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Arctic environment: European perspectives

Why should Europe care?

European Environment Agency

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Contents

Foreword

Much of the Arctic landscape remains undisturbed, however industrial activities in Europe and elsewhere are having noticeable and adverse effects on this once pristine environment. In addition, the growing exploitation of the Arctic's vast resources for export to Europe and other overseas markets — be it fish, timber or minerals — is raising the risk and severity of negative impacts. These interactions between the Arctic and the rest of the world also bring complications for indigenous peoples in the region, and an attendant obligation to assist them in their efforts to preserve their cultures and traditions.

The range of pressures is diverse, including those arising from the fragmentation of habitats and the unsustainable use of natural resources. Unique plant and animal species are already under threat or disappearing due to climate change. Fish stocks that were once abundant are now over-harvested and diminishing. Pollutants, such as polychlorinated biphenyls (PCBs), some of which are known to be carcinogenic, are present in key Arctic species and are of great concern for human health. Piecemeal development is also beginning to have a major cumulative environmental effect, leading to negative socio-economic consequences for the Arctic's indigenous peoples.

International and national agreements and legislation are much needed, and in this, Europe has an important role to play. Decision-makers need to take the current challenges seriously, and find solutions to them through a structured process of consultations and subsequent policy development and implementation. If this task is neglected, the consequences for the Arctic are very likely to be drastic.

A welcome initiative is being undertaken by the European Commission in close cooperation with EU Member States, partner countries (Norway, Iceland and the Russian Federation) and northern dimension regional bodies: the Arctic Council, the Council of Baltic Sea States, the Barents Euro-Arctic Council, and the Nordic Council of Ministers. A new three-year action plan — 'The second northern dimension action plan 2004–2006' — was endorsed by the European Council in October 2003. This addresses Arctic issues and pays particular attention to crosscutting themes, with a focus on sustainable development. The contributions that the indigenous peoples living in the High North and in the Arctic can make to this process, and the role they play in the stewardship of the region, are of key importance for the implementation of the new plan.

This report is a joint product of the United Nations Environment Programme (UNEP) and the European Environment Agency (EEA). It aims to focus attention on the Arctic region and highlight its crucial role in the future of Europe. It is our hope that it will promote discussion on European policy actions related to the Arctic, and contribute to the implementation of the second northern dimension action plan.

Klaus Töpfer, UNEP

Jacqueline McGlade, EEA

Executive summary

Arctic indigenous peoples and nature

- The Arctic's unique nature is still relatively undisturbed. However, it is under increasing threat from pollution, climate change and unsustainable development.
- The peoples of the industrialised countries outside of the Arctic are the primary beneficiaries of Arctic resources. These same countries, including those in the EU, are a major source of pollution and other problems in the Arctic region.
- Indigenous peoples have lived in the Arctic and utilised its resources in a sustainable manner for millennia. Today they receive a relatively small share of the benefits of its exploitation, yet incur the greatest negative effects. Contaminants, land fragmentation and declining wildlife populations have potentially far-reaching impacts on their health and ultimate survival in the region.

Exploitation of Arctic resources

- Some key commercial fish stocks are over-harvested. In addition, the future consequences of climate change on fisheries may be significant, though these consequences are difficult to predict.
- Arctic forests are sometimes mismanaged and prone to unsustainable logging practices. Mining activities and metal ore processing plants have severely polluted some areas, laying waste to taiga and tundra lands used by indigenous reindeer herders and hunters.
- The Arctic has large reserves of oil and gas and other minerals. Pipelines, roads, harbour facilities and other transport systems are required for the exploitation of these resources. Such infrastructure increases land fragmentation, threatens biodiversity, and heightens the risk of polluting land and water ecosystems. Decreasing sea-ice in the Arctic has led to renewed interest in the Northern Sea Route (NSR) linking the Atlantic and Pacific Oceans via Russia's northern coast. Oil spills could have catastrophic effects on some Arctic ecosystems.
- Northern Scandinavia and parts of Russia are examples of areas where the current growth of infrastructure related to transportation, oil, gas and mineral extraction is increasingly incompatible with land requirements for reindeer husbandry. There is currently no policy response in place to secure the rights of reindeer husbandry against piecemeal development.

Pollution in the Arctic

- Europe is a major source of pollutants that contaminate the Arctic as a result of long-range transport via air or water. Industry in and around the Arctic also contributes significantly to this contamination in some parts. Heavy metals — mercury in particular — and organic chemicals, which do not easily break down in the environment, are key concerns.
- Volatile persistent organic pollutants and mercury are among the substances that deposit in the Arctic as a result of specific chemical and physical processes, such as 'condensation' from cold air masses or photochemical reactions that take place in the Arctic.
- Many persistent organic pollutants are concentrated in the fatty tissues of animals that indigenous people rely on for food. The Inuit peoples of Greenland and Canada have some of the highest exposures to mercury and persistent organic pollutants anywhere on Earth. This raises serious concerns about possible effects on human health.
- Agricultural chemicals including organochlorine pesticides have been used in Europe and elsewhere, but generally not in the Arctic. However, they are present in the Arctic air, water and snow, and have been found in animals and humans at levels that give rise to considerable concern.
- New contaminants — such as flame-retardant chemicals and pesticides in current use — are now being detected in the Arctic. Their effects on the environment and human health are largely unknown.
- European nuclear reprocessing plants are the second largest source of historical radioactive contamination of the Arctic. Within the Arctic, there are numerous military and civilian nuclear installations — especially on the Kola peninsula of northwest Russia — that pose risks for large-scale radioactive contamination.

Climate change

- Global climate change is expected to have its most pronounced effects in the Arctic. These effects are likely to become evident in the Arctic sooner than in other parts of the planet.
- Significant recent changes have been observed. For example, the extent of sea-ice has decreased by approximately 3 % per decade over the last 25 years, and average temperatures have increased by 2 °C over large areas of Siberia and northern North America since 1960.
- Climate change may result in the tree-line advancing north, with decreasing areas of tundra and permafrost. The attendant effects on ecosystems could be an increased emission of greenhouse gases, and the introduction of alien species into the Arctic.
- Changes in Arctic ecosystems will affect the peoples of the Arctic, as changes in the availability of natural resources place pressures on cultures and lifestyles.
- Changes in ocean circulation and weather in the Arctic can have a strong effect on Europe. For example, a weakening of the Gulf Stream could result in a significantly cooler climate for Scandinavia, western Europe and northwest Russia.

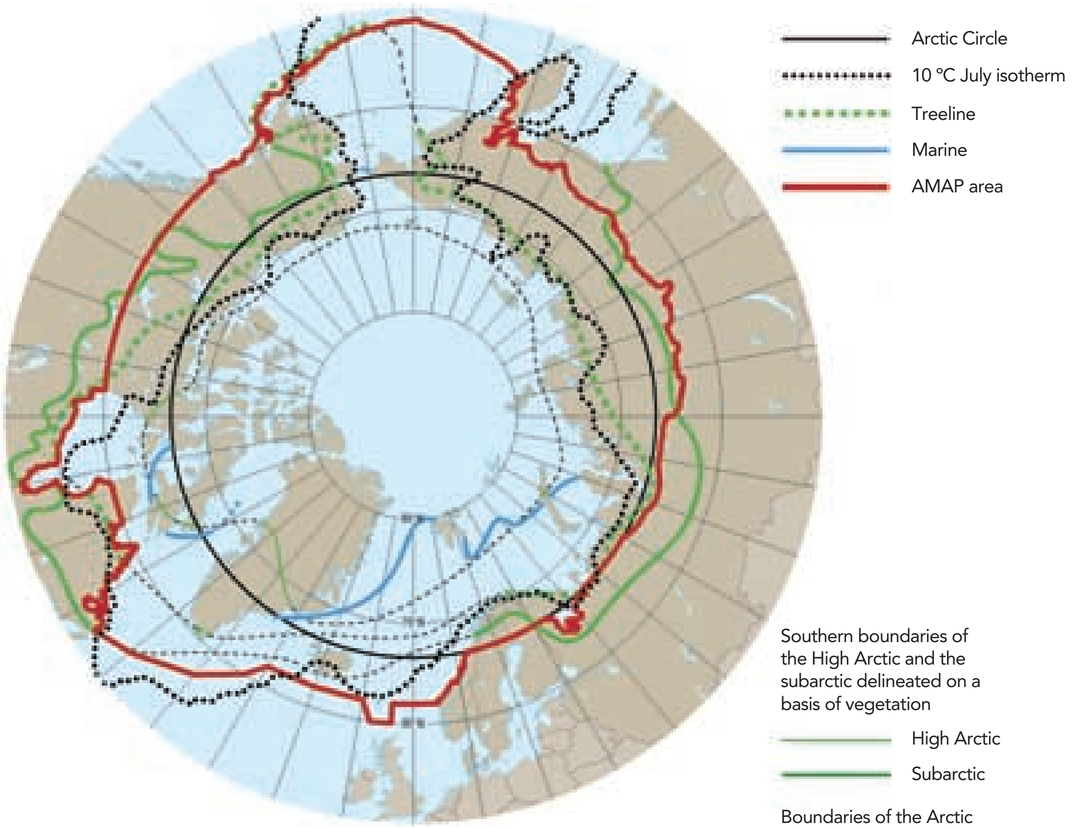
Actions and policies

- The EU's second northern dimension action plan 2004–2006 was endorsed by the European Council in October 2003. It will be the main political instrument to develop the necessary regional cooperation to tackle environmental problems in the Arctic stemming from activities in Europe.
- Given the variety and complexity of the issues, the environmental aspects of the action plan need to be implemented in close cooperation with the Arctic Council and its working groups.
- The Arctic indigenous peoples need to be fully involved in developing responses to issues such as exploitation of resources, pollution, biodiversity loss and climate change. This should involve co-management and community based natural resource management initiatives. The participation of Arctic indigenous peoples in top-level international forums could also have wide benefits.
- International conventions can significantly reduce some of the worst pollution threats to the Arctic. The process of ratification is slow, however, and existing conventions do not completely address all the issues. Now that the Stockholm POPs (Persistant Organic Pollutants) Convention and key protocols of the UNECE CLRTAP (United Nations Economic Commission for Europe — Convention on Long Range Transboundary Air Pollution) have been ratified and are entering into force, they are expected to make a significant impact. Continued vigilance is needed to further develop policy, as required, to meet emerging threats from new contaminants in the Arctic.
- Efforts by the EU and others to encourage ratification and implementation of the Kyoto Protocol are important for the protection of the Arctic environment. In order to improve the information available for decision-making, more emphasis could be given to supporting climate-related research in the Arctic.

1. The Arctic indigenous peoples

The Arctic (Figure 1.1) is recognised as one of the planet's relatively undisturbed regions, where indigenous peoples pursue their traditional lifestyles. Europe's dependence upon the Arctic's resources is increasing. At the same time, the Arctic is coming under increasing pressure from unsustainable development, land fragmentation, pollution and climate change. International cooperation is needed to address these problems through the Arctic Council and the second northern dimension action plan 2004–2006.

Figure 1.1 **The circumpolar Arctic**



Source: AMAP, 1998.

The Arctic's most pronounced feature is a large, mostly ice-covered ocean, which is surrounded by land governed by eight nations with independent national legislation and regulations. Different definitions of the Arctic are used depending on the context. One reference is the line where the average air temperature in the warmest month is 10 °C, known as the 10 °C summer isotherm. This boundary also corresponds roughly to the northern tree-line. The marine boundary denotes where the cool, less saline surface waters from the Arctic ocean converge with the warmer, saltier waters from oceans to the south. The Subarctic region is typified by the presence of taiga or forest tundra, with its southern limit generally corresponding to the limit of discontinuous and sporadic permafrost (where permafrost is still found, but is interspersed with scattered thawed areas). The High Arctic presents the most extreme conditions for life. Nevertheless, 8 species of terrestrial mammals and 360 types of vascular plants have their home here. The overall definition that is used by the Arctic monitoring and assessment programme (AMAP), as agreed by Canada, Denmark/Greenland, Finland, Iceland, Norway, the Russian Federation, Sweden and the United States, is shown in the map. See also Crane and Galasso (1999).

