The Research Council of Norway

Norwegian polar research

Policy for Norwegian polar research 2010–13

About the Research Council of Norway

The Research Council of Norway is a national strategic and funding agency for research activities. The Council serves as a chief source of advice on and input into research policy for the Norwegian Government, the central government administration and the overall research community. Moreover, the Research Council works together with research institutions as well as the private and public sectors to enhance financial and quality targets in Norwegian research and innovation activities. It is the task of the Research Council to identify Norway's research needs and recommend national priorities. The Council utilises specifically-targeted funding schemes to help translate national research policy goals into action. The Research Council provides a central meeting place for those who fund, carry out and utilise research and works actively to promote the internationalisation of Norwegian research.

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Preface


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The *Policy for Norwegian polar research 2010–13* was prepared by the Norwegian National Committee on Polar Research for the Research Council of Norway. This is the first time the Research Council has drawn up a document that covers research both in the Arctic, including Svalbard, and in the Antarctic. The document has been through a broad-based consultation process involving the research community, directorates and ministries and the Research Council's division research boards.

This policy document has been formulated on the basis of key challenges and opportunities for Norwegian polar research, new trends in the polar regions and Norway's overall interests in this context. Its priorities are in keeping with those set out in the white paper *Climate for Research* (Report No. 30 (2008–09) to the Storting), the most recent white paper on Svalbard (Report No. 22 (2008–09) to the Storting) and *New Building Blocks in the North – the next step in the Government's High North strategy*. The Research Council's polar research policy will serve as a tool for coordinating relevant measures set out in the documents mentioned above.

This policy is intended for a wide range of users of polar research, including the public administration, trade and industry, the research community and the Research Council itself. It identifies key challenges for both basic and applied research. The Research Council will use appropriate funding instruments to implement the policy. Two possible levels of ambition for polar research funding are outlined.

A broad-based consultation process was held on the draft policy in April 2008. This resulted in 45 responses, and a conference was held to discuss the input.

The Executive Board of the Research Council adopted the policy on 24 September 2009. The Board would like to emphasise that this document outlines general policy issues and is to be used as a basis for further work on polar issues in the Research Council, but that proposals for specific measures and separate funding must be evaluated and processed in the ordinary way, during the normal budgetary process.

Oslo, September 2009

Geir Stene-Larsen
Chair

Arvid Hallén
Director General

Summary

The changes currently taking place in the Arctic are on a larger scale than ever previously recorded. Knowledge about climate development, pollution and biodiversity in the region is limited, but the changes are of global importance. There is therefore a pressing need to learn more about these developments. In 2007–08, climate and ice cover in the Arctic changed in ways that could not have been predicted in early 2007, at the beginning of the International Polar Year (IPY 2007–08). Data are inadequate and the climate models are weakest in the Arctic. Shrinking ice cover and thinner ice make it highly probable that there will be growing activity in the fisheries, the oil and gas industry, shipping and tourism in the Arctic. We need to know more about the impacts of such activities, the challenges this will pose for management at national and international level, and what the Arctic states can do to address these challenges. Climate models and our understanding of climate trends must be improved so that it is possible to provide better weather, ice and iceberg forecasts and enhance safety standards and the emergency response; this will also include building up expertise in satellite monitoring. All these considerations mean that polar research has become even more vital than it was only a few years ago.

Moreover, polar research is of crucial importance for innovation and industrial development in the north. To ensure that the resources in the polar regions are used effectively and sustainably, research and development in the fields listed above must be intensified. This applies to the whole range of activities from independent basic research to product development. At the same time, industrial development in the polar areas will generate new opportunities for research and pose new research challenges.

The report *New Building Blocks in the North - the next step in the Government's High North strategy* states that Norway will be at the forefront of international efforts to develop knowledge in and about the High North, including knowledge about climate and the environment. Norway is ranked in fifth place in polar research productivity measured as the number of journal publications in the period 2005–07, after the US, Canada, UK and Germany. For Arctic research, Norway ranks third. To retain this leading role, it is essential to maintain the level of activity in Norwegian polar research. In autumn 2008, Norway gained approval for an Arctic Council project to maximise the legacy of IPY 2007-08. The main elements of the project are concerned with 1) cooperation and exchange of data, 2) access to all parts of the Arctic, 3) recruitment and coordinated international funding and 4) carrying out an assessment of the results of IPY 2007–08.

Polar research must be based on international cooperation if it is to be successful. Norway therefore plays an active part in a range of international organisations. Svalbard is an important base for Arctic research, and Norway has a key role to play as the host nation. Norway's ability to provide an arena for research collaboration and access to the extensive existing infrastructure places it in a unique position to attract high-quality research to Svalbard, and play a central role in implementing the research goals defined by the international cooperation organisations. This helps to strengthen research in Norway in general. The importance of Norwegian polar research lies in the vital input it can provide to efforts to deal with political issues such as environmental protection, climate change, the utilisation of natural resources and the law of the sea.

A key point discussed in this document is the importance of employing an Earth system science approach. There is a need for a targeted polar research initiative that uses an Earth system approach and has the capacity to accommodate broad, integrated projects. Projects of this nature will in addition be very well suited to activities under the Svalbard Integrated Arctic Earth Observing System (SIOS), which also uses the Earth system approach and requires continuity and long time series of measurements. The new initiative must moreover address the challenges society faces in the polar regions as regards management and policy, the cultural heritage and industrial development. Furthermore, there is a pressing need for monitoring and to maintain long time series of climate, environmental and biodiversity observations as a basis for management and research.

Priority should be given to the research areas that are most important for Norway on the basis of the scientific strength and quality of different research groups, the infrastructure available, Norway's natural advantages, and research, environmental, natural resource and industrial policy priorities. This means that Norwegian polar research must include both applied research (including management- and industry-oriented research) related to polar issues and basic research. Research fields where Norway is a leader or needs to obtain more knowledge from the leading international research groups should be given priority. These include topics within the natural sciences (climate, pollutants and biodiversity), economic activity and important topics in social science, law and the humanities. In the more traditional polar research disciplines, key areas are research to increase understanding of processes that control or lead to change in the following:

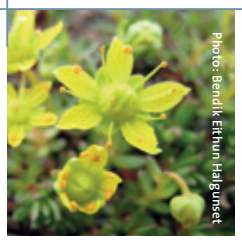
Photo: Bendik Efthun Halgunset


Photo: Linda Bakken


Photo: Harvey Goodwin, Norwegian Polar Institute

>> the climate system in the Arctic region, including improvement of regional and global climate models;
>> sea ice and glaciers;
>> marine ecosystems;
>> CO_2 in the oceans: uptake and ocean acidification;
>> ocean circulation;
>> atmospheric chemistry;
>> the upper polar atmosphere and near space;
>> permafrost;
>> vegetation;
>> pollutants.

To give an indication of the anticipated funding needs, the document outlines projected funding for two different levels of ambition. Funding level 1 is NOK 300 million per year, and includes continuation of a broad range of polar research activities at the 2008 level (including the IPY initiative) after 2010, strengthening research in Svalbard, use of the research infrastructure in the Antarctic (Troll research station) and industry-oriented research related to polar issues. There is also a pressing need for more funding for monitoring and to maintain long time series of climate, environmental and biodiversity observations.

Funding level 2 includes additional funding of NOK 80 million per year for research activities in Svalbard, in the Antarctic (based on Troll), research on the utilisation of marine resources in the Southern Ocean, and increased funding for industry-oriented research, monitoring and maintaining long time series of climate, environmental and biodiversity observations.


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Photo: Jon Aars, Norwegian Polar Institute

Photo: Marine Research Institute

Photo: Jan-Gunnar Winter, Norwegian Polar Institute

1 Introduction

Polar research can provide insight into processes of crucial importance for the Earth's environment and climate. It was a fortunate coincidence that the major research effort during IPY 2007–08 coincided with a period of rapid climate change in the Arctic. It is essential to follow up IPY by continuing data collection, international cooperation, research and monitoring in polar areas.

Why is polar research important?
Research in the polar regions can provide us with an insight into fundamental processes that are of crucial importance for the environment and climate of the Earth as a whole. The polar regions are an integral part of the global system, both as the regions where important processes originate and because they can provide an early warning of change. Norway has a special responsibility for polar research, among other things because our prosperity is linked to economic activity in the polar regions.

Large-scale changes are currently taking place in the Arctic. The minimum extent of the sea ice reached a record low in 2007, and was almost as low in 2008. Moreover, research results show that the Svalbard glaciers are retreating and that the Greenland ice sheet has a negative mass balance of about 150 km^3 per year. When ice on land melts, it raises the sea level. This is another reason why climate change in the Arctic is of global importance. Over the past 10 years, the temperature of the Atlantic water flowing into the Norwegian Sea and Barents Sea has been almost 1°C higher than the long-term mean. These changes are already having a noticeable impact on ecosystems: the distribution ranges of marine species are changing and new species are becoming established.

In autumn 2004, the Arctic Council released the Arctic Climate Impact Assessment (ACIA), a synthesis of current knowledge of the Arctic climate. The report made use of the best available data to describe the present situation, and the best climate models to make projections for the future. It concluded that the Arctic Ocean may be partly ice-free in summer by the middle of this century. This does not correspond well with more recent observations, which show that the process is already well under way. On the other hand, we know that natural fluctuations are also largest in the Arctic. Scientists know too little about various aspects of this complex of issues.

At the other pole, we lack basic information on whether the Antarctic ice sheet is growing or shrinking. We know that large ice shelves on the Antarctic Peninsula have collapsed and disintegrated, calving hundreds of icebergs that gradually melt as they drift northwards. The break-up of ice shelves means that ice masses further inland are no longer held back, and their movement accelerates. Glaciers and ice streams flow more rapidly towards the sea, where they calve to form icebergs. This process causes sea level to rise.

We know that ice has been accumulating in other parts of Antarctica, thus tending to lower sea level. However, we have no data on the net effect of these opposing processes. Since the Antarctic ice sheet is more than 10 times the size of the Greenland ice sheet, even modest changes in its volume will have a marked impact on global sea level. A one per cent reduction in volume would raise global sea level by 65 cm. This would force tens of millions of people to move. In other words, the level of uncertainty is very high and there is cause for great concern about the possible impacts.

It was a fortunate coincidence that the major research effort during the International Polar Year (IPY) 2007–08 coincided with a period of rapid climate change in the Arctic. International research cooperation has made it possible to collect a huge volume of new data and develop new knowledge of the climate in the polar regions. This will be of crucial importance in enabling researchers to provide more reliable advice on the climate change that we will have to take into consideration in future. It is essential to make use of this knowledge – to secure the IPY legacy – by continuing data collection, international cooperation, research and monitoring in the polar regions.

Climate change may have far-reaching effects on ocean currents, and we do not know how more rapid ice melt in the polar regions will affect global circulation patterns. There is no doubt that changes in the polar regions may be of great

significance at global level. Changes in ocean currents, temperature conditions and ice cover will have impacts on marine ecosystems, resulting in changes in species' distribution ranges and migration patterns. For some species, survival will be difficult, whereas others will enjoy better living conditions. There will be similar impacts in terrestrial ecosystems.

