shores. Today, these artefacts tell a fascinating tale of the past.



The grave of a whaler in Svalbard (photo: John Frikke).

The experiences of three schools

Ukaliussuaq School, Nuuk, Greenland: A 9th class spent 30 hours on the project that focused on the biology of whales. One result was a poster exhibition at the school. The pupils found information on the Internet and in books, and they paid a visit to the nature interpreter in Nuuk, where they were given up-dated information on whales in Greenland. The class made contact to an Icelandic class and one in Svalbard, but no real collaboration was established. According to the teacher a project like this contributes positively to the children's development, but she also points out, that without access to satisfactory information technology it is difficult to establish relations to pupils in other countries.

Grunnskólinn, Neskaupsstað, Iceland: A 6th and a 7th class spent 30 hours working on the project, which was organised as a theme week, where the ordinary schedule was substituted by multidisciplinary education. The school was visited by an out-side history teacher and mayor with a substantial knowledge on Icelandic whaling throughout history. The classes made an exhibition with sewed whales and fish, posters, and an entire whaling station made from clay. The pupils had contact with another school in Iceland and a school in Svalbard. The teachers were happy about that the topic was chosen before-hand, but they recommend that educational materials should be made for future projects, and they would have appreciated that partnerships with teachers at other schools had been established before the project started.

Longyearbyen school, Svalbard: A 5th, 6th and a 7th class participated in the project. All three classes were visited by the cultural heritage consultant of Svalbard who told them about the whaling period and showed pictures. The pupils also visited a museum, and they were given good advice at the public library. They had access to excellent information technology and found information on the Internet easily. There were sporadic contacts with classes in Iceland and Greenland. One of the teachers voiced the opinion that contact to another class should have been established prior to the project.



Local Agenda 21 in the Arctic

Three municipalities in Iceland, Greenland and Svalbard have worked to realise the Agenda 21 of the UN. The objective is to promote sustainable development in collaboration with the citizens, the business community and the local organisations.

The Agenda 21 is an action programme that was adopted at the UN Conference on Environment and Development held in Rio de Janeiro in 1992, and later strongly reaffirmed at the World Summit on

Sustainable Development held in Johannesburg in 2002. In Rio each and every society in the world was given the task of promoting sustainable development in the 21st century. On the local level the municipalities are responsible, and their action plans should be worked out in collaboration with the citizens, the business community, and the local organisations, because the Agenda 21 emphasise that common citizens do have an important responsibility for sustainable development.

In Sisimiut in Greenland most houses are built on rocks. Therefore it is difficult to bury water pipes and drainpipes (photo: Stefan Gíslason).





Children in a kindergarten in Flateyri in the municipality of Ísafjörður (photo: Rúnar Óli Karlsson).

The Nordic Council of Ministers has allocated 900.000 DKK to support Local Agenda 21 projects in the Arctic and as a result such projects have been initiated in the municipalities Ísafjörður in Iceland, Sisimiut in Greenland, and Longyearbyen in Svalbard.

Ísafjörður and Sisimiut both are traditional fishing villages with 4000-6000 inhabitants, while mining is the main industry in Longyearbyen with 1500-1600 inhabitants. Institutions for higher education are located in all three towns; the Centre for Adult- and Remote Education in Ísafjörður, the Centre for Arctic Technology in Sisimiut, and the University Centre of Svalbard in Longyear-

byen. The municipalities all regard improved possibilities for higher education as a decisive factor to sustain a versatile business community and to prevent people from leaving the towns. Furthermore, they aim at promoting the tourist industry.

Life in all three municipalities is based on exploitation of the natural resources, and in recent years the magnificent nature and the characteristic local culture has attracted a growing number of tourists. Nature and culture represent the strength of the municipalities, but also their weakness. The fish may disappear, the Arctic nature is vulnerable, and if people move away the culture gets lost. This is

the perspective in which the importance of the Local Agenda 21 projects should be considered.

Ísafjörður

The fishing banks at Ísafjörður are rich and fishing and fishery industry are the main occupations in the town and the surrounding settlements. Ísafjörður is also the centre for trade and services in a large area.

Ísafjörður experienced a considerable growth after 1788, when the monopoly of trade was lifted in Iceland, and there are many cultural heritage sites related to fishery such as old sailor's camps and factory ruins. During the Local Agenda 21 work the municipality



Passenger ship off Isaffjordur (photo: Rúnar Óli Karlsson).

drew up a status report stressing the need to catalogue the cultural heritage sites and artefacts. Cultural tourism is on the rise, and the municipality employs a civil servant who works both with tourism and Local Agenda 21 and this ensures proper exchange of information and promotes coordination.