For millennia, the Arctic's humans (Figure 1.2) have relied on biological resources for their subsistence and livelihood. Indigenous peoples (1) have developed

(1) Definition of indigenous peoples (ILO, 1989): (a) Tribal peoples in independent countries whose social, cultural and economic conditions distinguish them from other sections of the national community, and whose status is regulated wholly or partially by their own customs or traditions or by special laws or regulations; (b) Peoples in independent countries who are regarded as indigenous on account of their descent from the populations which inhabited the country, or a geographical region to which the country belongs, at the time of conquest or colonisation or the establishment of present State boundaries and who, irrespective of their legal status, retain some or all of their own social, economic, cultural and political institutions.

unique lifestyles that are in harmony with the land and the sea. But their societies are now threatened, as they are increasingly affected by a fast changing world. Recognition and respect for indigenous peoples' cultures and rights represent important challenges.

There is a commitment by the Arctic's indigenous peoples to build partnerships and to promote cooperation to address today's pressing political issues. International events are affecting the Arctic more and more and, in response, indigenous peoples have to be international in orientation and activity. They depend upon a healthy environment and recognise the interactions between environmental protection, sustainable development, human rights and cultural survival (Watt-Cloutier, 2003). Several organisations in North America, Europe and Russia represent the indigenous peoples (2).

Source: Bryan & Cherry Alexander Photography.

Photo: Reindeer husbandry

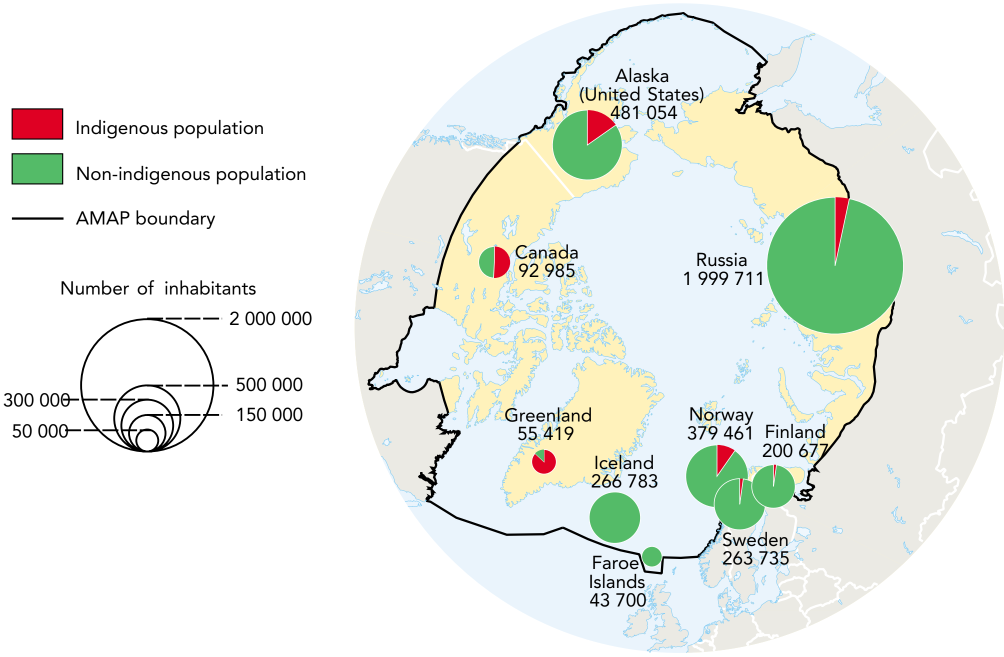
The Arctic indigenous peoples' social networks, traditions and lifestyles depend on the movements of wild and domestic animals. Traditional foods not only provide essential nutrients, but are also central to cultural and spiritual well-being. Any threats to food security, such as those posed by contaminants, land fragmentation and declining wildlife populations, have potentially far-reaching impacts on health and survival.

In some areas, especially in Russia, indigenous residents are exposed to a number of social problems associated with their relative isolation and differences in language and cultures. In a modern world, these societies do not receive adequate education and health services. Housing is often poor and the old ways of life are threatened by newcomers employed in modern industries, which offer few employment opportunities for the indigenous communities (Sulyandziga *et al.*, 2002).

(2) See also the Arctic Council Indigenous Peoples' Secretariat (IPS): http://www.arcticpeoples.org

Source: AMAP, 1998.

Figure 1.2 **The Arctic peoples**



The circumpolar Arctic is home to some 3.8 million people, about 850 000 of whom live in the Arctic areas of northern Norway, Sweden and Finland (AMAP). The Saami of northern Scandinavia and the Kola Peninsula in northwestern Russia are the most numerous indigenous peoples of the European Arctic, together with the Nenets and Komi in northwestern Russia. In a circum-polar context, the Inuit represent the largest indigenous group with communities in Alaska, Canada, Greenland and the Russian Federation. The proportion of the population in Arctic regions that is indigenous varies from 85 % Inuit in Canada's Nunavut Territory, to 2.5 % in the Saami region of Fennoscandia and the Kola Peninsula, to 0 % in Iceland and the Svalbard archipelago.

1.1. Actions and policies — giving indigenous peoples stewardship

Authorities and institutions need to understand the social and economic value of natural resources in order to craft the policy and management tools for conservation and sustainable use. Moreover, such instruments are most effective when they provide benefits to key stakeholders — in particular indigenous peoples — who depend upon natural resources.

Mechanisms that give indigenous peoples stewardship — and indeed ownership — over Arctic wildlife resources are therefore important. For example, supportive national legislation and regulations could allow indigenous peoples to decide if they want to hunt for subsistence, or if they want to sell their user rights to outsiders.

Capacity and institution building is crucial for designing and implementing such systems. Exchanging 'lessons learned' between projects and programmes under different social and political regimes could contribute usefully to co-management strategies involving indigenous peoples, authorities, the private sector and other stakeholders. Existing cases of co-management could be used as models. The co-management system of the Inuvialuit settlement region in Canada, for example, deals with all living resources in the region, including habitat (CAFF, 2001, pp. 64–65).

Complementary to these local and community-based approaches, the International Convention on Biological Diversity (CBD) seeks to promote conservation, sustainable use and equitable sharing. The latter two objectives receive little attention, however. There may be need for an Arctic protocol to the convention that would address sustainable use and equitable sharing under the stewardship of indigenous peoples.

Such a protocol could be harmonised with International Labour Organisation (ILO) conventions and other legal instruments' recognition of indigenous peoples.

2. The Arctic natural environment

The Arctic's unique animal and plant species survive under extreme conditions, and in turn enable the sustainable lifestyles of its indigenous peoples. The Arctic also represents an important source of commodities for Europe, such as fish, timber, oil and gas, and other minerals. Unsustainable and irresponsible development, pollution and climate change are driven to a significant extent by European demand and activities. Without concerted international action, the Arctic environment will be severely degraded.

2.1. Unique nature — adaptation to cold

The Arctic holds only about 10 % of the plant and animal species that may be found in temperate regions, which is a fraction again of those in the tropics (CAFF, 2001). However, the relatively few species that live in the Arctic can be surprisingly abundant and are extraordinarily well adapted to life under marginal conditions. The growing season for plants is very short — there is often no more than a few weeks to grow and set seeds.

Source: Thor S. Larsen.

Photo: The Arctic poppy

The Arctic poppy's white and yellow flower forms a parabola that collects the sunlight in the centre where the seeds are formed. Its flower faces the sun as it moves across the sky each day, using all available sunlight. Other plants grow in small balls so that the little heat from the sun is concentrated in the middle, where the roots are. Some plants require two or more summers to set seeds.

Reindeer, seals and polar bears have thick layers of fat that provide effective insulation against the cold. Such fat reserves are also important energy reserves during winters with little food.

Modern biotechnology enables genetic modifications of plants and animals that in turn may become beneficial for people. Tropical ecosystems have so far received particular attention in bio-engineering, mainly because of the richness of their species. However, cold resistant plants may be equally important, because they may allow for improved crops and better harvest in marginal areas, or where growth seasons may be affected by drought or changes in average temperatures. Arctic species may thus be of importance for the biotechnology and pharmaceutical industries in the future.

Source: Thor S. Larsen.

Photo: A polar bear

The polar bear's thick layer of blubber (subcutaneous fat) protects against low temperatures. In addition, its transparent white fur allows the sun's radiation to penetrate to the skin, which is black, and thus optimal for absorbing heat. Thus, the polar bear's fur acts as an effective greenhouse in utilising the sun's heat.

The polar bear's blubber also acts as a food reserve in times of hunger. The most extreme example is of pregnant female bears. They enter maternity dens in snowdrifts in late autumn and give birth to 2–3 cubs at the end of December or early January. Each cub weighs only a quarter of a kilo at birth, but they gain weight fast. Their mother's blubber is the source for producing nutritious milk. In this way, her muscle mass — which, in other mammals, usually is the reservoir for the provision of milk — is spared. When the mother bear emerges from her den in March or early April, she has starved for almost half a year. Each of her cubs has gained almost ten kilos from their mother's body.

Source: Thor S. Larsen.

Photo: Arctic bird cliffs

Droppings and spills from the bird-cliffs fertilise the slopes and the tundra. This triggers the growth of lush vegetation which is important for grazers such as reindeer and geese. Birds of prey and Arctic foxes raid birds' nests and live on eggs and chicks that fall off the cliffs. The abundance of plants, birds and mammals is in stark contrast to the barren land further away. The richness of plants and animals at the bird-cliffs is a visible and convincing demonstration of the links between marine and terrestrial ecosystems of the Arctic.

2.2. Links between life on land and at sea

Marine biodiversity is not equally distributed, but is clustered in specific, highly critical areas. These include the relatively shallow Barents Sea, estuaries and deltas such as the Lena Deltas, and coastal areas surrounding island systems such as Novaya Zemlya, Franz Josef Land and Svalbard. Near-shore waters, and open leads in the sea-ice are important food sources for seabirds such as auks, guillemots and gulls, with thousands and even millions of pairs breeding in cliffs near the shores.

Source: Thor S. Larsen.

Photo: The Arctic fox in the Svalbard ecosystem

Arctic foxes are usually dependent upon lemmings and other small rodents for their survival. But, in the Svalbard archipelago, such small mammals are lacking in the wild. Hence the Arctic fox has to rely on other food sources. During summers, they patrol under the bird cliffs where they scavenge on seabird chicks or adults that have been wounded or killed by falling stones and rocks or during the birds' fights over nesting space. Such prey, and meat from dead reindeer, is brought to depots for the winter. When the brief Arctic summer is over, with few opportunities for the foxes to catch their own prey, they rely upon their depots. Foxes often also follow polar bears onto the sea ice and scavenge on the leftovers from the bears' seal kills.

Because small rodents are absent in the wild, birds of prey such as falcons, owls and ravens cannot survive either. And because such birds are lacking in the ecosystem, the large glaucous gull has taken over as the air's predator. Glaucous gulls feed on eggs and chicks in the bird-cliffs, take eider and goose chicks whenever there is an opportunity, and are even able to catch adult little auks in flight.