In addition, climate change has major social impacts. If the rapid retreat of the Arctic sea ice continues, there will be a dramatic increase in the accessibility of the Arctic in the course of only a few years. This will open up new opportunities in sectors such as the fisheries, tourism, oil and gas and transport. Maritime transport between Europe and Asia through the Northern Sea Route may become feasible in only 5–10 years' time. In the slightly longer term, we can expect to see transport routes straight across the Arctic Ocean in summer.

Such scenarios will open up new opportunities for economic activity, but also make new demands on marine management, monitoring systems, emergency response systems and search and rescue services, and require closer international cooperation. Norway has jurisdiction over sea areas in the High North that are more than six times the size of mainland Norway, and therefore has a major responsibility for ensuring a steady and environmentally sound course of development in the Arctic. As a polar nation, Norway must actively promote development that maintains the highest possible standards and minimises the risk of conflict, accidents and environmental disasters.

How should we addresses the challenges facing us in the Arctic? The combination of rapid climate change and a lack of knowledge means that it makes sense in economic terms to intensify Norway's polar research effort as a follow-up to IPY 2007–08. Geographically, research should focus on Svalbard and the large sea areas where Norway has management responsibilities. Researchers are anticipating that climate change will be greatest and most rapid in the Arctic, and that the areas managed by Norway will experience greater climate change than the rest of the Arctic. Svalbard is in a special position because it is easily accessible, has advanced infrastructure and well-developed international research cooperation, and is of growing geopolitical importance.

The Government places knowledge at the core of Norway's High-North efforts, which is sensible in both scientific and strategic terms. Norway is the only country with management responsibilities in both polar regions. Norway has a direct responsibility for stewardship in the Arctic, and through international cooperation also plays a part in sound management of the Antarctic. Norway's presence in the polar regions, in the form of Norwegian research and monitoring activities, must be considered in the context of the exercise of sovereignty and enforcement of jurisdiction over Norwegian territory. The importance of Norwegian polar research lies in the vital input it can provide to efforts to deal with political issues such as environmental protection, climate change, the utilisation of natural resources and the law of the sea.

On the basis of the considerations discussed above, this policy gives priority to the research areas that are most important for Norway on the basis of the scientific strength and quality of different research groups, the infrastructure available, Norway's natural advantages, and research, environmental, natural resource and industrial policy priorities. This means that Norwegian polar research must include both applied research (including management- and industry-oriented research) related to polar issues and basic research.

Photo: Kjetil Nigard Aarskog, Svalbardposten

Photo: Norwegian Institute for Air Research (NILU)

International research cooperation under IPY has made it possible to collect a huge volume of new data and develop new knowledge of the climate in the polar regions. This will be of crucial importance in enabling researchers to provide more reliable advice on the climate change that we will have to take into consideration in future.

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2 Vision and overall objectives

>> Vision:
Norway will be a leading nation in polar research.

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Overall objectives:

1 Scientific
>> Norway will be the leading nation in certain fields of polar research.

>> Norwegian polar research will provide important input to research of global interest.

2 Management and environmental
>> Norwegian polar research will provide a basis for sustainable development and management of the polar regions.

3 Political
>> Norwegian polar research will provide an important knowledge base for Norwegian policy in the polar regions and contribute to sustainable development of the global community.

4 Industrial
>> Norwegian polar research will contribute to sustainable industrial development of the polar regions.

Strategic approach

To achieve these objectives, the following strategic approach will be necessary:

>> Areas where Norway has special expertise or national needs must be given priority.

>> Monitoring and long time series must be given high priority.

>> Existing high-quality infrastructure must be used effectively.

>> Where special needs exist, new infrastructure must be established and operated.

>> Norwegian polar research must comply with the highest environmental standards.


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3 Status and framework

To be successful, polar research must be based on international cooperation. Norway ranked third in the world in 2007 for Arctic research. Good management of the polar regions requires the best possible knowledge. A number of recent white papers have emphasised the need for research and integrated, long-term monitoring of the climate, pollutants and biodiversity.

Definitions
In this document, the term polar research includes both Arctic and Antarctic research. Polar research is not considered to be a separate discipline, but as part of the research activity in each scientific discipline. Polar research means research on material and phenomena in or of direct relevance to the polar regions. It thus includes thematic areas such as climate, the environment, pollution, biodiversity, geology, natural resources, the social and industrial challenges of activities in polar conditions, geopolitics and culture. The term "industrial challenges" does not include all industry-relevant research in polar areas, but focuses on the particular problems that arise as result of natural conditions in the polar regions.

For our purposes, the geographical term "Arctic" refers primarily to the polar part of the Arctic. It includes Svalbard, Jan Mayen, the northern part of the Norwegian Sea, the Barents Sea, the Greenland Sea and the Arctic Basin, together with adjacent land areas. The same definition was used in Official Norwegian Report 1989:9 and Report No. 42 (1992–93) to the Storting on polar research. It was also used by the Norwegian Institute for Studies in Innovation, Research and Education (NIFU STEP) in its two surveys of Norwegian polar research.

The geographical term "Antarctic" here means the area south of the Antarctic Convergence. This encircles Antarctica, and is where cold, northward-flowing Antarctic waters meet and mix with the warmer waters of the sub-Antarctic. Its position varies, but it normally lies between 50° S and 60° S. The Antarctic Treaty applies to the area south of 60° S. However, this policy also includes the sub-Antarctic islands such as Bouvet Island and South Georgia, which may at times be north of the Antarctic Convergence. See Appendix I for maps of the Arctic and Antarctic.

Status of Norwegian polar research
Norway is ranked in fifth place in polar research productivity measured as the number of journal publications in the period 2005–07, after the US, Canada, UK and Germany. For Arctic research, Norway ranks third. Norway's total expenditure on polar research in 2006 was NOK 933 million. Of this, an estimated NOK 180 million was research in/related to Svalbard. Norway is responsible for only 0.6% of the world's total scientific knowledge production, but for 6% of all polar research. Polar research accounts for about 2.9% of all R&D expenditure in Norway. Research institutions, universities and parts of the business sector are all active in polar research. See Appendix II for more details..

Norway and international cooperation
Polar research must be based on international cooperation if it is to be successful. Norway therefore plays an active part in a range of international organisations (see Chapter 6).

Svalbard is an important base for Arctic research, and Norway has a key role to play as the host nation. Norway's ability to provide an arena for research collaboration and access to the extensive existing infrastructure places it in a unique position to attract high-quality research to Svalbard, and play a central role in implementing the research goals defined by the international cooperation organisations. This helps to strengthen research in Norway in general.

In the Antarctic, the upgrading of the research station Troll for year-round use in 2005 has made research and monitoring activities possible throughout the year and encouraged international cooperation in Dronning Maud Land. Coordination of research is of interest to all parties, and Norway, represented by the Norwegian Polar Institute, plays an important part in this context as it is responsible for the Troll runway (part of the DROMLAN system) and research station.

The Government's High North Strategy and follow-up by the Research Council

The Government's High North Strategy (2006) is based on the premise that the High North is to be Norway's most important strategic priority area in the years ahead. An explicit goal of the strategy is for Norway to be at the forefront of international efforts to develop knowledge in and about the High North. The Research Council has followed this up with a separate research strategy for the Arctic and northern areas. Its aim is for Norway to be a leading research nation in the region by 2020 (see Appendix III).

Other national guidelines and the needs of the public administration

Good management of the polar regions requires the best possible knowledge of the natural environment and society. A number of white papers and official reports have emphasised the need for research and integrated, long-term monitoring of the climate, pollutants and biodiversity as a basis for managing Norway's polar areas.

The white paper *Climate for Research* (Report No. 30 (2008–09) to the Storting) states that the Government will ensure that research on the importance of the polar regions and the oceans for climate change continues. The most recent white paper on Svalbard (Report No. 22 (2008–09) to the Storting) notes that Norway has a special responsibility for developing knowledge about the polar regions, and states that Norway is to be a key actor in the development of knowledge in and about Svalbard, not just a facilitator. It goes on to state that Norway must secure itself a leading scientific role by maintaining a significant focus on, and the high quality of, Norwegian polar research activities. The report *New Building Blocks in the North – the next step in the Government's High North strategy* states that Norway will be at the forefront of international efforts to develop knowledge in and about the High North, including knowledge about climate and the environment. The Research Council strategy *In the Vanguard of Research* states "Research must seek to respond more directly to specific social and industrial challenges, especially in relation to welfare and industrial development, as well as global climate and energy problems."

Appendix IV gives an overview of other relevant documents.

International political guidelines

There are various international guidelines for polar research. Important documents, agreements and organisations include the *Strategy for Scientific and Technological Cooperation with North America* (2004), the Nordic Council of Ministers, the Arctic Council (including the Arctic Monitoring Assessment Programme (AMAP)), the Antarctic Treaty, the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), the Convention on Biological Diversity, the Agreement on the Conservation of Polar Bears, and bilateral polar research agreements with Italy, the US and Russia. More information is provided in Appendix V.

Conditions for research – restrictions and environmental considerations

The Norwegian authorities have decided that Svalbard is to be one of the world's best managed wilderness areas. The environmental legislation restricts the kinds of activities that can be carried out in the archipelago. Today, 65% of Svalbard is protected, and protection plans are being drawn up for Jan Mayen. Under the Antarctic Treaty, the whole continent is dedicated to research and to use for peaceful purposes. Norway has adopted Regulations relating to the protection of the environment in Antarctica, which implement the provisions of the Protocol on Environmental Protection to the Antarctic Treaty. These regulations govern Norwegian activities in the Antarctic, and lay down strict conditions for research activities. The general rule is that researchers must comply with national and international rules in any area where they operate.

Recently established infrastructure and access to new technology and measurement techniques

New infrastructure developments on land include year-round operation of the Troll research station in Antarctica, the Troll runway, upgrading of infrastructure in Ny-Ålesund (Marinlab), the Svalbard Science Centre in Longyearbyen, a new auroral station, the SPEAR radar system and constant expansion of capacity for downloading satellite data via SvalSat, TrollSat and EISCAT. Marine infrastructure includes vessels and fixed measuring stations. Construction of a new ice-class vessel will probably be completed by 2012.

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Photo: Kristen Ulstein

Photo: Sebastian Gerland, Norwegian Polar Institute

"Research must seek to respond more directly to specific social and industrial challenges, especially in relation to welfare and industrial development, as well as global climate and energy problems." (From *In the Vanguard of Research. Strategy for the Research Council of Norway 2009–2012*)

Photo: Edelpix

Photo: Linda Bakken

Photo: Bendik Eithun Halgunset

4 Thematic priority areas

Recent research has shown that it is difficult to gain an understanding of how complex systems function through studies of individual processes alone. Earth system science comprises studies of individual processes and their interactions at all levels in the biosphere, geosphere, atmosphere, cryosphere/hydrosphere and anthroposphere.

4.1 Introduction

Research in the polar regions can provide us with an insight into fundamental processes that are of crucial importance for the environment and climate of the Earth as a whole. The polar regions are an integral part of the global system, both as the regions where important processes originate and because they can provide an early warning of change.