The status report considers the following topics: Consumption and lifestyle, air pollution, noise, nature protection, cultural heritage, bicycle paths and footpaths, the quality of drinking water, exploitation of resources, domestic waste, public purchase, business, energy savings, and environmental education in schools. An action plan with concrete measures and timetables is to be worked out.

The participation of the citizens in the Local Agenda 21 effort has been rather limited, and this may be due to the fact that pollution never has been a big local problem. The municipality tried to raise the public awareness by arranging meetings, but the talks did not attract many citizens. Experience shows that it is better to arrange meetings at local industries, the schools, and local organisations.

Sisimiut

Sisimiut is the most northerly town in Greenland with an ice free harbour during the winter and the most southerly town with dog sledging. The main trades are fishing and fishery industry. Hunting mammals on land and in the sea is another important occupation, and trips on dog sledges are a great tourist attraction.

The Department of Environment and Nature under the Greenland Home Rule assisted the municipality in the Local Agenda 21 work that produced a status report and a pilot project on local management of living resources. Sustainable management of living resources is a cornerstone in the environmental policy of Greenland.

Longyearbyen

Longyearbyen is the main Norwegian town in Svalbard. Traditionally mining has been the main occupation, and today coal is mined south of the town. In later years new jobs have been created in the public sector, research and education, and in the tourist industry.

The local Agenda 21 working group consisted of representatives for the Governor of Svalbard,

the Svalbard Council and Svalbard Samfunnsdrift A/S. The group participated in drafting a local development plan for Longyearbyen and decided that future Local Agenda 21 work is best taken care of within the existing political framework.

Report: ANP 2005:702 "Lokal Agenda 21 i Arktis" www.norden.org/pub/sk/showpub.asp?pubnr=2005:702. Search for the report/the topic at: www.norden.org/pub



Longyearbyen is the Norwegian sea port in Svalbard (photo: John Frikke).



The conserved aerial rope-way in Longyearbyen (photo: John Frikke).

Pioneering an Arctic seabird colony database

Seabird colony databases are a valuable tool for research, management and conservation. A new Nordic database format may pave the way for the first circumpolar database of seabird colonies.

Seabird breeding colonies are important in nature. They contribute to the local biodiversity themselves, but also by attracting predators and scavengers and by creating habitats for other living organisms. They also play a major ecological role in the transport of nutrients and carbon from the sea to terrestrial habitats. In many Arctic regions seabird colonies

contribute to human existence as food resources for local communities and by providing opportunities for recreational activities such as tourism.

However, the large concentrations of breeding seabirds in the Nordic countries – often substantial fractions of the total populations – are vulnerable to human activities such as disturbances, habitat alteration, fisheries, and oil exploitation. Therefore careful management is necessary to protect the colonies.

In this context seabird colony databases are an indispensable tool. The purpose of the databases is to

Numerous Puffins breed at the bird cliffs of the Faeroes (photo: John Frikke).





One of the largest colonies in the world of the Great Skua is located in the southern part of Iceland (photo: John Frikke).

keep organized, updated information on the location, composition, and size of seabird breeding colonies. These data are available for research, management and conservation, and hence the databases are important for the development of sustainable use policies, local planning, environmental impact assessments, and monitoring.

As an example the Greenland seabird colony database has been used for considering conservation interests during the planning of oil exploration along the West Greenland coast. It is well known that seabirds are very sensitive to oil spills, and the database made it possible to localize and designate areas of high conservation

interests in order to minimise and mitigate impacts.

Harmonized seabird colony databases covering the entire Arctic region will be particularly valuable because they enable common analyses over larger areas than any individual country. A project group working under the Nordic Council of Ministers has now established a harmonized database format for seabird colonies in the Faroes, Greenland, Iceland, Jan Mayen, and Svalbard.

Comprehensive information

The new database system provides comprehensive information on the seabird breeding colonies. The parameters used to describe colonies include location, details

of conservation status, ownership, presence of alien predators, historical records, references, and how well the colony lends itself to catching birds for ringing or other research activities. The database also allows for details on individual censuses, such as species, data, observer, bird numbers, and

Great numbers of Brünnich's Guillemots are found in Svalbard (photo: Marie Lier/Naturplan).



census accuracy. Photo documentation can be included.

Goal: A circumpolar standard

The Nordic experts participate in the Circumpolar Seabird Group under the Arctic Council, and they have recently proposed to use their database format as a common standard for a circumpolar seabird colony database including the American, Canadian and Russian parts of the Arctic. The idea has been very well received.