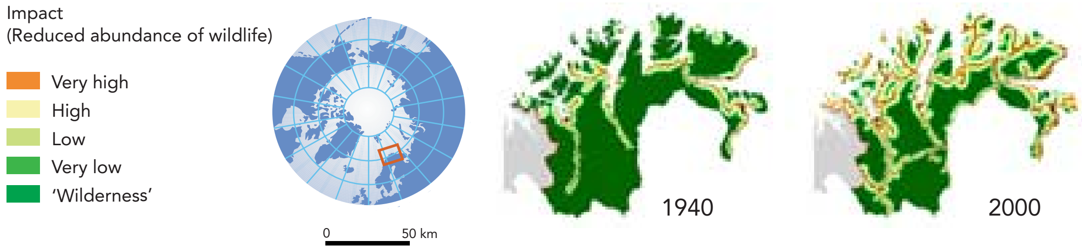
2.3. Threats to species and ecosystems

A boom in Arctic exploration for oil, gas and minerals has opened up vast, formerly inaccessible, land and seas to industry and modern development. The Arctic still contains some extensive wilderness areas, but over 70 % may be heavily disturbed in less than 50 years (Nellemann *et al.,* 2001a; Nellemann *et al.,* 2003a).

Fragmented and shrinking reindeer pastures result in over-grazing in what remains, which in turn leads to erosion and affects animals' conditions and reproduction abilities (Nellemann *et al.,* 2001b, 2003b). Extensive pipeline systems in Arctic Russia and in Alaska seriously affect the distribution of species (Cameron *et al.,* 1992; Nellemann and Cameron, 1996, 1998; Nellemann *et al.,* 2001a, b; Vistnes *et al.,* 2001, 2004). Land fragmentation and degradation exacerbates problems for indigenous peoples when they find their access and traditional use of land and resources restricted or barred (Nellemann *et al.,* 2001a).

Source: Nellemann *et al.*, 2001b, GRID-Arendal.

Figure 2.1 **Road development in northern Norway**



Reduced size of natural habitats is a growing problem. Reindeer may be affected by roads up to five kilometres away. Many birds and predators, which require large home ranges and which travel over long distances in their hunt for food, are even more sensitive to infrastructure. In northern Norway, undisturbed areas have been reduced from 48 % in 1900 to only 11.8 % in 1998.

Resource development requires road and utility networks. Roads, pipelines and other infrastructure are changing much of the face of the Arctic landscape through fragmentation (Figure 2.1). Vehicles can tear up the thin active layer and protective vegetation above the permafrost, exposing the frozen ground to melting and erosion. Because re-growth is slow in the Arctic, water and thawing can easily transform a vehicle track to a flowing river in a very short time (Forbes, 1998; OECD, 1999). Roads and pipelines also disrupt habitats for many Arctic birds and mammals. Permafrost degradation causes additional problems and new technology is needed to cope with waterlogged as opposed to frozen surfaces.

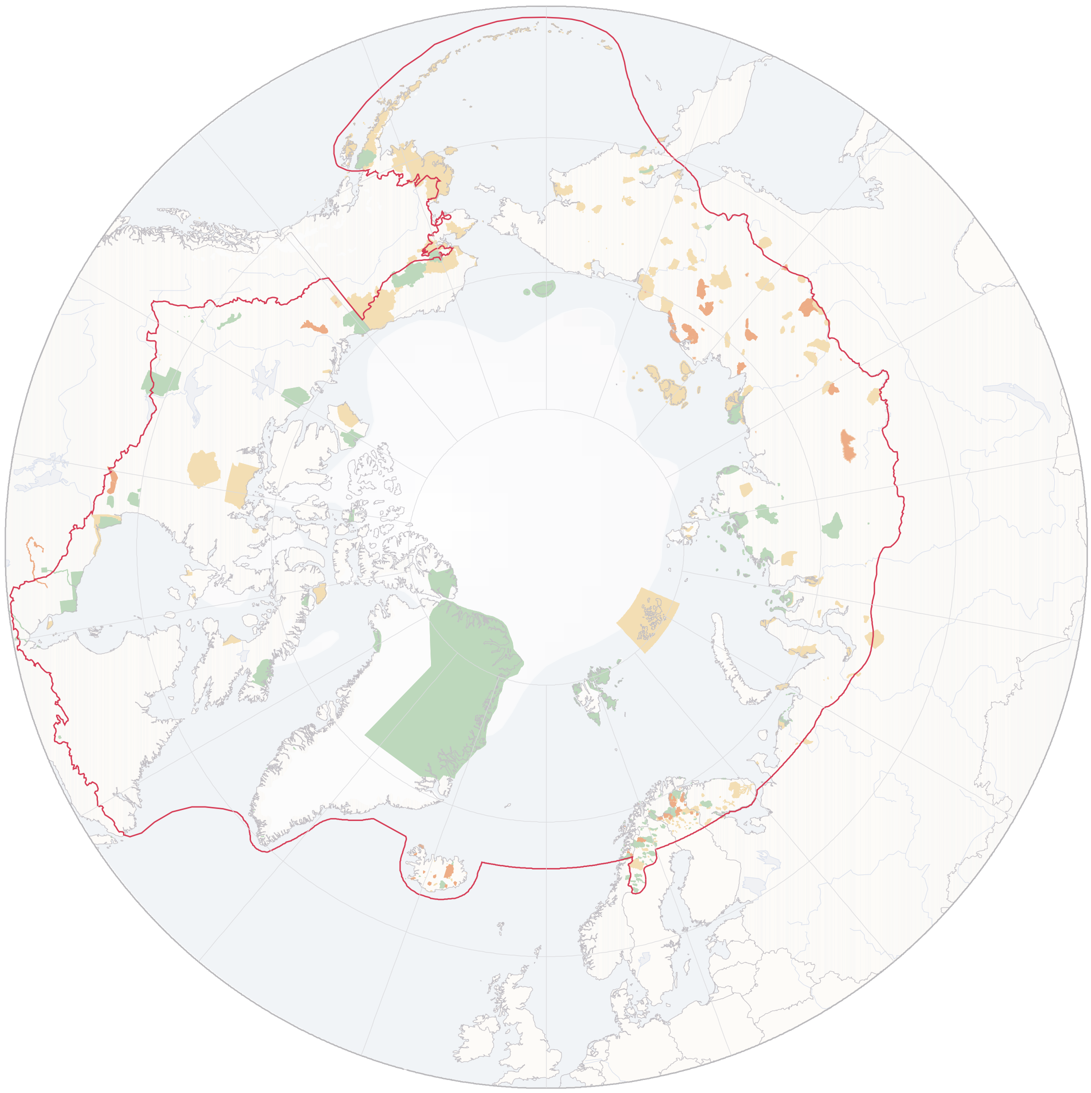
The Arctic environment is more vulnerable to spills than warmer environments. Oil breaks down more slowly under cold, dark conditions and Arctic plants and animals need a longer time to recover from damage. Contamination from oil and gas development, releases from marine shipping and chronic leakage from poorly maintained pipelines pose great threats.

2.4. Recent progress in conservation

International cooperation and global action through treaties and agreements are vital for Arctic conservation and for proper management and sustainable use of natural resources. The Arctic countries have taken several steps to reduce habitat loss and prevent fragmentation. The number of protected areas was increased from 280 in 1994 to 404 in 2001, while the overall protected coverage has been extended to 2.5 million km^2 (Figure 2.2) (CAFF, 1994 and 2001).

Figure 2.2 **Protected areas in the Arctic**

Source: CAFF, 2001.



I Strict nature reserve/wilderness area
II National park

III Natural monument
IV Habitat/species management area

V Protected landscape/seascape
VI Managed resource protected area

CAFF [1]) boundary

An extensive network of protected areas exists throughout the Arctic, but rules and regulations differ. Exploration and exploitation of minerals may be permitted in Northeast Greenland National Park, and fishing and hunting are often allowed in Norway's national parks. However, no visitors are allowed to Kong Karls Land Nature Reserve in Svalbard without prior permission. The reserve's two small islands are important polar bear denning areas and need to be totally protected. The map shows protected areas that are more than 500 hectares in size.

1) CAFF — Arctic Council working group on the Conservation of Arctic Flora and Fauna.

The Arctic is summer home to many migratory birds and marine mammals. They depend on healthy environments and protection both in their Arctic summer habitats and in their southern winter quarters. Some species receive adequate protection today, but there is still much to do. Networks of protected areas need to be put in place. These should recognise animals' home range and seasonal distributions, including Arctic migratory birds' flyways and wintering habitats. Today, some parks and reserves are strictly protected, while others allow mineral extraction and associated infrastructure development. Others permit harvesting of plants and animals (e.g. for subsistence use by indigenous peoples).

Source: Thor S. Larsen.

Photo: The Barnacle goose

In the 1940s, the Svalbard population of the Barnacle goose had been reduced to only 300 birds. This was mainly because of extensive hunting in its summer habitat in Svalbard and along the migratory routes towards its wintering quarters in the UK. The geese were then totally protected on their winter ranges in Great Britain. Hunting was prohibited in Svalbard and sanctuaries were established in their breeding grounds along Spitsbergen's west coast in the early 1970s. Through effective year-round protection, the Svalbard population is now estimated at 23 000 Barnacle geese (Madsen *et al.,* 1998).

Source: Thor S. Larsen.

Photo: The Atlantic walrus

The Atlantic walrus was once hunted in Svalbard to near extinction. Norway introduced total protection in 1953, but still only very few walrus were spotted in the Svalbard waters. Then herds of 50 or more animals were suddenly observed on their old hauling-out grounds in the early 1970s. Recent research on walrus, polar bears and other species suggests that Svalbard, Franz Josef Land and adjacent seas form a common ecological entity. The area probably shares populations of several species. In 1995, Svalbard's and Franz Josef Land's combined walrus population was estimated at a minimum of 1 450 animals (Gjertz and Wiig, 1995), and may still be increasing.

Relevant conventions: Nature conservation and terrestrial living resources

Convention concerning the protection of the world cultural and natural heritage (World Heritage Convention), Paris, 1972.

Convention on biological diversity (CBD), Nairobi,1992.

Convention on the conservation of migratory species of wild animals (CMS), Bonn, 1979.

Convention on international trade in endangered species of wild fauna and flora (CITES), Washington DC, 1973.

Convention on wetlands of international importance, especially as waterfowl habitat (Ramsar Convention), Ramsar, 1971.

For a general overview see Fridtjof Nansen Institute (2003) and Nowlan (2001).

Regulations for protected areas need to be harmonised

A challenging idea has been promoted by, among others, the World Wide Fund for Nature (WWF). It is to establish larger bilateral protected areas that embrace natural ecosystems with critical habitats and seasonal migration routes of key species (e.g. Svalbard, Franz Josef Land and adjacent seas). Interestingly, similar ideas are being pursued and implemented elsewhere in the world. For example, South Africa, Mozambique and Zimbabwe are establishing large common protected areas across their borders to ensure the survival of key African wildlife species and ecosystems.

3. Human use of Arctic resources

Arctic resources have been exploited for many years. Europeans have played a significant role in this exploitation, from traditional hunting activities to modern day tapping of the Arctic's natural reserves. Oil, gas and other minerals are among the valuable commodities sought after. Fishing, forestry and even tourism can threaten natural resources. Policies and actions are essential to control the use of resources and the impacts of infrastructure development.

3.1. Europe's use of the Arctic

Europeans have exploited Arctic resources for centuries. Hunters from Europe and elsewhere pursued whales, seals, walrus, polar bears and other Arctic animals, sometimes to the brink of extinction. In past centuries, immigrants' interactions with the indigenous populations resulted in the spread of diseases and social dislocation. Competition for land and resources still goes on. More recently, the Arctic's natural reserves of oil, gas and other minerals have been the focus of attention.