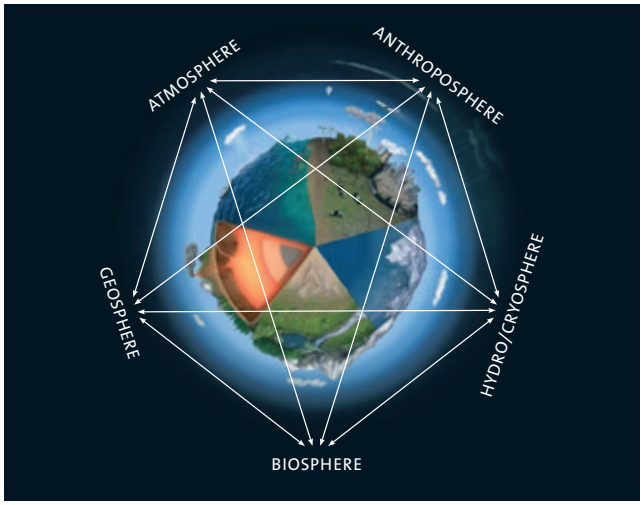
Research in the last few years has shown that it is difficult to gain an understanding of how complex systems function through studies of individual processes alone. An insight into the interactions between such processes may be equally important. For example, it is necessary to understand ice physics, local interactions between ice cover and conditions in the sea and the atmosphere, and how the global weather and circulation systems are changing to assess the impacts of reduced ice cover in the Arctic on the global climate.

Earth system science comprises studies of individual processes and their interactions at all levels in five spheres: the biosphere, geosphere, atmosphere, cryosphere/hydrosphere and the anthroposphere (see Figure 1).

The most recent assessment report from the UN Intergovernmental Panel on Climate Change (IPCC 2007) made it clear that a better understanding of the feedback mechanisms between the climate and clouds, the carbon cycle, the biosphere, the cryosphere and the ocean circulation is needed to improve climate scenarios. These mechanisms have been very poorly quantified in the polar regions, which are therefore of particular interest in the context of Earth system science. There are also several other reasons why the polar regions are of special interest in this context:

>> the ecological systems are often simpler in the polar regions;
>> both natural variations and the impacts of human activity may be greater in the polar regions than elsewhere;
>> several of the driving forces behind globally important processes, and their impacts, operate within the polar regions (thermohaline circulation, ice cover);
>> certain globally important processes are only seen in the polar regions (the aurora and other plasma phenomena).

This chapter describes research needs relating to:
>> topics within the natural sciences;
>> human pressure and economic activity;
>> important topics in social science, law and the humanities.



<< Figure 1: Earth system science seeks to build up an overall understanding of how the different elements of the Earth system, including people, contribute to its development over time.

4.2 Topics within the natural sciences

The great majority of questions within Earth system science involve several spheres, but in the overview that follows they are organised on the basis of the sphere to which they primarily belong:

Atmosphere/space-related questions

Atmosphere/space physics

Processes that govern energy transfer between the different layers of the polar atmosphere and between the atmosphere and space are important for the global energy balance. Despite the fact that atmospheric processes in the polar regions differ both

qualitatively and quantitatively from those at lower latitudes, parameters from lower latitudes are often used in models and to calibrate satellite data. It is therefore important to conduct process studies in fields such as cloud physics and atmospheric chemistry, including aerosols and radiation, in the polar regions. The polar regions are particularly suitable for studies of the middle and upper layers of the atmosphere, where the influence of space factors is strongest. Ready access to space-related infrastructure can give Norwegian research groups an advantage in the development of integrated regional models to study the interactions between all layers of the atmosphere and near space. This requires coordinated use of ground measurements, weather balloons, rockets and satellites.

Atmospheric dynamics
More insight into the processes that govern the wind systems responsible for transport into and out of the polar regions is necessary to understand the distribution of energy and precipitation across the Earth, and of long-range transport of pollutants that have direct impacts on global and regional processes. For example, deposition of soot on ice and snow will have a direct impact on the energy balance and conditions in the cryosphere.

Cryosphere-related questions
Sea ice
With constantly shrinking sea ice cover in the Arctic, the energy balance and feedback between air and water will change. This makes it important to understand how a thinner and weaker ice cover responds to wind and precipitation. Such processes can be studied using a combination of field studies and modelling. In the Antarctic, the floating ice shelves drive unique geophysical processes that are also closely linked to the renewal of bottom water in the world's oceans. Studies of processes that determine the future of the sea ice are one field where Norway is both able to play a leading role as a polar research nation and will benefit from doing so.

Glaciers and ice sheets
The hydrological changes associated with the retreat of glaciers and ice sheets and melting of the permafrost may result in considerable changes in the vegetation and also in social change. In addition, when ice on land melts, it has a direct effect on sea level. A better understanding of how rapidly ice sheets and glaciers can change, including the importance of meltwater for acceleration of ice movement, is important for climate scenarios. Norwegian polar expertise in this field can also be transferred to countries in other parts of the world that have alpine glaciers.

Permafrost on land and under water
Measurements of the temperature and ice content of permafrost, and of annual thaw depths (thickness of the active layer) in different parts of the Norwegian Arctic landscape provide data of crucial importance in developing models that can give credible projections of how climate variability will affect the permafrost. Research into how permafrost affects the stability of mountain slopes and the continental slope and associated landscape-forming processes is an area in which Norway has much to contribute. Thawing of the permafrost and a rise in sea temperature may result in melting of gas hydrates both onshore and offshore, with subsequent methane emissions and the risk of rapid enhancement of the greenhouse effect. These research fields are important internationally and are also of significance for Norway, and Norway should play a part in global research.

Hydrosphere-related questions
Ocean circulation
Variations in the energy supply from the sun, together with internal feedback mechanisms in the Earth system, have been an important driver of historical climate change. Such processes can be studied both in the field and using process models, and can be linked with studies of historical change. Basic research into natural processes of change can provide a basis for a better understanding of current climate and environmental change, which is partly anthropogenic.

The hydrological cycle
Access to fresh water is expected to change in the future as a result of climate change and resulting changes in rainfall patterns and melting of the cryosphere. A better understanding and quantification of the hydrological cycle will be an important contribution to Earth system studies.

Biosphere-related questions
Ocean acidification
The uptake of CO_2 by seawater is important for future development of the climate. Some change in the acidity of seawater has already been observed. Physical climate change processes can alter CO_2 uptake by the oceans, particularly in the polar regions where climate change is most marked. Key processes are linked to CO_2 uptake in freezing zones, for example in the Barents Sea, where the dense, cold water sinks after cooling. CO_2 is most rapidly transported into the deep water in the world's oceans via the polar seas. In the Arctic and Antarctic, ecosystems generally contain only a few species in large numbers. It is therefore important to quantify how these species are affected by ocean acidification.

Ecosystems
Climate change will have major impacts on marine, limnic and terrestrial ecosystems. It may lead to changes in the timing of reproduction at various trophic levels. Some species may be indirectly affected by climate change through impacts on their prey or species they compete with. The stronger such indirect effects are, the more difficult it is likely to be to predict the overall impacts on the system. The distribution patterns of microorganisms, zooplankton, fish, mammals and seabirds are expected to change, and more knowledge is needed on how rapidly changes take place. In addition, long-range transport of hazardous substances will have a direct impact on local ecosystems. Our understanding of interactions between hazardous substances and climate change is currently very limited.

Vegetation
Changes in hydrology and precipitation levels and patterns may result in substantial changes in vegetation. The length of the growing season and the mean temperature in summer are important factors, and changes in them can result in alterations

in the ranges of plants and subsequently animals. There are also feedback mechanisms between vegetation and snow cover and the reflection of solar radiation (albedo), so that vegetation cover influences climate development at global and regional level.

Geosphere-related questions

Natural fluctuations in the climate system

Instrumental records of the climate and climate processes are too short to document the extremes of climatic variation and slow processes of change that could lead to irreversible changes in climate and the natural environment. An understanding of climate processes and the drivers of such processes is important. On a geological time scale, climate development has been influenced by continental drift and other changes in the geosphere, including the polar regions. There are still major gaps in our knowledge in this field, especially as regards the geological development of the Arctic Ocean and the associated continental margin. Studies of the historical climate make it possible to build up climatological time series that can stretch over many thousands of years and may include both periods of extreme cold such as ice ages and warm periods with a climate similar to the present. We have only a limited understanding of rapid and slow processes of climate change, polar amplification of global warming, the speed of change, the sensitivity of the Arctic response to global change, earlier warm periods and "tipping points" in climate history, such as the growth and disintegration of large ice sheets in the Barents Sea, Svalbard and northwestern Russia. Studies of the historical climate are also important to increase our understanding of the relative importance of natural and anthropogenic climate change.

Natural pollution

Fluid seeps can be found both on the seabed and on land. These may be large sources of natural pollution with a direct impact on climate and the environment. There is a pressing need for better information on the distribution of fluid seeps and the quantities of substances such as CO_2 and methane emitted from land and the seabed at high latitudes. It is also important to learn more about the distribution of submarine and terrestrial permafrost, how this is changing with global warming, and the effects a reduction in the area of permafrost may have on gas hydrates and fluid seeps. Furthermore, the upper sediment layers provide an important archive for studies of the natural levels of various substances, and can be used to provide baseline levels for studies of pollution on land and in lake and marine sediments.

Earth system modelling

Earth system modelling poses a computational, technical and scientific challenge, since all the spheres shown in Figure 1 must be linked together to make realistic projections as effectively as possible. Norwegian researchers are developing a Norwegian Earth system model with the aim of providing scenarios for use in the next IPCC assessment report. It is important to incorporate improved understanding of processes and feedback mechanisms in the Arctic into Earth system models as quickly as possible. It is also important to downscale global scenarios for the polar regions, and to carry out studies using a hierarchy of models of varying resolution and complexity.

The great breadth of Norwegian polar research during IPY 2007–08 has created a good basis for continuing research using an Earth system approach. In following up this policy, it will be necessary to find a balance between thematic areas where Norway has particular strengths and more specifically-defined research objectives. By using an Earth system approach to polar research, it is possible to link projects to global environmental and climate research and generate a better knowledge base for integrated national-level management and international policy-making alike.

Key task

>> Developing an Earth system science approach using models that link regional studies in the polar regions with global studies, among other things by initiating an integrated study of the Arctic region.

Photo: Bendik Eithun Halungset

AREAS TO BE GIVEN PRIORITY

Priority should be given to the research areas that are most important for Norway on the basis of the scientific strength and quality of different research groups, the infrastructure available, Norway's natural advantages, and research, environmental, natural resource and industrial policy priorities. This means that Norwegian polar research must include both applied research (including management- and industry-oriented research) related to polar issues and basic research. Research fields where Norway is a leader or needs to obtain more knowledge from the leading international research groups should be given priority. Using an Earth system science approach as a basis, this will include research to increase understanding of processes that control or lead to change in the following:

>> the climate system in the Arctic region, including improvement of regional and global climate models;
>> sea ice and glaciers;
>> marine ecosystems;
>> CO_2 in the oceans: uptake and ocean acidification;
>> ocean circulation;
>> atmospheric chemistry;
>> the upper polar atmosphere and near space;
>> permafrost;
>> vegetation.

Basic research related to these topics will be of crucial importance. Research on pollutants will also be based on the results of research on several of the topics in this list (see 4.3 below).