As it was the case for some of the Nordic countries other Arctic nations also have well established seabird colony databases for both scientific and management purposes. During the Nordic database project five of the eight Arctic countries agreed to a standardized format, while the national needs of each country were taken into account. It is likely that the Nordic database format also covers most of the needs of Canada, USA and Russia; although some minor changes and additions may turn out to be necessary. A common set of criteria for describing seabird colonies will be a major step forward in facilitating a circumpolar approach to many scientific, management and conservation issues.

The seabirds of the Arctic

Faroese: Number of breeding species: 20. Number of colonies: 1600. Number of breeding pairs: 1.7 million. Main monitoring programs involve Common Guillemots, Kittiwakes and Gannets.

Greenland: Number of breeding species: 21. Number of colonies: 3700. Number of breeding pairs: 39 million. Monitoring programs have been initiated or proposed for Brünnich's Guillemots, Common Eiders and Arctic Terns.

Iceland: Number of breeding species: 23. Number of colonies: 7000. Number of breeding pairs: perhaps 7.5 million. Two species are monitored nation-wide, Great Cormorant and Gannet, ten species at selected colonies, while no programs exist for eleven species.

Svalbard: Number of breeding species: 18. Number of colonies: 1500. Number of breeding pairs: around 3 million. Seven species are monitored: Northern Fulmar, Common Eider, Glaucous Gull, Black-legged Kittiwake, Common Guillemot, Brünnich's Guillemot, and Little Auk.

Jan Mayen: Number of breeding species: 15. Number of colonies: 92. Number of breeding pairs: 300.000. No monitoring of seabirds is undertaken.

Report: TemaNord 2006:512 "Nordic Seabird Colony Databases".
<http://www.norden.org/pub/sk/showpub.asp?pubnr=2006:512>
Search for the report/the topic at:
www.norden.org/pub



The Northern Fulmar breed in large colonies at Jan Mayen (photo: John Frikke).



The Little Auk is common at many locations in Greenland (photo: John Frikke).

Bottom trawling and scallop dredging in the Arctic: Vulnerable habitats need protection

Bottom trawling and dredging can increase the mortality of a wide range of benthic species and destroy corals, sponges and archaeological remains on the seabed. Vulnerable habitats require urgent protection.

Two common demersal fishing gears in the Arctic are the otter trawl and the scallop dredge. The otter trawl is used to catch fish and shrimp, and during towing the boards and the groundrope are in contact with the seabed. The scallop dredge has a heavy metal frame that scrapes the seabed.

Trawling and dredging have been shown to have a large impact on benthic communities. Most benthic fish and invertebrates live in mixed assemblages of both target and non-target species. However, the trawls and dredges are not very selective since they are designed to sweep and create a disturbance on the seabed that will lead the animals into the net. Consequently, all animals in the path of the gear are at risk of being captured, displaced, killed or seriously injured. Bottom trawling and dredging increase the mortality of both target and non-target species, although the impact of fishing operations is highly vari-

able between taxonomic groups. Species that reach a large size, have a slow growth rate, and mature at a high age are often most vulnerable. Demersal fishing can also result in decrease of diversity, alteration of predator-prey relationships and long-term changes in community structure, including dominance of species that are resilient to fishing.

Long-lasting alterations in benthic communities may take place even with a relatively short history of fishing. In habitats where the majority of animals consist of fragile three-dimensional structures, such as deep-water corals, a significant impact can take place the very first time the area is fished. The surface area swept during a single tow tends to range between one and two square kilometres. In other words, few tows are needed to disturb benthic communities in a relatively large area.

Advances in gear technology and development of larger and better-equipped vessels enable fishing in areas that are often populated by vulnerable organisms and were previously inaccessible, such as steep slopes, deep waters, lava and boulder bottoms, or areas that have recently become ice-free due to climate change.



A shrimp trawl is cleaned on the deck (photo: Morten Rasmussen/Biofoto).

The Nordic Action Plan states the need to investigate the effect of bottom trawling and scallop dredging in the seas between Greenland, Iceland, Svalbard and Jan Mayen. The marine region along the Norwegian coast south to 67°N and the Norwegian territorial waters in the Barents Sea were included because the discovery and recent protection of coral reefs off West Norway can serve as a cornerstone for further initiatives to protect marine habitats, whereas the Barents Sea is an important ecosystem under great pressure from the fishing industry.

The scallop fisheries

The start of the scallop fisheries in Iceland, Greenland and Norway

followed the discovery of virgin scallop beds made up of old and large specimens in high densities, but the fisheries have followed very different trends in each region, with drastic decline in catches in Iceland and Norway.