Hunting continues in most of the Arctic outside reserves and protected areas, but is often tightly regulated, favouring indigenous and local peoples' needs and traditional rights. Some species are surviving in good numbers due to international agreements and new national legislation. Others have not fared so well and are still subject to strict conservation controls through national and international regulations. Illegal exploitation, including supply of illicit markets in rare and endangered species, or generous quotas are constant threats.

Several commercially important fish stocks have collapsed in recent decades, although some have recovered. Over-fishing and changes in marine ecosystems — possibly caused in part by climate change — have led to serious reductions in many sea-bird colonies, e.g. in Svalbard.

Tourism is one of the world's fastest growing industries. Recent studies show that the proportion of tourists 'seeking the sun' on sub-tropical and tropical beaches is on the decline. More people want to explore cultural sites and exotic nature. The Arctic is no exception in this respect. Aircraft and ice-going vessels allow travel to very remote areas. Today, tourists can even visit the North Pole in icebreakers or aircraft. Snow-scooters and all-terrain vehicles make it possible for tourists to explore new polar landscapes and places of interest. New 'products' are marketed, such as the Arctic's northern lights *(Aurora Borealis)*.

Shipping tourism is on the increase in some regions, such as Alaska, Greenland and Svalbard. But the companies that run such enterprises are mostly based in the capitals and cities in the south. Thus, little of the revenue from this kind of tourism benefits the indigenous peoples or local communities in the Arctic.

Further, mass tourism frequently leads to serious deterioration of places of interest, as hundreds, and sometimes thousands, of tourists trample the ground in very limited areas where they go ashore. They leave litter and may remove objects that should be left where they are.

Eco-tourism is also on the increase, but this may sometimes lead to disturbance of wildlife at times when they need rest in order to breed or to feed.

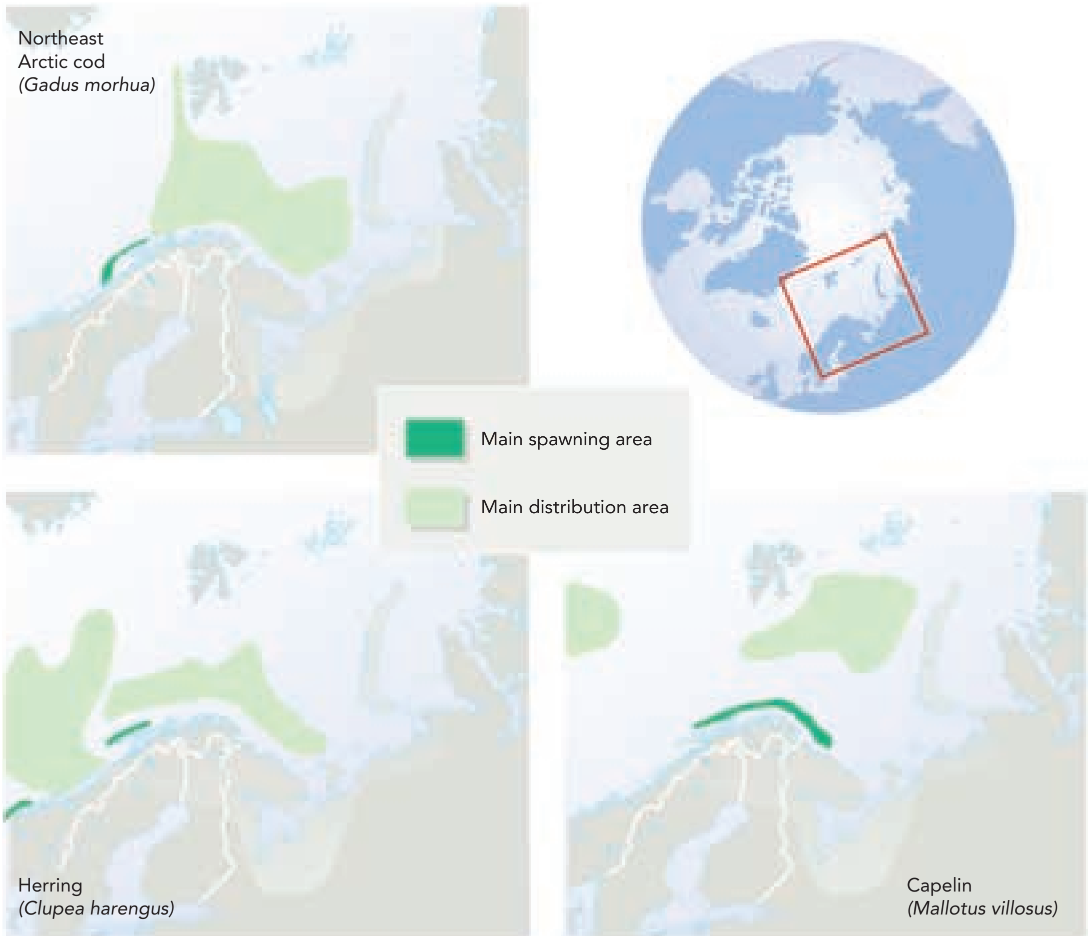
3.2. Fishing in the Arctic

Europeans have been fishing in the Arctic for hundreds of years, and the industry is still vital for many countries. However, changes in technology and economic pressures have resulted in some stocks being over-harvested. Legislation, the enforcement of regulations and international cooperation are all needed to maintain healthy fish stocks and marine ecosystems.

For more than a thousand years, the productive North Atlantic and Arctic waters have been the main source of fish for Europe. Fish exports provided the Nordic countries with hard currency to import commodities from Europe. Wind dried cod and salted cod and herring were primary export products. For centuries, cod-liver oil was used for Europe's lamps, for tanning hides, and as a lubricant in European industrial plants. Early fishing was purely coastal and seasonal, but there was a movement towards offshore fishing by the end of the nineteenth century. Technical improvements and motorisation of the fleet have multiplied by several factors the number and scale of fish landings (Nordic Council of Ministers, 2000).

The seas of the North Atlantic are characterised by a mixture of polar waters from the north and warm Atlantic waters from the south. In years with large Atlantic influence, plankton production — food for fish, birds and some whales — is enhanced. This benefits population growth of many fish species. Some commercially important fish stocks spawn on the shelf off northern Norway, while the larval stages drift back into the Barents Sea (Dragesund and Gjoesaeter, 1988). The location of important Arctic fish stocks is shown in Figure 3.1.

Figure 3.1 **Important Arctic fish stocks**



Main spawning and general distribution areas of three economically important Arctic fish stocks.

Source: Norwegian Polar Institute.

Trawling for shrimp and hunting for minke whale, harp and hooded seals are important for some Nordic countries. The most important species is Atlantic salmon, which is produced mainly in Norway and the Faroe Islands. Fish farming for trout, cod and Greenland halibut is steadily increasing.

3.2.1. Europe's fishing nations and communities

Today's European Arctic fisheries take place in four main regions of the North Atlantic: the northeast Atlantic (including northern parts of the Norwegian Sea, the Barents Sea and the White Sea), Faroe Islands, Iceland and Greenland. About half of the fish consumed in the EU comes from the European Arctic. Approximately 54 % of Norwegian seafood exports went to the EU in 2002 ([3]). In 2001, Iceland exported fish products worth EUR 1.46 billion; about 74 % of this sum came from the EU ([4]).

(3) Seafood Norway: http://www.seafood.no/whatsnew
(4) Statistics Iceland: http://www.hagstofa.is

The Barents Sea large marine ecosystem (LME) is particularly important. Bordered by Norway and the Russian Federation, it supports a large fishery that had total annual catches of around 2.5 million tonnes in the late 1970s. There have been major changes in recent years, however (see Figures 3.2–3.5). The changing and transboundary nature of marine fisheries in this area requires management approaches that recognise ecosystem perspectives ([5]).

3.2.2. Trends in Arctic fish resources

Cod, haddock, herring and capelin are some of the main fish stocks in the European Arctic. Cod fishing in the North Atlantic shows large fluctuations, and has been steadily declining for the past 50 years (Figure 3.2). It peaked in the 1960s at roughly two million tonnes. From 1969 onwards, the International Council for the Exploration of the Sea (ICES) has almost consistently expressed concern at the future size of the northeast Atlantic cod spawning stock.

Figure 3.2 **Total catch of Atlantic cod in the North Atlantic in the latter half of the twentieth century**

Source: CAFF, 2001.

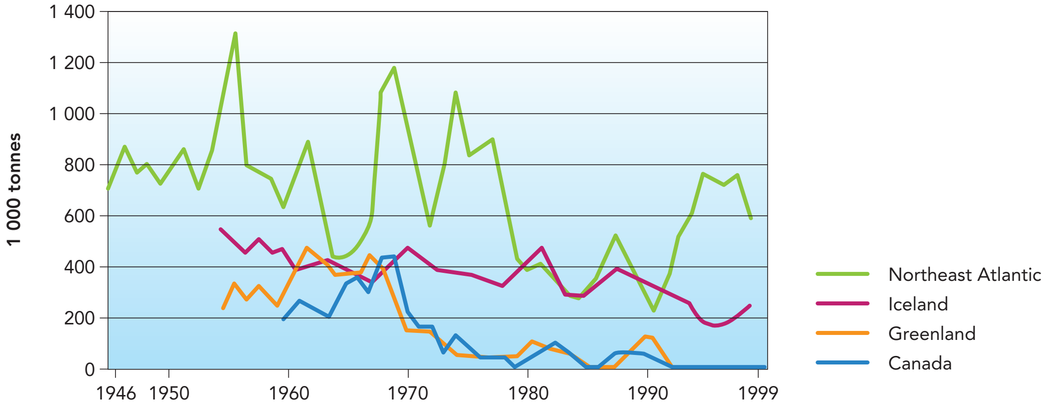
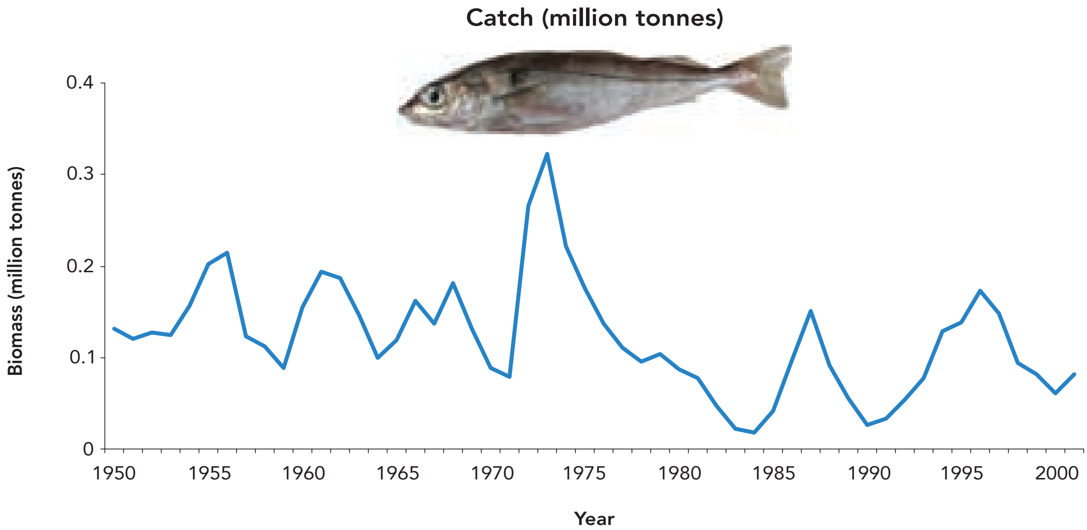