4.3 Man-made pressures and economic activity

In the polar regions, research needs and economic activity should be more closely linked together than in other regions where the knowledge base is more extensive, the environment is less vulnerable and the external physical conditions are less extreme.

To ensure that the resources in the polar regions are used effectively and sustainably, research and development in the fields listed above must be intensified. This applies to the whole range of activities from independent basic research to product development. At the same time, industrial development in the polar areas will generate new opportunities for research and also pose new research challenges.

The polar regions are rich in marine resources, which have been managed and harvested for a very long time. As the Arctic becomes more and more accessible, new opportunities open up and the pressure on the environment increases. It is essential to base value creation in the polar regions on environmentally sound utilisation of resources.

Achieving the goals of the management plan for the Barents Sea–Lofoten area will require a good understanding of ecosystem structure and functioning and the impacts of human activity. The management plan assesses knowledge needs and priorities, which include ecosystem structure and functioning; species distribution and status; inputs, levels and impacts of pollution; impacts of climate change and the importance and function of the marginal ice zone. Management of the area requires knowledge from many different sectors and types of activity.

With the expansion of business interests in the Antarctic, the Norwegian authorities have a responsibility to ensure that the standards for knowledge-based management are just as high here as in the Arctic.

It is also important to focus on raising safety standards, for example by improving communications and navigation; weather, ice and sea state forecasting; and reducing pressure on the environment through improvements in technology and better crisis management.

Fisheries

There is a pressing need to improve understanding of the relationships between different trophic levels in marine ecosystems, particularly given that climate change is taking place. As larger sea areas become ice-free, the areas where biological production takes place will expand. Knowledge of how the production cycle can be expected to change and which organisms will become dominant in the future will be needed. These changes will affect ecosystems in both the Arctic and the Antarctic. The question is whether production will rise and whether the distribution of fish stocks will change. Harvesting of marine resources must be maintained at sustainable levels. At present, we have a relatively good qualitative understanding of how the climate influences ecosystems, but almost no quantitative data. However, research activities are under way in other parts of the Arctic, and comparative studies would be useful. Binding cooperation in this field should be established between several countries. In the Antarctic, Norway is involved in the krill and toothfish fisheries, but has made very little contribution so far to research on harvested species. In addition, we should focus on the impacts of the use of different types of fishing gear on ecosystems and take part in the development of gear that will have less ecosystem impact where possible.

Oil and gas

Both Norway and Russia have expectations of substantial discoveries of oil and gas in the Arctic. Field development in the Arctic will involve many of the same challenges as in the North Sea and Norwegian Sea, and it will be possible to use similar technological solutions. However, there are additional challenges specific to the Arctic, such as the cold climate, ice, darkness and distinctive ecosystems.

A specific R&D initiative related to petroleum activities is therefore needed, focusing on technical solutions for exploration and production under Arctic conditions. New solutions for field development must comply with strict requirements for discharges to the sea and high health, safety and environmental standards generally, both because of the harsh climate and because of the long distances to shore, which make emergency response and search and rescue operations difficult.

Knowledge of ice conditions, ice loads, ice mechanics and ice physics, methods for ice forecasting and steps to reduce ice problems will be essential to developing new solutions for oil and gas exploration, drilling, production and transport adapted to Arctic conditions.

To ensure sound management of petroleum resources, more knowledge is needed about the long-term effects of offshore activities on marine and terrestrial ecosystems and about the impacts of spills. Environmental monitoring is therefore a priority area.

In addition, emergency response systems must be further developed and research is needed on methods for dealing with oil spills in ice, regardless of whether the oil originates from ships, offshore installations or pipelines.

Maritime transport in the polar regions

New sea routes will be opened up by melting ice in the Arctic, and issues relating to maritime transport will become increasingly important. Three research areas are particularly relevant in this context. Firstly, there will be a need for technological R&D on the vessels to be used in the Arctic and on communications equipment. Secondly, an increase in the volume of maritime transport will result in local pollution, which will reduce the reflectivity (albedo) of snow and ice surfaces locally. Research on how much pollution from shipping will accelerate melting should be given priority. Thirdly,

shipping will break up the ice surface, exposing larger areas of open water. This is also expected to have a positive local feedback effect on melting by reducing albedo.

Bioprospecting
Bioprospecting is the search for and use of bioactive molecules and substances from living organisms for commercial purposes. Little research has been done on biodiversity at molecular level in the marine environment, particularly in the polar regions. The distinctive and extreme growing conditions in these regions mean that marine organisms are of particular interest for bioprospecting, as is the microflora of algae, bacteria and viruses. Marine organisms are surrounded by a microflora of bacteria and viruses to a greater degree than terrestrial organisms, and have developed effective molecular strategies as a defence against infections, etc, and thus offer unique opportunities for bioprospecting.

The purpose of marine bioprospecting is to find substances or genes that can be used commercially as components of products or processes. There are many areas of application, for example in medicine, the process industries (including oil and gas refining), foods, feed and biofuels. The commercialisation of research results based on marine bioprospecting often requires a long-term perspective, a cross-disciplinary approach, business expertise, sufficient capital and a willingness to take risk. Both national and international cooperation is necessary.

For more than 20 years, Norwegian research groups have been studying enzymes, particularly from cold-adapted organisms. The high levels of activity maintained by such organisms at low temperatures are of particular interest in the context of utilising their enzymes in various energy-intensive industrial processes. Until now, there have been no systematic investigations of large numbers of enzymes from cold regions, but about 20 enzymes have been studied in detail, and some have been commercialised, with very good results. One of the most characteristic features of bioprospecting is the range of expertise needed. Research groups need to put together specialists in many different fields. The research tasks are complex and require costly infrastructure. Bioprospecting in the polar regions must build on relevant research communities and their research infrastructure.

The Government is planning a targeted national initiative for marine bioprospecting. This is an important element of its High North Strategy and also forms part of its innovation policy and its maritime strategy (the Government published its new strategy for marine bioprospecting in 2009, *Marin bioprospektering – en kilde til ny og bærekraftig verdiskaping).*

Pollutants
During the past 50 years, the polar regions have been affected by long-range transport of pollutants including persistent organic pollutants (POPs), heavy metals, acidifying substances and radioactivity. It is now possible to document the impacts of different types of pollutants on plants, animals and people in the polar regions. Marine food chains appear to more seriously affected by POPs, whereas heavy metals, acidification and radioactivity are having greater impacts in terrestrial and freshwater food chains. In the last 10 years, it has also become apparent that climate change (changes in temperature, precipitation, wind direction, etc) are affecting ecosystems and the biological availability of long-range pollutants. Pollution and habitat degradation are now threatening people and animals, the wilderness and the cultural heritage in the polar regions.

Pollution of the polar regions today is a very clear indication of the global dispersal of pollutants and studies may help to clarify the mechanisms involved in their environmental dispersal and their uptake in different organisms. Because of the simple structure of polar ecosystems and the special adaptations of polar organisms, studies of the effects of pollutants on polar organisms may be particularly informative.

New substances are constantly being taken into use and enter the environment during use and as waste. Research and monitoring of the polar regions are of crucial importance for documenting new threats, the behaviour of chemicals in the environment, and their impacts. Documentation of the presence of new chemicals, their environmental mobility and their impacts is needed to draw up proposals for action to reduce or eliminate threats to both polar and global ecosystems and people.


Photo: Research Council of Norway

AREAS TO BE GIVEN PRIORITY

The following thematic areas should be given priority:

>> marine ecosystems and the impacts of climate change, linked to fisheries;

>> technical solutions for maritime transport and oil and gas exploration and production in the Arctic;

>> knowledge of ice conditions, ice loads and ice mechanics, linked to economic activity;

>> environmental impacts of economic activity in the polar regions;

>> marine bioprospecting in the polar regions;

>> the dispersal and impacts of local and long-range pollutants in the polar regions.

4.4 Important questions within social science, law and the humanities

Social science and international law
New challenges within the humanities and social sciences will emerge as a result of the major changes that are taking place in the polar regions, and particularly in the Arctic. These changes may have considerable impacts on individuals and communities, including indigenous communities, and at the same time human activity is putting pressure on the environment in these regions. There are unresolved issues relating to the continental shelf and sea areas that involve social science and legal considerations, and that will have an impact on economic interests. Research in this field must generate insight into these challenges and identify potential responses.

It is important to clarify the limits national and international law currently set for economic activity, environmental protection and the resolution of conflicts between different interests and states, and to analyse how these affect efforts to achieve the objective of sustainable development. The need to develop new legal mechanisms and solutions to achieve a more integrated management regime than is currently possible should be analysed, and possible ways of doing this should be reviewed. Bioprospecting and rights to natural resources in both the Arctic and the Antarctic are relevant research areas.

The impacts of climate change on geopolitical conditions, regional fisheries management, the shipping routes and oil and gas activities raise questions about jurisdiction and property rights in the Arctic Ocean. International attention has focused strongly on these questions over the past year, and there are large gaps in our knowledge in this field.

Management
Other problems are related to transboundary pollution and the management of natural resources that are shared by several countries. Changes in the migration patterns of fish stocks are likely, and will pose new challenges for international fisheries management, for example related to fishing rights and the enforcement of legislation in cases where more stocks become available in areas outside national jurisdiction. This requires knowledge of other Arctic states' interests and policies, including their management strategies. International institutions can also play a part in areas such as the petroleum sector where management is largely a national responsibility, for example through agreed transfers of expertise, joint environmental monitoring and emergency response systems, or even international minimum standards for activities in the Arctic region. A number of the research questions in these areas are closely linked to research on technology and the natural sciences. It is important both for the management of Norwegian polar areas and for an understanding of current international trends that researchers obtain the necessary background knowledge.

History
Historical research on earlier activities and circumstances in the polar regions is another important element of the whole picture, and provides information that is needed to understand and describe the present and near future.

Cultural heritage
The cultural heritage provides an important basis for understanding human activity in the polar regions, and international research should be continued in both the Arctic and the Antarctic.

Climate change will pose new challenges as regards the management of the cultural heritage and the regulation of tourism in both polar regions. Research should make a contribution in both these areas, and Norway already possesses a good deal of knowledge that is recognised internationally. Strengthening research in these areas can give Norway a leading international position. Cross-disciplinary research should be encouraged. Examples are observations of relevant climate variables and studies of the effects of climate change on the cultural heritage and of the effects of expanding research and tourism activities. This work includes obtaining better background data on vegetation types, distribution and resilience, and developing methods for measuring impacts.


Photo: Shutterstock

AREAS TO BE GIVEN PRIORITY

>> Research on long-range transboundary pollutants and natural resource management.

>> Research on circumpolar issues relating to indigenous peoples.

>> Social science research on change and adaptation.

>> Research on geopolitical issues relating to change in the polar regions.

>> Historical and cultural heritage research on earlier human activities in the polar regions.

>> Research on the management and conservation of the polar cultural heritage.

Photo: Bjørn Lytskjold, Norwegian Polar Institute

Photo: Norwegian Polar Institute

Photo: Norwegian Polar Institute

Photo: Karine Nigard Aarskog, Svalbardposten

AREAS TO BE GIVEN PRIORITY

>> Secure funding for important measuring stations and data series that already exist (as defined in the Research Council's 2003 reports on long time series).