The Icelandic fishery dates from 1969. Landings in Breiðafjörður in West Iceland, where the largest scallop beds were located, peaked at 12.700 tonnes in 1986, but decreased to 7.500-9.000 tonnes between 1994 and 2000. In addition, several parasites were detected in adult scallops and by 2003 the fishery was closed as a precautionary measure.

Offshore scallop dredging began in Norway at Jan Mayen in 1984

but by 1986 the area had been depleted and the fleet turned to Svalbard. Annual catches peaked at 44.100 tonnes in 1987 and declined afterwards to 3.000-7.000 tonnes until 1995, when the archipelago was closed to dredging. The available data show declining populations more than ten years after dredging ceased but some signs of recovery have been detected lately.

Scallop dredging commenced in West Greenland in 1983. Most catches are from Nuuk, with average annual landings of 580 tonnes for the period 1984-2002. No surveys have been carried out since the late 1980s but there are indications that each scallop bed is extensively dredged before the



A coral reef at Hornafjörddybet off Iceland provides a habitat for many species (photos: S. A. Steingrímsson).

fleet moves on to new areas. The annual total allowable catch is fixed at 2000 tonnes.

The effect of scallop dredging on benthic communities in Breiðafjörður was investigated by analysing existing by-catch data. Emerging epifauna was absent from the benthic megafaunal community in Breiðafjörður that consisted mostly of hard-shelled molluscs, sea cucumbers, crabs and starfish, all of them known to be characteristic taxa of disturbed communities. No clear correlation was found between the intensity of fishing effort and the distribution and abundance of by-catch taxa. However, studies in other countries concluded that the effects of fishing are most severe in the early phase of the fishery. Dredging in Breiðafjörður started in 1970, but by-catch data have been available only since 1993. It is possible that prior to 1993 the scallop dredging had already altered the benthic communities by effectively removing the sensitive species from the scallop grounds in Breiðafjörður.

The shrimp fisheries

The Icelandic offshore shrimp fishery started in 1975, and

by 1995 landings had risen to 66.000 tonnes. Offshore catches have been declining since 1997, and the minimum catch for the period 1998-2003 was 21.500 tonnes in 2000.

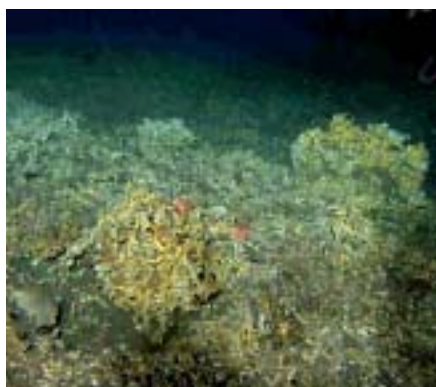
The Greenland offshore shrimp fishery is by far the largest in the Northeast Atlantic, and shrimp has been the main export product of Greenland since the collapse of the cod fishery. The shrimp fishery started in 1970 with landings of 1200 tonnes and reached a maximum of 113.000 tonnes in 2004 and a stock estimation of 300.000 tonnes. The spectacular growth of the offshore fishery has been possible because of technical improvements of the fishing fleet and a spatial expansion from the original fishing grounds in the Disko Island area to the whole West coast south of 75°N.

The main problem with the shrimp fishery in Greenland is the overlapping of fishing grounds with nursery areas of redfish, Greenland halibut, cod and other demersal fish species. This has recently led to the implementation of sorting grids and closure

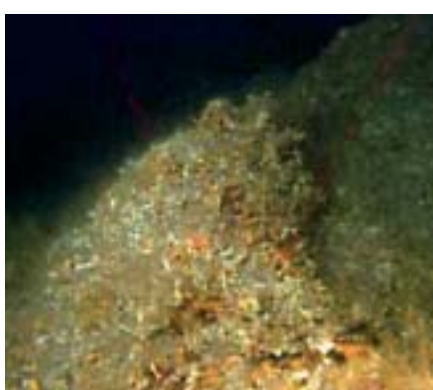
of fishing grounds if by-catch exceeds legal limits.

The offshore Norwegian shrimp fishery started in 1973 and the main fishing grounds are in the Svalbard area and Barents Sea. Catches and stock size have varied greatly over time. Shrimp stock size seems to depend on abundance of predator species, mostly cod, as well as the hydrographic variability in the area, including the location of the Polar front. The fishery is not regulated with a total allowable catch system, but employs licences, minimum size of shrimp and maximum by-catch limits. The implementation of sorting grids in 1991 was not enough to solve the by-catch problem. Since 1993 a bioeconomical model has been applied to estimate the allowable maximum by-catch of commercial species. However, this strategy has not produced the expected results and all commercial fish species in the shrimp grounds are currently below safe biological limits.