Figure 3.3 **Landings of haddock from the Barents Sea since 1950**

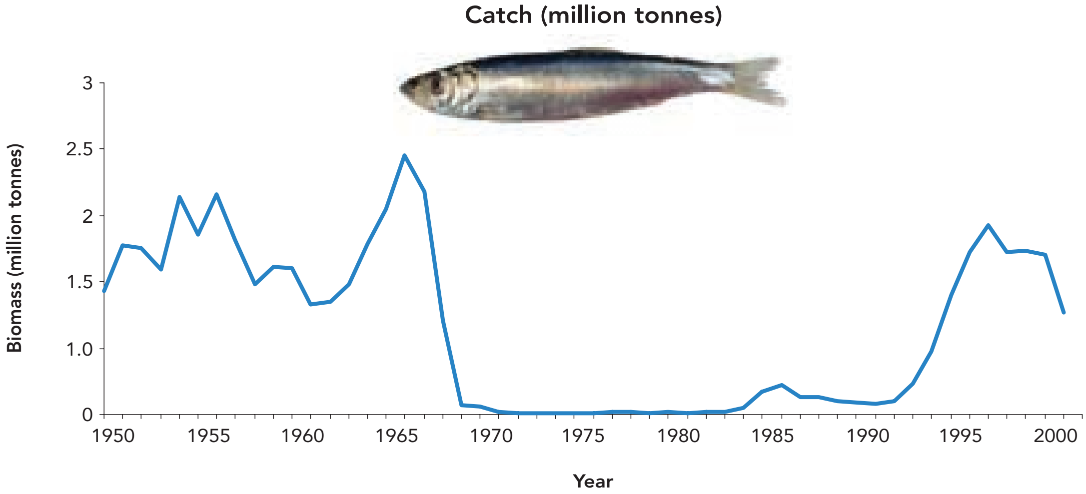
Source: Institute of Marine Research, Bergen, Norway, 2003.



The Barents Sea haddock stock (Figure 3.3) has been over-fished for several years. The stock is currently growing because of three good years in a row. A total allowable catch of 55 000 tonnes is recommended for 2002–2003 (Icelandic Ministry of Fisheries, 2002).

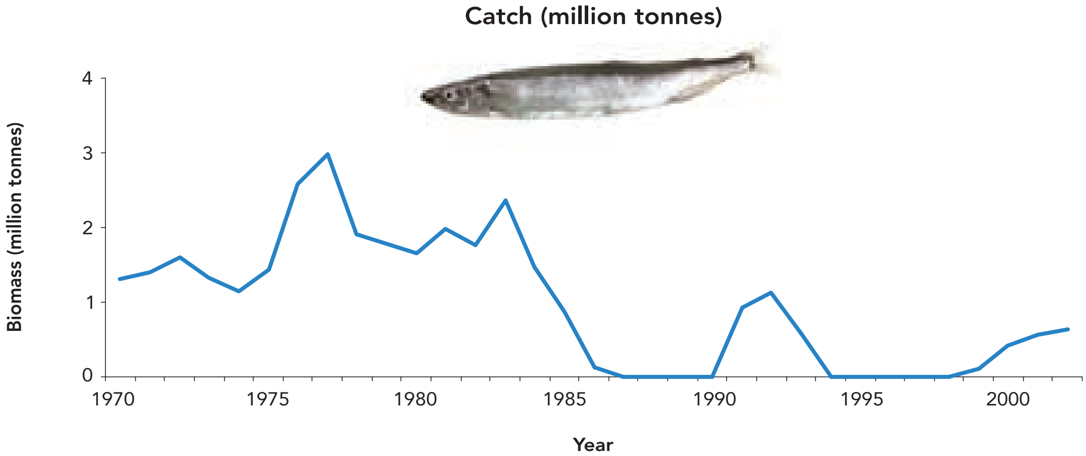
(5) Source: http://www.seaaroundus.org/lme/lme.aspx. For cooperation between Norway and the Russian Federation, see http://www.odin.dep.no

Figure 3.4 **Landings of Norwegian spring spawning herring from the Barents Sea since 1950**



Source: Institute of Marine Research, Bergen, Norway, 2003.

Figure 3.5 **Landings of Barents Sea capelin since 1970**



Source: Institute of Marine Research, Bergen, Norway, 2003.

Fishing of Norwegian spring spawning herring remained largely seasonal and near shore until the 1950s. Better knowledge of migration routes and new technologies led to an international herring boom in the late 1950s and early 1960s. The total catches increased until the early 1970s, when it collapsed, mainly due to over-exploitation (Figure 3.4). Unfavourable environmental conditions and poor feeding conditions during the late 1950s and 1960s may also have contributed to the collapse. The stock remained at low levels for more than 20 years, but recovered during the 1990s.

In the late 1960s, capelin fishing replaced rapidly dwindling herring fishing. Capelin is a short-lived species with highly variable stock size. Capelin fishing in the Barents Sea peaked in the mid 1970s at some three million tonnes. However, depleted numbers caused the stock to collapse in 1986 and in the mid 1990s (Figure 3.5).

Because capelin is a key species in the marine food web, its collapse affected other components of the Barents Sea ecosystem. Growth and condition of cod became poor, and there were numerous seal invasions along the Norwegian coast. Some seabirds, such as puffins, died off, causing their colonies to be significantly reduced (Skjoldal, 1990). By the late 1970s, capelin fishing in Icelandic waters had increased to more than one million tonnes annually and has remained at high levels since, with the exception of 1982 and 1992.

Too many ships chase too few fish …

Society today has increased its demand for fish and fish products. Fishing industries, including vessels and processing plants, have grown, and become more effective. Important fish stocks are diminishing in many parts of the world. As a World Bank representative said some years ago: 'We are heading into another renewable resource disaster.… We have too many vessels chasing too few fish, worldwide. It's like deforestation — but you can't see it under the ocean!'

Politicians and institutions agree that there is a need for better control of fisheries where several nations have stakes. But national fishing industries provide jobs and are important contributors to the economies, so must be supported. A vicious circle is created. Although it is in everybody's interest that fisheries should be sustainable, job losses and bankrupt fish processing plants are also political realities. The end result seems to remain in quotas that are too large to sustain fish populations. See also EEA (2001) (pp. 17–30).

3.2.3. Actions and policies — the role of international fishing agreements

National legislation regulates fishing within territorial waters. However, cooperation towards fisheries' legislation and regulations is equally important in international waters, and in closed or protected marine areas. Among those who seek to address the challenges are the:

- UN Convention on straddling stocks and highly migratory stocks' (UNFA);
- 1982 UN Law of the Sea Convention;
- 1995 UN Fish Stocks Convention;
- 1995 FAO Code of Conduct for responsible fisheries;
- 1979 Convention on future multilateral cooperation in the northwest Atlantic fisheries (NAFCO).

The North Atlantic Marine Mammal Commission (NAMMCO) also plays a role as an international body for cooperation on the conservation, management and study of marine mammals in the North Atlantic ([6]).

The Northeast Atlantic Fisheries Commission (NEAFC) ([7]) covers the Atlantic and Arctic Oceans. NEAFC's contracting parties are: the EU, Denmark (in respect of the Faroe Islands and Greenland), Iceland, Norway, Poland and the Russian Federation.

The North Atlantic Salmon Conservation Organisation (NASCO) ([8]) was established under the 1983 Convention for the conservation of salmon in the North Atlantic Ocean. It contributes to the conservation and rational management of salmon stocks which migrate beyond jurisdiction areas of coastal states of the Atlantic Ocean, north of 36° N latitude.

A three-party agreement between Norway, the Russian Federation and Iceland controls fishing on the high seas in the northeast Atlantic. A five-party agreement among the coastal states in the northeast Atlantic manages Norwegian spring spawning herring. The Russian Federation and Norway have a joint fisheries commission, which sets total allowable catches and shared quotas for cod, haddock and capelin in the Barents Sea. Additional catches are traded to third countries in exchange for fish quotas to Norwegian fishermen in their waters ([9]).

The International Council for the exploration of the sea (ICES), gives particular priority to fisheries research and management in the North Atlantic ([10]).

Fisheries management in the European Union is basically a matter for the Community rather than the Member States. Although several important institutions and regulations already are in place, there may, however, also be opportunities for new initiatives and achievements though the second northern dimension action plan 2004–2006.

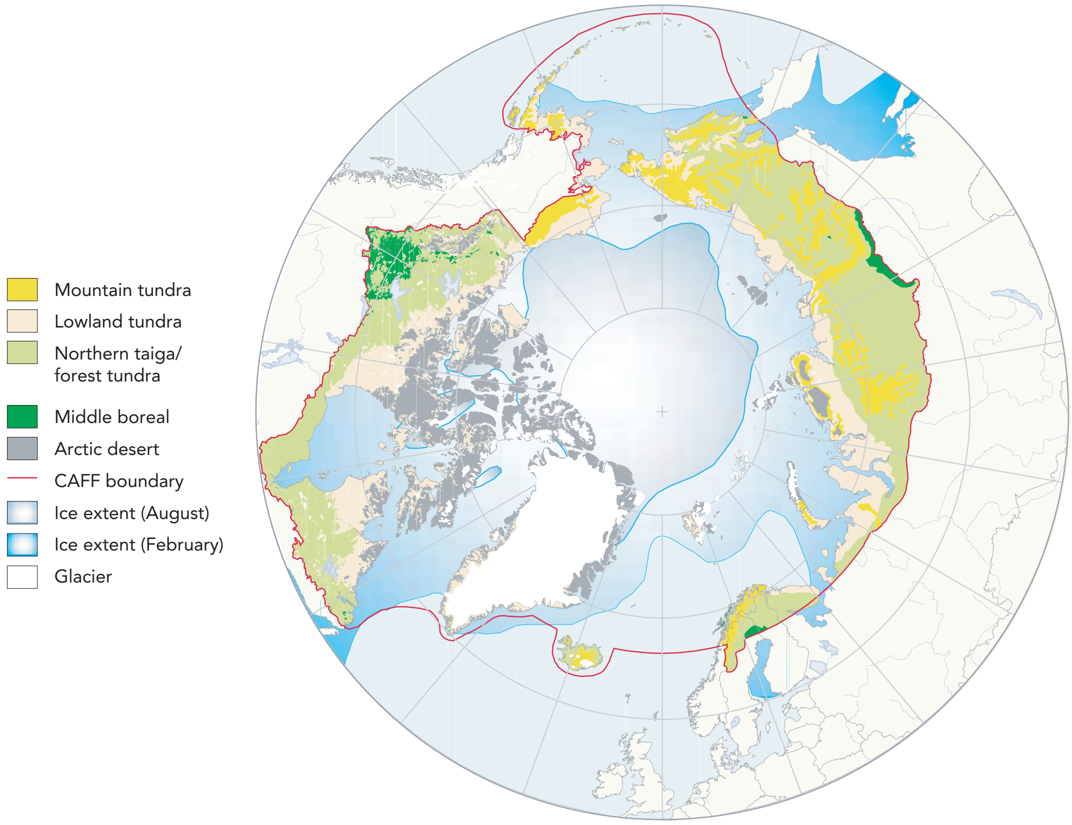
3.3. Forests and forestry

The Arctic forest boundary — often called the tree-line or the timberline — is the transition zone from closed boreal forest (or taiga) to the open treeless tundra (Figure 3.6). The timberline can be up to 300 km wide in flat areas but is compressed to a few hundred metres in mountainous areas (Kankaanpää *et al.*, 2002).

(6) See http://www.nammco.no
(7) See http://www.neafc.org
(8) See http://www.nasco.int
(9) See http://odin.dep.no/odin/engelsk/norway/environment/032091-120004/index-dok000-b-n-a.html
(10) See http://www.ices.dk

Source: CAFF, 2001.