>> Ensure adequate spatial and temporal coverage.

>> Integrate satellite and ground-based data collection, focusing on continuity and validation.

>> Make use of existing measurement technology and develop new technology for use in the polar regions.

>>Play a leading role in an Earth system science observation system in the Arctic using Svalbard as a base (Svalbard Integrated Arctic Earth Observing System (SIOS) will be an important Norwegian contribution to SAON).

>> Secure a permanent observation system in Antarctica through coordination between Troll and other research stations.

>> Ensure that Norway continues to take it share of the responsibility for monitoring the marine ecosystems in the Norwegian parts of the Antarctic through international programmes.

Photo: Tom Grydeland, www.flickr.com/togr

5 Long time series and environmental monitoring as a basis for research and management

Developing and continuing mapping and monitoring programmes and long time series in Norwegian polar areas is vital for research and management alike. In both the natural and the social sciences, regular series of observations are the only way to reveal processes of change.

Mapping data and long time series are important resources in many research programmes and a key element of all climate, environmental and natural resource monitoring. They are also essential for other activities such as fisheries and the petroleum industry. In both the natural and the social sciences, regular series of observations are the only way to reveal processes of change.

Norway maintains some of the world's longest hydrological, meteorological and oceanographic time series. For example, the Norwegian Meteorological Institute is still maintaining time series that go as far back as 1867, the Institute of Marine Research has been taking standard hydrographic sections since 1936, weather station M in the Norwegian Sea has been operative from 1948 to 2009, and the Norwegian Polar Institute maintains a series of measurements of an important oceanographic section in the Fram Strait. In 2001, the Research Council launched a review of the many Norwegian time series to identify those that are particularly important for studies of the climate, ecosystems and marine environment. This work was completed in 2004, and the reports that were published are still the most important documents on long Norwegian time series.

Despite this long tradition, Norway still does not have sufficient or long enough time series covering key climate parameters. For example, many of the time series obtained from biodiversity monitoring are too short to give reliable information on the numbers and ranges of species. Nor do we know enough about the pressures a combination of climate change and pollution exerts on ecosystems. A lack of data means that management is less knowledge-based and managers must instead use their judgement, which involves a greater element of risk. It is therefore essential to develop and continue mapping and monitoring programmes and long time series in Norwegian polar areas. Time series are important not only for monitoring purposes, but also as a basis for a great deal of research. The management plans for the Barents Sea–Lofoten area and for the Norwegian Sea identify a number of time series that should be continued or established.

However, a modern monitoring system involves much more than long time series. It combines data from remote sensing and direct measurements with scientific modelling systems for various purposes, including quality assurance of observations and models, calibration of sensors and ensuring permanent access to observations. Satellite observations and observations from ocean and ground-based instruments integrated into modelling systems are the basis for modern process studies and for climate and environmental monitoring. Further work is needed to develop new, integrated measurement technology for the atmosphere, land and ocean, specially adapted to the polar regions. This type of technology may find a large international market.

In connection with IPY 2007–08, steps have been taken to systematise Arctic observations. In 2006, the Arctic Council asked all its member states to maintain and continue their long time series as a means of securing the legacy of IPY. These processes were formalised in 2007 as the Arctic Observing Network (AON) and Sustaining Arctic Observing Networks (SAON). A corresponding Norwegian initiative was approved by the Arctic Council in autumn 2008. A similar initiative was presented to the Antarctic Treaty Consultative Meeting (ATCM) in April 2009 to ensure that the maintenance of long time series and improved international cooperation on scientific data is a permanent legacy of IPY.

The Research Council will take the initiative for the preparation of a strategy for funding already existing long time series and if appropriate establishing new climate and environment time series. This work should be based on the reports on long Norwegian time series published by the Research Council in 2003 and work done by relevant institutions since then.

Areas to be given priority; see factbox on page 22.

Photo: Herbjørn Presthus Eggen, UiB

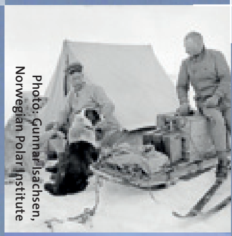


Photo: Gunnar Isachsen, Norwegian Polar Institute

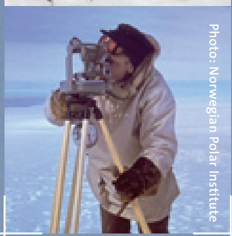


Photo: Norwegian Polar Institute

Photo: Terje Tellefsen, Kings Bay AS

6 International research cooperation

Norway's prominent role during IPY 2007–08 was made possible by a major expansion of resources and the presence of dynamic research communities with an extensive international network and good facilities and logistics support in the Arctic and Antarctic. Norway allocated NOK 330 million over four years, making it one of the largest contributors.

General
Norway plays an active part in many bodies, including the Scientific Committee for Antarctic Research (SCAR), the International Arctic Science Committee (IASC), the Arctic Ocean Sciences Board (AOSB) (which became part of the IASC in 2008), the World Meteorological Organization (WMO), the Working Groups of the Arctic Council, the World Climate Research Programme (WCRP), the International Arctic Social Sciences Association (IASSA), the EU framework programme for research, the European Polar Board (EPB) and the European Marine Board. Large-scale research programmes are developed within the framework of these bodies to improve coordination and deal effectively with the logistical challenges and costs of polar research. Such programmes also direct countries' efforts towards the major cross-cutting research questions.

The legacy of IPY 2007–08
IPY 2007–08 has spawned a great deal of interest in polar research and led to a more visible profile for research communities and Norway's role internationally. It is producing important new research results; international research networks, observation and measurement series and international networks of measuring stations have all been established or strengthened; and there has been enhanced recruitment and development of expertise. As research results continue to emerge, they will lead to new lines of thinking on which we must continue to build in the future.

Norway's prominent role during IPY 2007–08 was made possible by a considerable expansion of the available resources and by the existence of high-quality research communities with an extensive international network and good facilities and logistics support in both the Arctic and the Antarctic. Norway allocated NOK 330 million to IPY over a four-year period, making it one of the largest contributors. This has provided an important boost for Norwegian polar research. The main objective of IPY was to leave a legacy of scientific knowledge and an international observing system. It is of crucial importance to use this legacy to continue the development of Norwegian polar research.

Norway has taken very active part in bipolar IPY projects, and must make use of the advantages provided by research experience from both polar regions. Integrated cooperation on infrastructure in both polar regions can result in savings, ensure continuity and open up new research opportunities, particularly in an international perspective. This applies especially with regard to research vessels.

Furthermore, it will be important to maintain on a more permanent basis the structure for data storage and the system for user searches, access to data and retrieval of observations and modelling results. In addition, steps should be taken to ensure continued use of the most important components of the observation capacity and research network funded by IPY 2007–08. Cooperation with Russian researchers and authorities should be given priority so that the border between Russia and Norway does not form a discontinuity in observations, calculations and evaluations. In autumn 2008, Norway gained approval for an Arctic Council project to maximise the legacy of IPY 2007–08. The main elements of the project are concerned with 1) cooperation and exchange of data, 2) access to all parts of the Arctic, 3) recruitment and coordinated international funding and 4) carrying out an assessment of the results of IPY 2007–08.

The Antarctic
In the Antarctic, measuring stations on floating ice shelves are being developed that are designed to measure changes in the sensitive sea areas under the ice shelves. During IPY 2007–08, Norway led a very demanding and ambitious expedition, the Norway-US Scientific Traverse of East Antarctica, from the Troll research station to the South Pole during one austral summer and back again in the next season. The expedition investigated areas of Antarctica that have never been studied before and collected valuable data that can be used to improve climate

models and our understanding of the impact of the Antarctic on sea level.

Norway presented an initiative similar to that approved by the Arctic Council to the Antarctic Treaty Consultative Meeting (ATCM) in April 2009 to maximise the scientific legacy of IPY.

Infrastructure
Many phenomena and processes in near space can only be studied from the polar regions. Norway has unique, world-leading space-related infrastructure in Svalbard (EISCAT, a new auroral station (Kjell Henriksen Observatory), SvalRak and SvalSat). The fact that Norway has research stations both in the Arctic (Svalbard) and in the Antarctic (Troll) means that it is uniquely equipped to carry out comparative studies of the two polar regions. Moreover, Norway's strong expertise in Arctic marine research should be used to carry out comparative studies of Arctic and Antarctic sea areas.

Several international initiatives concerning research infra-structure in the polar regions are being planned. Norwegian research groups have shown interest in taking part in the following initiatives under the European Strategy Forum on Research Infrastructures (ESFRI): *Aurora Borealis, European Multidisciplinary Seafloor Observatory (EMSO), EURO-ARGO, Integrated Carbon Observation System (ICOS), LifeWatch and Svalbard Integrated Arctic Earth Observing System (SIOS)*. Norwegian consortia have been established for participation in all these ESFRI projects. See Appendix VI for more details.

The Research Council is currently implementing a national investment initiative for research infrastructure that includes both large-scale national infrastructures and Norwegian participation in some of the projects on the ESFRI Roadmap. In this process, the different projects will be assessed in the overall context of strategic research planning. It is therefore difficult at the time of writing (March 2009) to say anything more about priorities. The infrastructure strategy will be followed up in the Research Council's budget proposals in the years ahead. It is generally important for Norway to have access to modern polar research infrastructure, which makes extensive international cooperation possible.

Svalbard
Research institutions from roughly 20 nations are more or less permanently represented in Svalbard. There are permanent research and monitoring stations in Ny-Ålesund, Longyearbyen, Sveagruva, Hornsund, Barentsburg, Hopen and Bjørnøya. Several countries make considerable use of research vessels, not only in the waters around Svalbard, but across the whole of the Barents Sea, the Norwegian Sea and the Greenland Sea. Research aircraft also operate from the archipelago.

Norwegian research and knowledge production in Svalbard is largely made possible by the University Centre in Svalbard (UNIS) and the Norwegian Polar Institute. UNIS has expanded since its establishment in 1994 as a centre for Arctic studies, and now has a staff of more than 80, who live and work in Longyearbyen. Teaching and research efforts have been increased in scope, as have activities with external funding. UNIS offers study programmes in Arctic biology, Arctic geology, Arctic geophysics and Arctic technology. A new study programme, energy and environment, has been established and includes studies of carbon storage.

The Norwegian Polar Institute is Norway's central institution for mapping, environmental monitoring and management-oriented research in the Arctic and Antarctic. It also provides the government administration with scientific and strategic input, and the environmental directorates and the Governor of Svalbard with scientific input on polar issues. Its tasks also including contributing to environmental management in Svalbard and planning, coordination and facilitation of research on the archipelago.

Most of the foreign research stations have been established in Ny-Ålesund. The company Kings Bay AS is responsible for infrastructure and services in the settlement. Its tasks are to promote international scientific research and environmental monitoring in Ny-Ålesund and the surrounding area.

The most recent white paper on Svalbard (Report No. 22 (2008–09) to the Storting) was submitted on 17 April 2009. It highlights the fact that Svalbard is the most research-intensive part of Norway, and also the most international part. Research and education are emerging as an increasingly important element in management of the archipelago.