The effect of shrimp trawling on the benthic fish assemblage in North Iceland was investigated by analysing by-catch data. During the period 1988-1994, prior to



A damaged coral reef. To the left: Live corals broken off from the reef. In the middle: Grooves on the sea floor. To the right: Lost fishing gear (photos: S. A. Steingrímsson).



Damaged coral reef 250 metres below the sea surface at Öræfagrunn, off Southeast Iceland (photos: S. A. Steingrímsson).

the introduction of sorting grids in 1995, reported by-catch represented between 2.7 and 7.3 per cent of the shrimp catch. Considering the 71 species recorded in shrimp and groundfish surveys, the abundance of demersal fish has decreased since 1997.

Vulnerable habitats

In the Nordic waters habitat forming deep-water corals include both soft and stony corals, like the reef-building coral *Lophelia pertusa*. *Lophelia* reefs are found along the entire Norwegian coast, including large complexes up to 40 kilometres long, and off the South coast of Iceland. There are no records of *Lophelia* reefs from Greenland waters. Off Iceland, soft corals are most abundant on

the Reykjanes Ridge and off South East Iceland. The distribution of soft corals off Norway is not well-known.

Deep-water corals are fragile, slow growing and may live for hundreds of years. Therefore corals are very sensitive to bottom trawling, and the recovery of impacted corals may take centuries. Corals provide a habitat for a large variety of species, both invertebrates and demersal fish. If coral reefs are destroyed the associated species may have difficulties in sustaining their populations.

It is estimated that 30 to 50 per cent of the coral areas off Norway may be damaged or impacted. Information from fishermen

in Iceland suggests that some coral grounds off Iceland were destroyed by bottom trawling during the 1980s and 1990s. Severe damages to coral reefs have been documented off Norway and Iceland using underwater photography.

In 1999 Norway was the first country in Europe to protect cold water corals from bottom-tending fishing gear. So far, five reefs have been protected (total area around 1.900 km²). Five coral areas off Iceland (total area around 80 km²) have been protected since January 1st 2006.

Other vulnerable habitats within Nordic waters are sponge communities, maerl beds of calcified

Archaeological remains in Arctic waters

The environmental conditions in Arctic waters favour the survival of shipwrecks, which have been found with masts, hull and superstructure intact after 150 years on the seabed. A well preserved vessel represents a time capsule, where little is added or destroyed by later actions, as it is often the case with archaeological remains on land.

Trawling and dredging have a great negative impact on wooden wrecks and artefacts as the fishing gear crushes, displaces and depletes the wreck sites on each passage. This study indicates that many potential archaeological sites in the Barents Sea overlap with the most heavily trawled locations.

It is important to enforce the legislation in all Nordic countries stating that it is mandatory to report wrecks. According to the research carried out for this project, fishing fleets and survey vessels have never, or rarely, complied with these regulations.

At the moment only the Environmental Act of Svalbard protects archaeological sites from trawling and dredging in a 100 metre radius from the archaeological finds.

red algae, hydrothermal vents and cold seeps.

Recommendations

The project group outlined ten recommendations grouped in three categories, including the following:

Habitat mapping:

- More resources should be allocated to map areas with undisturbed vulnerable habitats and cultural remains in order to protect them before any damage may be inflicted by fishing gear in the future. Priority could be given

to areas that have become ice-free over the past few years.

- Detailed maps on the occurrence of vulnerable habitats are important for future studies on the ecological function and relevance of these habitats.

Research:

- Promote research on the biology and ecology of deep-water coral reefs and forests, sponge aggregations, maerl beds, hydrothermal vents and cold seeps. All these vulnerable habitats are very important from both a general biodiversity perspective and as fish habitats, but our understand-

ing of these ecosystems is still fragmented and incomplete.

- Increase research on impact of fishing.

Management measures:

- Vulnerable habitats such as coral reefs and sponges should be protected. It is necessary to develop and adopt precautionary regulations to prevent further deliberate or accidental damage by human activities.
- Improve management of scallop stocks, e.g. by improving stock assessment surveys, closing permanently the scallop beds that act as larval sources, increasing landing size, decreasing fishing effort and introducing rotational fishing.
- Environmental impact assessments should be a prerequisite prior to fishing in pristine areas.
- Secure proper implementation of legislation and management at national and international levels to protect cultural heritage on the seabed.

Report: TemaNord 2006:529 "Bottom trawling and scallop dredging in the Arctic – Impacts of fishing on non-target species, vulnerable habitats and cultural heritage".

Search for the report/the topic at: www.norden.org/pub



Deep-water shrimp (photo: Dieter Betz/Scanpix).