Figure 3.6 **Arctic vegetation zones**



In Scandinavia and Finland, the timberline is at about 71° north, thanks to the influence of the warm North Atlantic (Gulf) current. The altitude of the timberline was once 500 m higher than today, i.e. during warm periods over the last 10 000 years (Kullman and Kjällgren, 2000). This may indicate what could happen with higher temperatures caused by climate change.

The mountain birch forests in Norway, Sweden and Finland are home to the Saami people. Through the years they have used the forests for hunting, trapping, reindeer herding and grazing, for supplementary food (berries, mushrooms), fuel gathering and for other raw materials. The timberline forests in Arctic Russia have also been inhabited by indigenous groups, e.g. the Saami, the Nenets and the Komi. Their lifestyles did not lead to large-scale degradation, although reindeer overgrazing has been a problem in some areas in recent decades (CAFF, 2001).

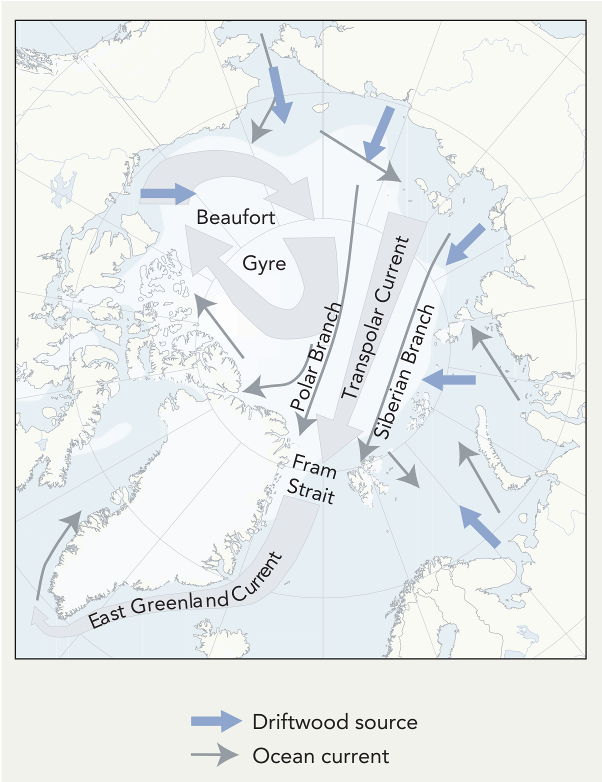
In some parts of the Scandinavian countries, summer-grazing pastures were established in the birch-belt. The mountain birch has high concentrations of inorganic nutrients, making it important fodder for livestock in earlier times. Heavy grazing lowered the natural tree-line in many areas. However, in recent decades, these summer-grazing areas have been abandoned. This move, as well as climate warming, has promoted the recovery of the birch-belt (Wielgolaski, 2002).

In Iceland, centuries of extensive logging for firewood and sheep grazing almost wiped out the entire birch forest, causing widespread soil erosion (Aradottir and Arnalds, 2001). Extensive re-planting projects have therefore been launched in the country.

Today, land use in the European Arctic's forests varies from reindeer herding and other traditional use by indigenous peoples, commercial logging over much of the region, intensive mining and smelting on the Kola Peninsula, to sheep grazing in Iceland, and oil and gas extraction in some parts of north Russia. Hunting and fishing and non-consumptive outdoor activities are becoming increasingly important, and can sometimes yield better revenues than timber extraction (e.g. in the Scandinavian countries).

Figure 3.7 **Arctic rivers and ocean currents**

Source: CAFF, 2001.



Major northbound river transport contributes to currents across the Arctic Ocean towards East Greenland, Svalbard and the Barents Sea. Timber and wood that is transported by Russian northbound rivers drift with the ice across the Arctic Ocean before being washed up in large piles along the shores in Svalbard and East Greenland.

Source: Thor S. Larsen.

Photo: Timber transported by Arctic rivers and ocean currents

3.3.1. Threats to forests
The sub-Arctic has vast forests. Between four and 5 %, or approximately 164 million hectares, of the world's forests lie within northwest Russia (Murmansk, Karelia, Arkhangelsk, Nenets, Komi). Although forestry only accounts for 4.3 % of the Russian Federation's total export earnings, this percentage exceeds 50 % in some districts of northwest Russia (Voropaev, 2002).

Timber products are important for industries in Europe and elsewhere, and logging operations are expanding further north where large islands of old-growth forests still exist (CAFF, 2001). Forestry in north Russia is particularly attractive, not least because the Nordic countries are unable to match its low prices for forest products. During 1998–1999, timber production increased by 25–35 % in the Archangelsk District and Komi Republic.

However, logging practices in north Russia are often wasteful, destructive and in violation of regulations. Between 40 and 60 % of the harvestable wood is lost during logging and transport. The World Wide Fund for Nature estimates illegal logging in northwest Russia to amount to 20–25 % of total logging (Voropov, 2002). State forest management authorities have insufficient funds to perform required inspection, control and reforestation activities (Vlassova, 2002).

In addition, vast areas have been altered by large-scale industrial development activities (AMAP, 1998). In the Archangelsk and Komi districts, the northern border of the timberline forest, as it was defined in 1959, now lies 40–100 kilometres to the south. This is due to low regeneration capacity after logging, exacerbated by permafrost and swamping of the soil. It is estimated that man-made tundra caused by logging in northern Russia, from the Kola Peninsula to Chukotka, is in the order of 500 000 km^2 (Vlassova, 2002).

3.3.2. Actions and policies — forestry
In the late 1960s, the Soviet Government was already concerned about industrial impacts within the timberline forest. It established the 'Protection belt of Pretundra forest'. This protective zone stretches from Karelia to Chukotka and covers about 2.1 million hectares or half of the timberline forest.

While this is a positive step for environmental protection, more could be done; serious consideration needs to be given to recommendations that have already been presented. One example is for Russian forestry companies to apply wood certification schemes, such as the Pan-European Forest Certification (PEFC).

There is a need to assist the Russian Federation with its forestry legislation. Protected areas need to be established and especially those that include old-growth forests. Illegal logging needs to be curtailed.

The second northern dimension action plan 2004–2006 supports sustainable utilisation of forests through a number of means, such as the:

- implementation of the northern dimension forestry sector programme prepared by the Barents Euro-Arctic Council forestry sector task force;
- development of model forests in the Barents Region;
- follow up on the EU initiative on forest law enforcement, governance and trade (FLEGT) in the northern dimension area;
- creation of a forest certification standard in the boreal zone of the Russian Federation.

3.4. Other renewable resources: freshwater

The Arctic's landscapes are dominated by ice and freshwater systems. Frozen sheets of ice once moved across much of North America and northwest Europe, leaving a rich deposit of lakes and wetlands when it receded. These systems still cover 8.5 % of Sweden and 10 % of Finland, for example. The Arctic has several huge and permanent ice fields that store fresh water. The Greenland ice cap, at 1.7 million km^2, is the world's second in size after the Antarctic ice cap. Permanent ice also covers parts of the Svalbard archipelago, Franz Josef Land, Novaya Zemlya and Severnaya Zemlya.

The Arctic's lakes, rivers and ice reservoirs are becoming increasingly important as a possible fresh water supply for water-deficient regions of the world. They may soon become a very important commodity, and there have already been proposals to tap such resources, e.g. in Canada. Russian newspapers have recently referred to plans originally dating from the early 1970s: namely, to divert the river Ob and other northbound rivers towards water-starved regions in the south.

Such plans may never be implemented but, if they should, the impacts and consequences could be very significant. A diminishing flow of freshwater into the Arctic Ocean will affect ice formation off the Siberian coast. The consequences for marine production, and possibly also ocean currents and climate, are unknown but could be dramatic.

3.5. Non-renewable resources: oil and gas

The politically stable Arctic (as compared with the Middle East) holds a significant share of the world's gas and oil reserves, which may make the region even more important in the future. European companies are playing key roles in developing Arctic reserves. However, oil exploitation in the Arctic brings environmental dangers. Installations, roads and pipelines contribute to land fragmentation. Clean-up operations of oil spills on land and in ice-covered waters are difficult, and oil slicks can be carried with ocean currents to seas and shores far away.

The Arctic contains huge deposits of oil, gas and minerals (Figure 3.8). There will be increasing pressure to develop these reserves, depending on oil prices and the supply of oil from existing producing regions such as the North Sea and the Middle East. The Arctic may thus become one of the main sources of gas and oil in the twenty-first century.

The Barents Sea contains some very large gas fields in the Russian areas. Additional, but more modest, reservoirs in the Norwegian areas were opened for production in 2002. A disputed border area also has several promising prospects (Ræstad, 2002). According to Russian sources, their Arctic region possesses over 200 billion tonnes of oil equivalents (Sulyandziga *et al.,* 2002). Unofficial sources indicate that about seven billion tonnes of oil equivalents have already been discovered on the Russian side.

Norway's Snøhvit (Snow-white) field has recently begun construction. This move, as well as further exploration off the Norwegian coast, has boosted development optimism. However, plans for exploration have led to strong opposition from conservation movements.

3.5.1. Oil and gas in north Russia

The Russian Arctic is very important to the Russian Federation, contributing 20 % of the country's gross national revenue and providing almost 60 % of the foreign currency supply (Sulyandziga *et al.,* 2002).

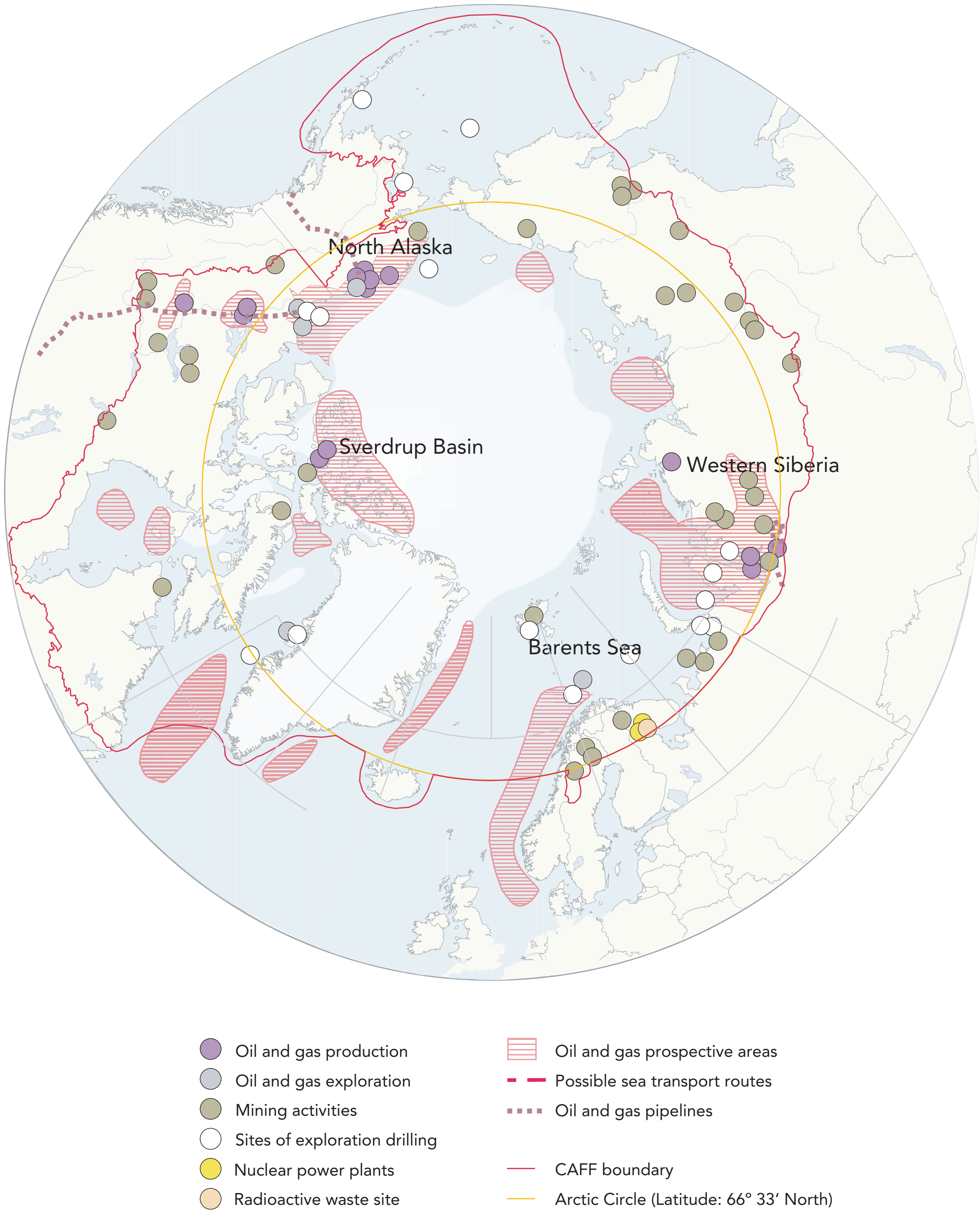
Russian companies plan to supply the US with 10–15 % of its crude oil requirements. An oil terminal with a capacity of 50–60 million tonnes a year will be built in Murmansk. That will then become the main port for oil export to the USA. The western Siberia–Murmansk oil pipeline is currently being planned. It will transport up to 80 million tonnes of oil a year.