As research activity expands it becomes more and more important to strengthen coordination at both the practical and the scientific levels. In the Government's view, it is most appropriate to consider practical coordination in the context of a general strengthening of the presence of the Research Council through the Svalbard Science Forum. The Government also takes the view that the Research Council should play a more active role in ensuring effective coordination of research activities. This can best be done by strengthening the administrative configuration of the Svalbard Science Forum, which should improve research management, cooperation, planning and establishment of overall priorities for research in Svalbard. Moreover, the Government believes that the Forum should be able to play a more active role in further development of Ny-Ålesund as a research arena. The Research Council is ready to take on these tasks, and will through the National Committee on Polar Research further assess which scientific tasks could be assigned to a revitalised Svalbard Science Forum. A stronger position for the Research Council will require close coordination with other actors.

The international research presence in Svalbard and inter-national investments in research and research infrastructure have grown considerably in recent years. A total of NOK 3 million per year is now earmarked for allocation to Norwegian institutions that cooperate with Russian researchers in Svalbard. This funding is crucial in promoting cooperation between the two countries. It would be constructive if similar arrangements could be established with other countries and if funding could be shared by several countries at once.

In addition to providing resources for research management,

cooperation between Norwegian and foreign projects would be strengthened by setting aside research funding earmarked specifically for activity in and around Svalbard. This would put Norway in a position to initiate and contribute to the startup of international research programmes in Svalbard. Such funding should be granted on condition that institutions from relevant countries present in Svalbard collaborate and integrate their activities with each other, and that non-Norwegian institutions also provide funding. The Svalbard Science Forum will continue to develop flagship programmes that identify coherent research priorities for thematic areas, including marine ecosystems, atmosphere research and terrestrial systems. Relevant Norwegian and international research groups in Ny-Ålesund and later in the whole of Svalbard will take part in the development of these programmes. It will be possible to use Norwegian research funding to contribute to the startup of flagship programmes.

Experience shows that in most disciplines, Norwegian and international researchers could make much better use of the existing research infrastructure in Svalbard throughout the year. Earmarking funding for research in Svalbard could be one way of making more efficient use of existing capacity.

The Arctic Fieldwork Grant Scheme to cover supplementary costs related to fieldwork in Svalbard should be strengthened, and should be expanded to include applicants from international institutions. The grant scheme promotes recruitment and national as well as international cooperation.

The Svalbard Integrated Arctic Earth Observing System (SIOS) initiative consists of two main elements. The first is to further develop existing observation systems in Svalbard and the surrounding area and organise them to form a complete system with four observation platforms for data collection: land-based, sea-based, glacier/ice-based and space/air-based. The second is to establish a knowledge centre in Longyearbyen to store and integrate data from all relevant infrastructure. This initiative can provide a basis for cooperation on research and monitoring, teaching and dissemination activities, contribute to regional and global climate models, and create a joint Arctic platform for climate-related research in Europe. SIOS will also be a node in the planned Sustaining Arctic Observing Networks (SAON) initiative under the Arctic Council, which is intended to be part of the follow-up to IPY 2007–08 and an integral component of the EU's Arctic policy (COM (2008) 763 final), which includes research and monitoring as key elements.

Administrative and legal issues related to a permanent organisational model, operation and cooperation with international partners in Svalbard will be reviewed during the Research Council's pre-project in 2009. It will be natural to draw on experience from other ESFRI projects and on the work being done by the European Commission to develop a Community legal framework for a European research infrastructure. However, it already seems likely that SIOS will become a separate organisation based at the Svalbard Science Centre. The SIOS initiative will involve at least three types of costs: investments to close gaps in the infrastructure and to establish the knowledge centre itself; operating costs for the infrastructure and the knowledge centre; and the costs of making observations and collecting various types of data.

An application for funding for the preparatory phase of SIOS will be sent to the EU Seventh Framework Programme for research by 1 December 2009. An allocation of EUR 4–7 million may be forthcoming for this phase. The investment and operation phase will probably start in 2012. At the moment, only very preliminary and uncertain figures are available. It is estimated that investments of NOK 300–400 million will be needed (with contributions from many countries: as the host country, Norway should provide about 30% of this, or about NOK 100–150 million), and that the operating costs will be around NOK 80 million per year. The plan is for the countries taking part to cooperate on operation of the infrastructure.

The Norwegian research community and educational institutions in Svalbard have a particular responsibility to play a leading role in the international cooperation that is being developed. Svalbard is becoming a research and knowledge hub of a high international standard. It is therefore crucial that the Norwegian research community shoulders the tasks necessary if we are to achieve the vision of Norway as a leading polar research nation.


Photo: Sebastian Gerland, Norwegian Polar Institute

AREAS TO BE GIVEN PRIORITY

The Research Council will focus on the following:

- ensuring that Norwegian polar research community plays an active role in developing and carrying out international polar research;
- ensuring that the Norwegian polar research community makes use of all national infrastructure capacity: research groups will be expected to cooperate to make the best possible use of the available infrastructure;
- active participation in the IASC (Arctic), SCAR (Antarctic) and EPB to promote Norwegian polar research and link it to the international research agenda;
- strengthening bilateral and multilateral polar research cooperation, including cooperation with Russia;
- ensuring that forums such as the Svalbard Science Forum, the Ny-Ålesund Science Managers Committee (NySMAC) and the Longyearbyen Science and Education Forum (LySEF) are in the best possible position to facilitate coordination and international research cooperation in Svalbard;
- ensuring that the SIOS initiative is used to enhance international cooperation on Svalbard as an obser vation platform, under Norwegian leadership;
- further developing Ny-Ålesund as an international research base.

Photo: Norwegian Polar Institute

7 Recruitment

To meet future challenges, a special effort to recruit junior researchers is needed. This may entail increasing the number of doctoral and post-doctoral fellowships dedicated to polar research, establishing graduate-level researcher schools and improving the general framework for polar research.

The strategic priority being given to the High North, as set out in the Government's and the Research Council's strategies, means it will be necessary to strengthen educational activities. This need is made even more pressing by the fact that a major generational shift will be taking place in top-level positions in the traditional polar research disciplines at the universities and independent research institutes in the near future. It will be important for the universities to ensure continuity and further development of polar research when recruiting new staff to these positions. The same considerations apply to technical personnel.

To meet the challenges of the future, a special effort to recruit junior researchers will be needed. This may entail increasing the number of doctoral and post-doctoral fellowships dedicated to polar research, establishing graduate-level researcher schools and improving the general framework for polar research. The research institutions should be encouraged to cooperate with industry on master and doctoral programmes. Although the research infrastructure in Svalbard is excellent, costs related to travel and logistics are a limiting factor for use of the archipelago. Grants for Arctic field research should therefore be increased and more support should be provided for research trips to Svalbard.

UNIS' mission is to carry out research and offer teaching based on Svalbard's geographical position in the Arctic and the advantages this provides. UNIS works closely with the universities of Oslo, Bergen, Trondheim and Tromsø. The study programmes at UNIS form part of the curriculum at the four universities, and UNIS has a special responsibility to provide university-level education in Arctic studies.

The Norwegian projects under IPY 2007–08 included a considerable number of research fellowships. It is important to help these researchers to make use of their expertise in polar research as they pursue their careers in research, education, the business sector or the public administration.

The Research Council will focus on the following:

>> improving the framework for recruitment to disciplines that are important for polar research and increasing the number of doctoral and post-doctoral fellowships;

>> strengthening the role of UNIS in recruitment to Norwegian polar research;

>> increasing the number of permanent positions for researchers.

Photo: Jørgen Gunnar Winther, Norwegian Polar Institute

Photo: Sebastian Gerland, Norwegian Polar Institute

8 Dissemination activity

An important aim is to communicate findings to the public in a way that interests people, and stimulates interest in scientific training and research among young people.

Research carried out in Svalbard deals with many scientific, sociological and historical issues that are of great interest to the general public. Activities under IPY 2007–08 have resulted in considerable exposure of polar research in both internal and public channels for dissemination of research. It is important to maintain this level of activity, and the IPY outreach efforts should be used as a model in further funding of projects, so that dissemination activity is required as an integral part of the projects.

Polar research will make a significant contribution to the knowledge base for the climate debate, and it is important to encourage polar researchers to play a part as experts in the public debate and to give them the skills to do so.

Dissemination activity must be targeted towards the public administration in order to provide a better basis for decision-making. Another important aim of this activity is to communicate findings to the general public in a way that interests people, and for example to stimulate an interest in scientific training and research among children and young people.

More publication of the results of polar research in scientific journals should also be encouraged.

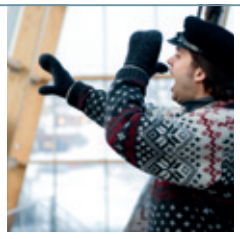
The Svalbard Science Forum should become an important platform for information on Arctic research. The large numbers of tourists who visit Svalbard can also benefit from information on research findings.

The Research Council will focus on the following:

>> encouraging more publication of the results of Norwegian Arctic and Antarctic research in recognised scientific journals;

>> continuing to encourage dissemination of polar research to a broad public;

>> encouraging better utilisation of research results in order to make sound management decisions.



Scenes from a production by the Sadio Nor Theatre Company. On this page, actor Klaus Løkholm Bergli; on the opposite page, actor Nina Rosenlund. Photo: Ingun A. Mæhlum

Photo: Digital Vision

Photo: Hallvard Strøm,
Norwegian Polar Institute

Photo: Malin Rue

9 Research funding

Norway's aims to be the leader in certain polar research fields and make important contributions to research of global interest. Although there is already a great deal of polar research activity in Norway, this needs considerable strengthening in the years ahead. A long-term approach, predictable funding and coordination are essential.

In spring 2009, the Government presented three documents that clearly recognise the importance of focusing on climate and environmental research, management-oriented research and industry-oriented research in the polar regions. The white paper *Climate for Research* (Report No. 30 (2008–09) to the Storting) states that the Government will ensure that research on the importance of the polar regions and the oceans for climate change continues. . The most recent white paper on Svalbard (Report No. 22 (2008–09) to the Storting) notes that Norway has a special responsibility for developing knowledge about the polar regions, and states that Norway is to be a key actor in the development of knowledge in and about Svalbard, not just a facilitator. It goes on to state that Norway must secure itself a leading scientific role by maintaining a significant focus on, and the high quality of, Norwegian polar research activities. The report *New Building Blocks in the North – the next step in the Government's High North strategy* states that Norway will be at the forefront of international efforts to develop knowledge in and about the High North, including knowledge about climate and the environment. The Research Council strategy *In the Vanguard of Research* states "Research must seek to respond more directly to specific social and industrial challenges, especially in relation to welfare and industrial development, as well as global climate and energy problems."