There are two options for pipeline routes. The first is 2 500 km long and partly across the White Sea. The other, 3 600 km long, is on land only and allows links with the Kharyaginskoe field in the Nenets autonomous area. Participants of the project signed a declaration of intent in April 2003 and construction should be completed in 2007.

Norway has expressed concerns over Russia's increasing westbound oil shipping transport, because of possible serious environmental consequences from accidents and oil spills.

Source: CAFF, 2001.

Figure 3.8 **Industrial activities and oil and gas reserves in the Arctic**



High oil prices and a more stable political situation have inspired new investments and plans for development of Russia's mineral deposits. But oil and gas exploration in ice-covered waters, such as the Barents Sea, will incur technical problems, high costs and many environmental risks. The Barents Sea supports some of the world's major fisheries that are also very important economically. Conflicts between fisheries' interests and oil and gas exploration are likely to escalate in the future, as possible major oil spills in ice-covered areas heighten concerns.

Vast pipeline networks will secure Russia's crude oil flow to places of consumption. New gas pipeline projects are under preparation for export to China, Japan, Korea and other Pacific countries. New pipelines to the Baltic may also be required for export of oil to Europe. Leaks from pipeline systems can be massive, and lack of proper equipment allied with the remoteness of many sites would make clean-up operations problematic.

Figure 3.9 **The Northern Sea Route**

Source: AMAP, 1997.

Russia's Northern Sea Route (NSR) makes it possible to sail from Europe to the Far East. The NSR cuts sailing distance to less than 7 000 nautical miles, bringing substantial economic advantages. As Arctic sea ice continues to decline in extent and thickness, more extensive use will be made of the NSR. Icebreakers may not be needed to the same extent as before, and ice-strengthened freighters may sail the route with a sailing time half of what it is today.

But the northern Russian waters are not sufficiently charted and there are serious risks that oil tankers could run aground. Massive oil spills would destroy marine ecosystems over wide areas, and ultimately be carried great distances by ocean currents. The social, economic and environmental impacts of future NSR operations represent significant concerns and challenges for the future. The associated gas, oil and mineral exploitation along the Siberian coast and subsequent shipwrecks and spills from oil and other cargo form a large part of these concerns (Brigham, 2001).

Oil pollution in polar lands has far-reaching consequences that are often more serious than in temperate regions. Oil spills on the tundra can be trapped in wetlands and marshes that are extensively used by water birds and mammals. Permafrost prevents pollutants from sinking into the ground, while low temperatures slow down the oil's deterioration. Domestic reindeer grazing areas can be seriously affected.

Offshore oil and gas exploitation and associated transport in Arctic marine waters pose particular risks and dangers. The serious environmental consequences from the Exxon Valdez accident in Alaska some years ago are well known. Northern Russia, where regulation and control are uncertain, may be particularly vulnerable in the future.

Climate change may lead to less sea ice, which will encourage new offshore exploration in remote locations. Any oil spills will tend to be trapped in open leads or *polynias* (year-round ice-free areas of water), along the ice edge, or between drifting ice floes. It is here that the marine production is particularly rich and important, and where fish, seabirds, seals and whales find their food.

3.5.2. Actions and policies — circumpolar cooperation needed to combat oil pollution

Increased activity in the petroleum industry in the Arctic necessitates strengthened cooperation among the national stakeholders.

The growth in oil and gas industries in the European Arctic calls for strengthened bilateral and circumpolar cooperation. There is an urgent need to develop better technology and the means for safe production and transport. There is a need to safeguard the fragile Arctic ecosystems at risk. Some challenges are imminent. Europe should contribute to harmonisation between mineral exploitation and other forms of land use.

There is a particular need to assist the Russian Federation with its ongoing transition to a market economy for which oil and gas supplies to Europe and the USA are crucial issues. The role of the private sector in the Arctic is important. A warmer climate with less ice and longer shipping seasons has led to a renewed interest in the Northern Sea Route (NSR) (Figure 3.9), and the environmental consequences of more frequent use need to be addressed. Close cooperation between the Arctic Council and

EU may provide important synergies on mineral exploitation and transport in the Arctic within the framework of the second northern dimension action plan 2004–2006.

3.6. Mining for other minerals

Alaska's mining industry, which achieved record production in 2000, was valued at over US$ 1 billion/year between 1995 and 2000 (Swainbank and Szumigala, 2001). Gold, lead, zinc and diamond production continue to be important in the Canadian Arctic. Lead and zinc mining have ceased in Greenland (Taagholt and Hansen, 2001), but a new gold mine has started production (Crew, 2004).

Russia's Norilsk non-ferrous mining complex is extensive, and was the world's largest nickel producer in 1997 (11). There is also exploration for gold and diamonds in the Russian Arctic, e.g. in Yakutia.

Coal mining by Norway and the Russian Federation has always been important in Svalbard. Here, mining and associated road system and shipping activities repeatedly cause concerns among conservationists.

3.7. Impacts of piecemeal infrastructure development

One of the most significant links between the European continent and the Arctic environment is the expanding infrastructure network to facilitate exploitation of Arctic resources (Nellemann *et al.,* 2001a; Nellemann *et al.,* 2003a). A network of roads, power lines and pipelines are being developed to support and facilitate transportation of goods and resources. This network extends through the Arctic to the south or to the coast for shipping.

While systems are in place to facilitate and evaluate the potential environmental impacts of each individual development project, there is little policy awareness of the cumulative impacts of the overall web of infrastructure on biodiversity and on the chosen lifestyles of many indigenous people. Reindeer and caribou are particularly sensitive to infrastructure development.

Caribou and reindeer represent a key species in the traditional ways of life for a large proportion of indigenous people, including, but not limited to the: Saami, Nenets, Komi, Khanti, Dolgan, Nganasan, Yukagir, Even, Evenk, Sakha (Yakut), Chukchi, Koryak and Chuvan. In North America, this proportion of indigenous people includes the: Gwich'in, Iñupiat, Dogrib, Koyokon Dene, Metis, Cree, Chipewyan, Innu, Naskapi, Yupiit, Inuvialuit and Inuit.

Northern Scandinavia and parts of the Russian Federation are examples of areas where the current growth of infrastructure is increasingly incompatible with reindeer husbandry (Forbes and Jeffries, 1999; Nellemann *et al.,* 2001a; Vistnes and Nellemann, 2001; Jernsletten and Klokov, 2002). In these areas, infrastructure growth means the loss of traditional lands, and conditions that force indigenous people to abandon nomadic herding patterns for more sedentary life styles.

Infrastructure development is often concurrent with changes in regional economic activity, enticing southern-based resource extraction companies interested in short-term economic gains. Such socio-economic changes not only affect cultural practices directly related to traditional reindeer husbandry, but also conflict with the use of traditional homelands for hunting, fishing and gathering.

Numerous studies now relate loss of habitat, overgrazing and, to some extent, lower productivity to the continuing loss of grazing ranges. This comes about as a result of reindeer and caribou avoiding areas of infrastructure development (Bradshaw *et al.,* 1997; 1998; Dyer *et al.,* 2001; Vistnes *et al.,* 2001; Wolfe *et al.,* 2000; Mahoney and Schaefer, 2002; Nellemann *et al.,* 2003b). The coastal zone is vital for the semi-domestic Saami reindeer. They depend on the coast for spring calving, and summer and early fall grazing, which, in turn, are central to the productivity and survival of the herds.

Piecemeal development is currently generally unchecked in terms of recreational cabin development, windmill parks, hydro power, mining, road construction and military bombing ranges. The Arctic region comprises one of the few continuous low-level flying

(11) See http://www.mining-technology.com

ranges in Europe. NATO is, therefore, increasingly interested in using the traditional grazing lands of the Saami indigenous people for bombing and exercise ranges. One of the largest bombing ranges in Europe is proposed in the Halkavarre/Porsanger region.

At the same time, the opening of the Barents Sea for oil and gas exploration will increase the need for secondary housing and associated development related to supporting activities. Such development will greatly accelerate the loss of vital grazing ranges to the Saami people. Currently, c. 35 % of the coastal area is heavily disturbed, as far inland as 20 km, rendering traditional reindeer husbandry very difficult. With continued development, this figure will increase to 78 % by 2050, which represents a potential detrimental loss to the Saami reindeer herders if no policy action is taken. Indeed, surveys among herders across the Arctic, initiated by the Arctic Council of Ministers, have noted piecemeal industrial development of infrastructure as among the most significant threats to their livelihoods (Jernsletten and Klokov, 2002).