Norway's objective is to be the leading polar research nation in certain fields of polar research and make important contributions to research of global interest. Furthermore, Norwegian polar research is to provide a basis for sustainable development and management of the polar regions. Although there is already a great deal of polar research activity in Norway, this needs to be considerably strengthened in the years ahead. These are among the thematic areas that should be strengthened:

- polar research based on an Earth system science approach. Earth system science comprises studies of individual processes and their interactions at all levels in five spheres: the biosphere, geosphere, atmosphere, cryosphere/hydrosphere and anthroposphere. By using an Earth system approach to polar research, it is possible to link projects to global environmental and climate research and generate a better knowledge base for integrated national-level management and international policy-making alike;
- marine research in the Antarctic and comparative studies of the two polar regions;
- glaciological research related to the influence of Antarctica on global sea level;
- research programmes specifically targeted toward Svalbard, better utilisation of existing infrastructure, research management in Svalbard;
- following up the SIOS initiative;
- research as a basis for industrial development (oil and gas, fisheries, bioprospecting);
- following up international cooperation;
- long time series and environmental monitoring as a basis for research and management;
- data and modelling systems for cross-disciplinary, integrated research and monitoring.

At present, much of the funding for polar research and monitoring is short-term and split between many different ministries and institutions. Implementation of this policy document will require an increase in funding, a long-term approach and coordination.

Polar research under the Research Council forms part of many programmes and activities. In addition to the allocations in connection with the IPY initiative (NOK 320 million over the four-year period 2007–10), polar research is included under the Large-Scale Programme Initiative through the NORKLIMA programme (1/3 of which is concerned with Arctic issues) and the PETROMAKS programme (about NOK

32 million in 2008). Furthermore, polar research is being conducted within the DEMO 2000 programme, the Programme for Space Research, Oceans and Coastal Areas, the EASTERNEUROPE programmes, the SOUTHAFRICA programme and the POLRES programme, and as basic research on many scientific issues. In addition, support is provided to projects and research groups within biology and geoscience and to strategic institute programmes within land-based industry. In all, the Research Council allocated about NOK 211 million to polar research in 2008, of which about NOK 76 million was for Svalbard-related research.

Two levels of ambition for polar research funding are outlined below.

Level 1: NOK 300 million per year
Knowledge about developments in the polar regions is urgently needed: ice cover is shrinking faster and the temperature is rising both more and more rapidly in the Arctic than in other parts of the world, but we have only limited knowledge about climate development, the environment and biodiversity. For example, climate and ice cover in the Arctic changed from 2007 to 2008 in ways that were not predicted at the beginning of IPY. Shrinking ice cover and thinner ice make it highly probable that there will be growing activity in the fisheries, the oil and gas industry, shipping and tourism in the Arctic. Increasing economic activity will make it necessary to improve climate models and learn more about climate trends so that it is possible to provide better weather, ice and iceberg forecasts and enhance safety standards and the emergency response; this will also include building up expertise in satellite monitoring.

A comprehensive polar research initiative is needed in the Research Council, with funding maintained at the 2008 level. It should use an Earth system approach and be able to accommodate broad, integrated projects. Moreover, it should include the challenges society faces in the polar regions as regards management and policy, the cultural heritage and industrial development. Experience shows that in most disciplines, Norwegian and international researchers could make much better use of the existing research infrastructure in Svalbard throughout the year, and earmarking funding for research in Svalbard (for marine, atmospheric, terrestrial and space research) would be one way of making more efficient use of existing research infrastructure.

Norway has research infrastructure at the Troll station that is currently being under-utilised for research and monitoring – there is an imbalance between the funding needed to cover logistics and running costs for the infrastructure and the research funding provided for use of the infrastructure. There is thus a need to increase funding for Antarctic research.

Natural conditions in the polar regions pose many challenges to economic activity. With climate change, new opportunities may open up in sectors such as the fisheries, tourism and oil and gas, and more research on technological challenges and environmental conditions will be of crucial importance for operations in the polar regions.

There is also a pressing need for more funding for monitoring and to maintain long time series of climate, environmental and biodiversity observations as a basis for management and research. The Research Council will take the initiative for a strategy for long time series of climate and environmental observations.

Summary:
Funding level 1 (NOK 300 million per year) includes:

1) Continuation of polar research at the 2008 level: about NOK 210 million.

2) In addition, new and specifically targeted research activities in Svalbard, use of the research infrastructure at Troll, industry-oriented research and funding for long time series. In all about NOK 80–100 million per year.

Level 2: NOK 300 + 80 million per year
For this, additional funding is proposed with the same profile as in level 1, but with more focus on research on the utilisation of natural resources in the Southern Ocean.

Funding for the SIOS initiative is additional to that outlined for the two levels of ambition above, since it requires a separate allocation from the Government. Moreover, the figures above do not include funding in the event of Norwegian participation in other European polar-related infrastructure projects (*Aurora Borealis*, EMSO, EURO-ARGO, LifeWatch, ICOS). From 2009 onwards, there will be regular strategic assessments to determine which projects Norway is to take part in.

The Research Council will focus on the following:

>> in cooperation with line ministries, working towards better long-term funding for polar research in accordance with the levels of ambition described above;

>> ensuring satisfactory long-term provision for dynamic research groups;

>> helping to obtain more EU funding for Norwegian research in the Arctic and Antarctica;

>> arguing in favour of and contributing to funding for long time series and environmental monitoring as a basis for research and management, including the continuation of measurement series that were established during IPY 2007–08.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Appendices >>

APPENDIX I

Definition of the Arctic and Antarctic

Definition of polar research. The shaded area shows the delimitation of the Arctic as it is defined in this policy document.

This policy document covers the area south of the Antarctic Convergence (darkest blue).

APPENDIX II

Status of Norwegian polar research

Norway has long traditions as an important polar research nation. As might be expected given Norway's geographical position, Norwegian polar research has focused mainly on the Arctic. The Norwegian research effort in the Antarctic has been more sporadic, but the opening of the Troll research station in Dronning Maud Land for year-round use in 2005 means that continuous research activity is now possible in Antarctica. In 2006, 6% of Norwegian polar research was in the Antarctic. This is a small rise from 2002.

The Norwegian Institute for Studies in Innovation, Research and Education (NIFU STEP) has drawn up a status report for Norwegian polar research in 2006 and compared the figures with similar data from 2001/2002. The report emphasises that the figures are uncertain, and that the survey must only be considered as giving a rough quantification of Norwegian polar research. However, the results do show a considerable expansion of polar research in this period in terms of both person-years and total funding. Most of the increase comes directly from the ministries or from industry, and is therefore linked to management tasks or the interests of trade and industry.

In 2006, the total polar research effort expressed in person-years was split as follows: the natural sciences 85%, technology 10%, social sciences 3%, medicine 1% and humanities 1%. The increase from 2002 was largest for the following fields: atmospheric research/meteorology, oceanography/geophysics, petroleum technology and environmental technology. Between 2002 and 2006, there was a considerable shift towards marine research within polar research. Research into marine science, the natural sciences and technology has expanded most, particularly research concerned with the Barents Sea.

The data from NIFU STEP show that Norway measures up well internationally judged by the number of scientific publications in the field of polar research. Norway ranks fifth in polar research as measured by the number of papers published in the period 2005–07, after the US, Canada, UK and Germany, and third in Arctic research. From 1999–2002 to 2003–06, the number of publications with Norwegian authors rose by 16%. The rise for polar research publications is weaker than for the total number of papers in all research fields published in international scientific journals and weaker than the overall rise in research activity. A possible explanation is that the largest share of the rise in research activity was in the public administration and trade and industry, where results are less likely to be published in international scientific journals.

Citation indices can be used as a measure of the quality of research, and Norwegian papers were cited 1% more often than the world average in the period 2001-2007. This is considerably below the results achieved by larger nations

such as the US, the UK and France, which achieve the highest citation indices.

NIFU STEP's data show that in the period 1991–2007, 11% of all Arctic research papers were related to Svalbard. The number of Svalbard-related papers published per year has doubled in this period. The Norwegian share of publications on Svalbard was fairly stable from 2000–2002 to 2005–07 (31 and 32% respectively), but lower than Norway's share of the research effort (expressed as person-years) in Svalbard would indicate.

It should be noted that the report discusses a period before the increase in research effort in connection with IPY 2007–08. The IPY allocation through the Research Council totalled NOK 330 million over a four-year period, and has led to substantial investment of resources on the part of the research institutions as well.

Total expenditure on polar research in 2006 was NOK 933 million. Of this, an estimated NOK 180 million was for research in or related to Svalbard. Polar research accounts for about 2.9 % of all R&D expenditure in Norway. Independent research institutes, universities and to some extent the trade and industry are all active in polar research. The total expenditure of NOK 933 million was distributed as follows: NOK 548 million was used by the research institutes, NOK 259 million by the universities and university colleges and NOK 126 million by industry. In all, 26 research institutes are involved in polar research. The most important of these are the Institute of Marine Research and the Norwegian Polar Institute, which recorded expenditure of NOK 180 and 80 million respectively. Among the universities, expenditure was highest at the University of Tromsø (NOK 80 million), followed by the University of Bergen, the University of Oslo, the University Centre in Svalbard (UNIS), the Norwegian University of Science and Technology (NTNU) and other institutions. The contribution from industry was about NOK 33 million.

APPENDIX III
The Government's High North Strategy and follow-up by the Research Council

The Government's High North Strategy (2006) is based on the premise that the High North is to be Norway's most important strategic priority in the years ahead. The Government will intensify efforts to exercise Norwegian sovereignty and to ensure the sustainable management of the rich fish and energy resources. The aim of Norway's High North policy is to protect the environment, maintain settlement patterns and promote business development in the north. The Government will utilise opportunities for more extensive international cooperation on the use of natural resources, environmental management and research through closer contact with Norway's neighbour Russia and its European and North American partners.

An explicit goal of the strategy is for Norway to be at the forefront of international efforts to develop knowledge in and about the High North. The strategy emphasises that the knowledge needs identified in the white paper on an integrated management plan for the Barents Sea–Lofoten area (Report No. 8 (2005–06) to the Storting) must be given priority. Norway has internationally leading centres of expertise in the fields of petroleum, maritime transport, utilisation and management of marine resources, environmental protection, climate and polar research and research on indigenous peoples. The Government intends to strengthen the knowledge infrastructure in the region, and will strengthen both knowledge building in the High North and High North-relevant research through the Research Council.

The Research Council has followed this up with a separate research strategy for the Arctic and northern areas. Its aim is for Norway to be a leading research nation in the region by 2020. Its main elements are an overall strategic approach, a substantial increase in research activities and better horizontal integration between different programmes and initiatives. The strategy focuses on safeguarding Norway's interests and fulfilling its responsibilities, ensuring the sustainable development of opportunities relating to the northern seas, Svalbard, cooperation with Northwestern Russia and regional Arctic cooperation, and making use of the great potential of North Norway. Research related to the northern areas has a considerably broader scope than polar research, but polar research will be an important element of research that is relevant to the northern areas.

APPENDIX IV

Other national political guidelines

The white paper *Protecting the Riches of the Sea* (Report No. 12 (2001-2002) to the Storting) identified research and monitoring needs.

The 2008 white paper on Svalbard (Report No. 22 (2008–2009) to the Storting) points out that Svalbard is an important platform for both Norwegian and international research. Research and education will be an important element of Norwegian activities in Svalbard in the years ahead. As a result of IPY 2007-08, there has been a growing focus on climate and environmental research. Longyearbyen and Ny-Ålesund are the logical centres for research and education based on the natural advantages of the archipelago, and the scientific activities in these areas should ensure a strong, coherent overall research effort.

The IPY initiative has provided an important boost for Norwegian polar research, which is a field where Norway is in a unique position to contribute to global knowledge development. It will be important to maintain the networks established during IPY. Norway will also be able to use experience gained during the IPY initiative in its efforts to develop Svalbard as a research platform.

The white paper *Climate for Research* (Report No. 30 (2008–2009) to the Storting) sets out the Government's research policy goals. One of these is for Norwegian research policy to be instrumental in resolving global problems by ensuring a particular emphasis on research in the following fields: the environment, climate, the oceans, food safety and energy. Promoting high-calibre research, ensuring that the research system functions smoothly and encouraging internationalisation of research are other very important goals. Cooperation between the business sector, research communities and academia is now being established to exploit opportunities for value creation in the High North within tourism, Arctic technology, climate research, environmental technology and bioprospecting. Norway has a special responsibility for developing knowledge about the role of the polar regions and the oceans in development of the climate system.

An integrated, ecosystem-based marine management regime
The purpose of the management plan for the Barents Sea–Lofoten area (Report No. 8 (2005–06) to the Storting) is to provide a framework for the sustainable use of natural resources and goods derived from the area and at the same time maintain the structure, functioning and productivity of its ecosystems. To achieve this, the management plan is based as far as possible on knowledge of ecosystem structure and functioning and of how this is affected by human activities. Management of the Barents Sea–Lofoten area requires knowledge from many different sectors and from the different types of activity in the area. The management plan assesses knowledge needs and priorities, which include ecosystem structure and functioning; species distribution and status; inputs, levels and impacts of pollution; impacts of climate change and the importance and function of the marginal ice zone. A similar integrated, ecosystem-based management plan for the Norwegian Sea was submitted in spring 2009.

The white paper *The Government's Environmental Policy and the State of the Environment in Norway* (Report No. 26 (2006–07) to the Storting) sets out Norway's political goals for environmental trends, and includes the northern areas.

The white paper *Norwegian climate policy* (Report No. 34 (2006–07) to the Storting) reiterates the Government's aim for Norway to be at the forefront of international efforts to develop knowledge in and about the High North. By intensifying research and integrated, long-term monitoring in the High North, we can gain unique insights into the ongoing process of climate change, and the positive feedback effects climate processes in this region have on global warming and its impacts on nature and society. At present, climate-related monitoring programmes in the High North are fragmentary, and there are few long time series for climate and climate-related measurements in the Arctic. Climate monitoring programmes should cover the oceans, land, ice and the atmosphere.

The report *The Office of the Auditor General's investigation of the management of Svalbard* (Document no. 3:8 (2006–07)) points to the fact that time series are not long enough and do not cover critical areas. This means that the basis for decision-making used by the public administration is not sufficiently knowledge-based and that discretionary judgement is often applied instead. The Office of the Auditor General therefore considers it to be necessary to strengthen environmental monitoring systems for Svalbard to make it easier to judge environmental status and trends and thus provide a better basis for making decisions on what action to take.

APPENDIX V

International political guidelines

The Government's *Strategy for Scientific and Technological Cooperation with North America* (2004) mentions polar research and research related to the High North as areas of particular interest for closer collaboration.

On the basis of a recommendation by the Nordic Council (2005), the Nordic Council of Ministers commissioned a survey and analysis of the need and framework for Nordic research collaboration on climate change and its consequences in the Arctic (2007). The analysis is intended as a key planning tool for Nordic collaboration on climate research in the Arctic.

The need to strengthen international cooperation on research and education in the Arctic is set out in the 2004 Reykjavik Declaration, in which research and education ministers from the eight member states of the Arctic Council proposed the establishment of formal cooperation between their countries in this field. Norway, Denmark and Sweden have agreed on common objectives for their respective chairmanships of the Arctic Council in the period 2006–12. These state that:

- the Arctic Council should continue its efforts to provide high quality information on climate change that includes input from all Arctic states and peoples;

- the environment faces pressure from multiple uses, and a holistic perspective on the management of activities and the environment is therefore required;

- a key objective for the next three chairmanships will be to enhance discussion on and promote the integrated management of natural resource use in accordance with high environmental standards.

The Arctic Council
The Arctic Council was formally established in 1996, and is an intergovernmental forum for cooperation on common Arctic issues. It is intended to promote sustainable development, including social and economic development. A number of working groups have been established, and are responsible for carrying out research projects and programmes mandated by the member states through the Council. Two working groups are particularly relevant here:

- *Conservation of Arctic Flora and Fauna (CAFF)*. Through its participation in CAFF, Norway has undertaken to focus on research that is relevant to the conservation of Arctic biodiversity. Two important processes at present are the Circumpolar Biodiversity Monitoring Program (CBMP) and the Arctic Biodiversity Assessment (ABA 2010).

- *Arctic Monitoring and Assessment Programme (AMAP)*. AMAP has produced a series of assessments (including the ACIA and reports on Arctic pollution and Arctic oil and gas) that describe challenges, threats and gaps in our knowledge about the Arctic environment. Snow, Water, Ice and Permafrost in the Arctic (SWIPA) is a new project under AMAP. Its purpose is to generate up-to-date knowledge about the impacts of changes in sea ice cover, reduction of the Greenland ice sheet, snow cover, glaciers and permafrost on people and the environment in the Arctic and globally in the period up to the next assessment report from the IPCC, which is expected in 2012/13.

In the 2004 Reykjavik Declaration, research and education ministers from the eight member states of the Arctic Council proposed the establishment of formal cooperation between their countries on research and education.

The Nordic Council and the Nordic Council of Ministers
Official cooperation in the Nordic region is organised through the Nordic Council and the Nordic Council of Ministers. On the basis of a recommendation by the Nordic Council (2005), the Nordic Council of Ministers commissioned a survey and analysis of the need and framework for Nordic research collaboration on climate change and its consequences in the Arctic (2007). The analysis is intended as a key planning tool for Nordic collaboration on climate research in the Arctic.

The Antarctic Treaty
The Antarctic Treaty identifies research and research cooperation as a cornerstone of management and international cooperation on the continent. Norway has undertaken to comply with many of the decisions that are made under the Antarctic Treaty system and that provide guidelines for knowledge generation in the Antarctic. For example, ATCM Resolution 3 (2007) urges the parties to "maintain and extend long-term scientific monitoring and sustained observations of environmental change in the physical, chemical, geological and biological components of the Antarctic environment".

Other relevant international guidelines
- *The Convention on the Conservation of Antarctic Marine Living Resources* (CCAMLR): establishes a management regime based on an ecosystem approach, which requires a considerable body of knowledge about the Antarctic marine environment. Norwegian activity and interests in the Southern Ocean are expanding, entailing a greater need for Norwegian management-related research and monitoring activity. Norway has taken on commitments on Bouvet Island as part of the CCAMLR Ecosystem Monitoring Program (CEMP).

- *The Convention on Biological Diversity* (CBD) sets out general guidelines and obligations as regards the generation of new knowledge and monitoring of biodiversity in the polar regions. The Convention's objectives are conservation of biological diversity, the sustainable use of its components and ensuring access and benefit-sharing as regards genetic resources. The Arctic nations therefore have a general obligation to reduce biodiversity loss in

the polar regions by expanding research and monitoring activities and applying an ecosystem approach.

>> The 1973 *Agreement on the Conservation of Polar Bears* requires the parties to conduct national research programmes to improve the management of polar bears. A new international management regime is planned with regular meetings of the parties, coordinated with the Polar Bear Specialist Group (PBSG), will maintain a close focus on the species and on circumpolar knowledge generation.

>> The Government's *Strategy for Scientific and Technological Cooperation with North America* (2004) mentions polar research and research related to the High North as areas of particular interest for closer collaboration.

Norway has three bilateral polar research agreements with the US, Russia and Italy.

The agreement with the US includes joint projects, exchanges of research scientists and students, and the convening of joint workshops and conferences. It lists the following topics for joint activities: upper and lower atmosphere research, oceanography and geophysics, paleoenvironmental research and biology. Since 2000, the Research Council has earmarked NOK 2 million per year for activities under this agreement.

The purpose of the agreement with Russia is to develop technical-scientific cooperation on studies of the Arctic and northern areas. Thematic areas of interest are geophysics, oceanography (including research on sea ice), meteorology (including climate change), terrestrial and marine Arctic biology and geology. The Research Council does not have funding earmarked for this agreement, and practical cooperation is therefore dependent on both countries finding funding through their national research programmes. In addition to this general agreement, Russian and Norwegian researchers have established cooperation in Svalbard. This includes networking between Norwegian and Russian research groups through joint activities carried out in Svalbard, the establishment of a database of Russian research on the archipelago as a basis for new joint projects, intercalibration of instruments for comparative studies, expanding Russian participation in cooperative projects at Norwegian research stations in Ny-Ålesund and cooperation through UNIS. Since 2006, the Research Council has allocated about NOK 3 million per year to this cooperation.

The agreement with Italy involves cooperation on polar research, including joint projects within the EU framework programme for research. Areas of interest are biology, atmosphere research, geophysics, glaciomorphology, technology and social science research. The Research Council does not have funding earmarked for this agreement, and practical cooperation is therefore dependent on both countries finding funding through their national research programmes.

APPENDIX VI
Planned international initiatives concerning research infrastructure in the polar regions

Several international initiatives concerning research infrastructure in the polar regions are being planned. Norwegian research groups have shown an interest in taking part in these, including the following initiatives under the European Strategy Forum on Research Infrastructures (ESFRI):

>> *Aurora Borealis* – a new powerful icebreaker that will be able to operate in the central Arctic Ocean all year round and will have deep drilling capability;

>> *EMSO* (European Multidisciplinary Sea Observation) – fixed seafloor observatories with power and signal cable connections to shore to provide real time data and allow control of the instruments;

>> *EURO-ARGO* – the array is the European component of the Global Ocean Observing System (GOOS), based on autonomous profiling floats. The objective is to develop a global array of floats spaced about 300 km apart throughout all ice-free areas of the deep ocean. The data are transmitted in real time by satellite;

>> *ICOS* – aims to build a network of standardised, long-term, high precision integrated monitoring of atmospheric greenhouse gas concentrations of CO_2, CH_4, CO and radiocarbon-CO_2 to quantify the fossil fuel component, and of ecosystem fluxes of CO_2, H_2O, and heat together with ecosystem variables. The ICOS infrastructure will integrate terrestrial and atmospheric observations at various sites into a single, coherent, highly precise dataset;

>> *LifeWatch* – this project is to build up infrastructure and governance structures for research on the protection, management and sustainable use of biodiversity;

>> *SIOS* (Svalbard Integrated Arctic Earth Observing System) – under Norwegian leadership. SIOS will be an important Norwegian contribution to the Sustaining Arctic Observing Networks (SAON). SIOS is included in the updated ESFRI Roadmap.

Trykksak

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The Research Council of Norway
P.O. Box 2700 St. Hanshaugen
N0-0131 Oslo

Telephone: +47 22 03 70 00
Telefax: +47 22 03 70 01
post@forskningsradet.no
www.rcn.no/english

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