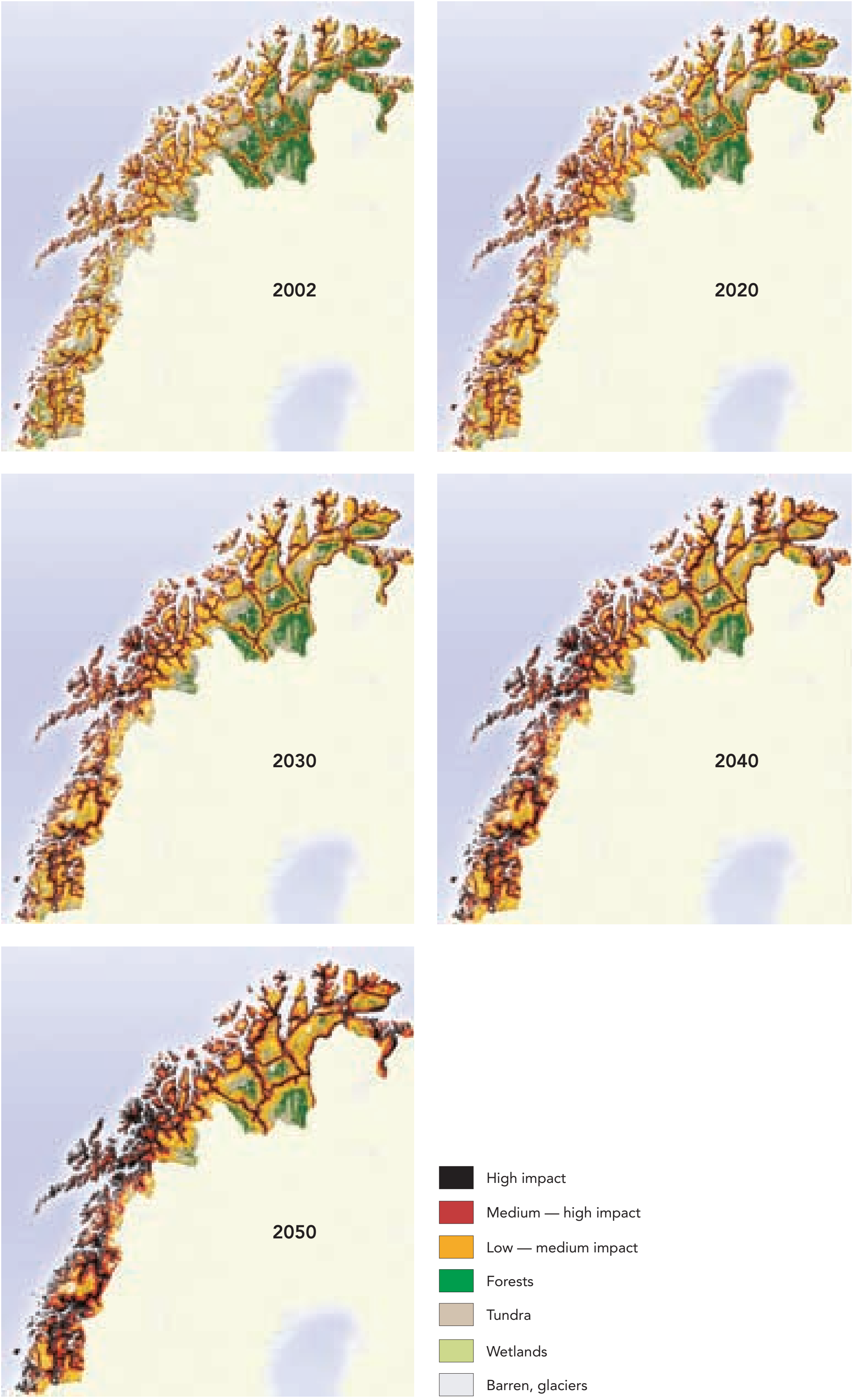
Given the critical impact and the extreme difficulty in reversing established infrastructure to natural lands, the complete lack of policies for controlling cumulative piecemeal development in infrastructure is particularly grave.

Source: Thor S. Larsen.

Photo: Dog sledge on the sea ice in Storfjorden, Svalbard.

Source: GLOBIO/UNEP/ GRID–Arendal.

Figure 3.10 **Infrastructure development scenarios for northern Scandinavia 2002–2050**



The area available to reindeer husbandry will rapidly decline, particularly in the coastal areas vital to summer grazing of reindeer. These areas are increasingly exposed to development of recreational cabins, power cables, dams, oil installations and military bombing ranges. Refer also to Figure 2.1 that showed the development of roads in northern Norway.

4. Pollution in the Arctic

Some humans and animals in the Arctic are exposed to high levels of certain heavy metal and organic pollutants. Cancer, changes in behaviour, disruption of reproductive hormones and weakened immune systems are some of the effects that have been linked to exposure to mercury, polychlorinated biphenyls (PCB) and other persistent organic pollutants (POPs). All of these contaminants are found in the Arctic environment, including its animals and human inhabitants. Europe is a major source of this contamination. It is in the interests of Europe that international agreements addressing contamination of the Arctic should be ratified and implemented as soon as possible. As a contracting party to the Stockholm Convention and UNECE LRTAP Convention, the EU is already a signatory to some of these agreements, but some European countries have yet to take this step.

4.1. Air, oceans and rivers link Europe to the Arctic

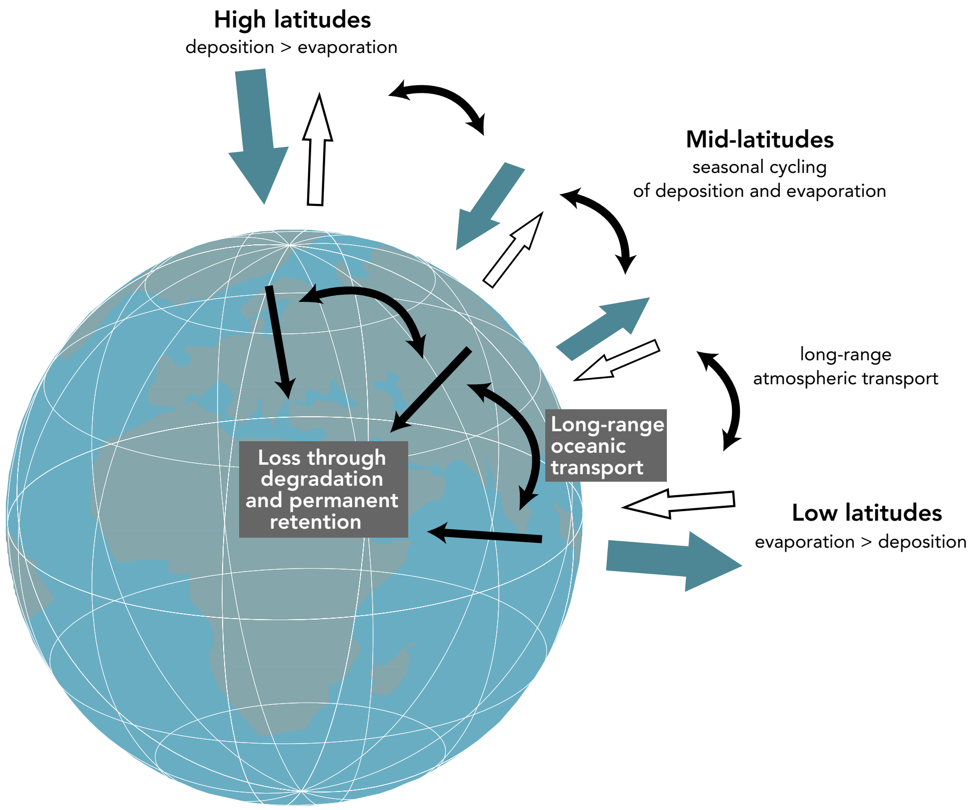
Northern Europe forms a bridge between the heavily populated areas of central and southern Europe, and the sparsely populated Arctic. From an environmental perspective, this bridge includes air and ocean currents, and also river systems that connect the two regions.

Contamination released into the atmosphere from Europe can reach the Arctic very quickly, within a matter of days with prevailing northerly winds. Up to two-thirds of Arctic air pollution associated with some heavy metals and acidifying gases has been attributed to emissions from Europe.

Seven of the world's largest rivers are in Arctic Russia. These northern rivers and their tributaries drain more than half of the land area of the Russian Federation and pour 73 million tonnes of sediments each year into adjacent Arctic coastal areas. These Russian rivers, and other northbound rivers in Europe, can also transport contaminants to the Arctic Ocean.

Ocean currents like the Gulf Stream transport water masses over long distances and contribute to the distribution of chemicals and radioactive substances.

Figure 4.1 **The 'grasshopper' effect pathways and processes involved in the long-range transport of semi-volatile persistent organic pollutants (POPs)**



Source: EEA, 1999.

Pollution carried from Europe to the Arctic by air, or by ocean and river currents, has had a major impact on the Arctic environment. Industry in and around the Arctic also contributes significantly to contamination, with sources including copper-nickel smelters on the Kola Peninsula and at Norilsk in Siberia.

The remoteness of the Arctic generally results in the deposition of much lower levels of contaminants than that which occurs closer to urbanised and industrial areas. However, as a result of specific physical and chemical properties and processes that influence their long-range transport, some contaminants may be preferentially transported to, and deposited in, the Arctic (Figure 4.2). Here, they concentrate in the tissues of animals high in the Arctic food web, such as polar bears, seals and whales (see illustration on biomagnification). These animals are important food sources for indigenous peoples, thus exposing people to potentially serious health effects (AMAP, 1997).

Source: AMAP, 1997.

Figure 4.2 **Lead contamination in Norway from European sources**

Moss studies show decreasing gradients of contaminants such as lead further away from the sources in industrialised Europe. These results are consistent with deposition patterns obtained from air transport models.

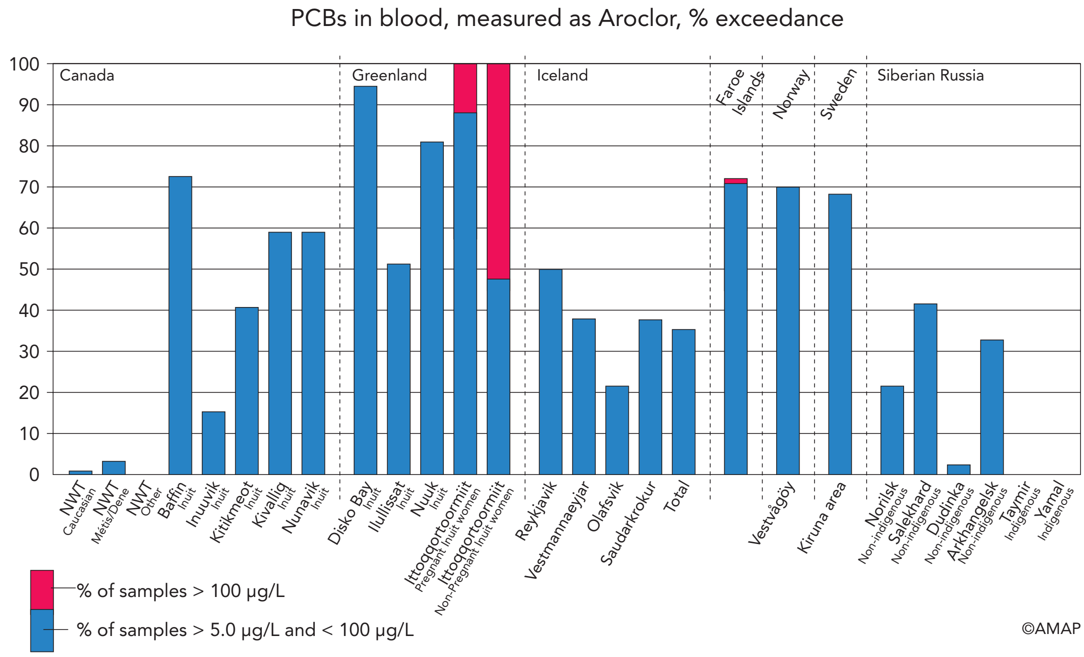
4.2. Human and animal health

The Inuit of Greenland and Canada have some of the highest dietary exposures to mercury and POPs anywhere on Earth (Figure 4.3 and 4.4). A large proportion of women in communities throughout the Arctic have mercury or PCB levels in their blood significantly above the guidelines set by regulatory authorities, such as the US EPA, Health Canada and others. POPs accumulate and concentrate in fatty tissues — and mercury in the meat — of seals and whales, which are a major part of some Arctic peoples' diets (Figure 4.5 and Table 1). Pregnant women and children are a special concern as these contaminants pose a threat to children's development, both in the womb and after their birth (AMAP, 1997).

Recent studies in the Faroe Islands (Grandjean *et al.*, 1997, among others) suggest that neuropsychological dysfunction in children, such as problems with fine motor control, mental concentration, language, visual–spatial abilities and verbal memory, are associated with elevated concentrations of mercury in the blood. See also EEA (2001) (pp. 64–75).

Figure 4.3 **PCB contamination in women**

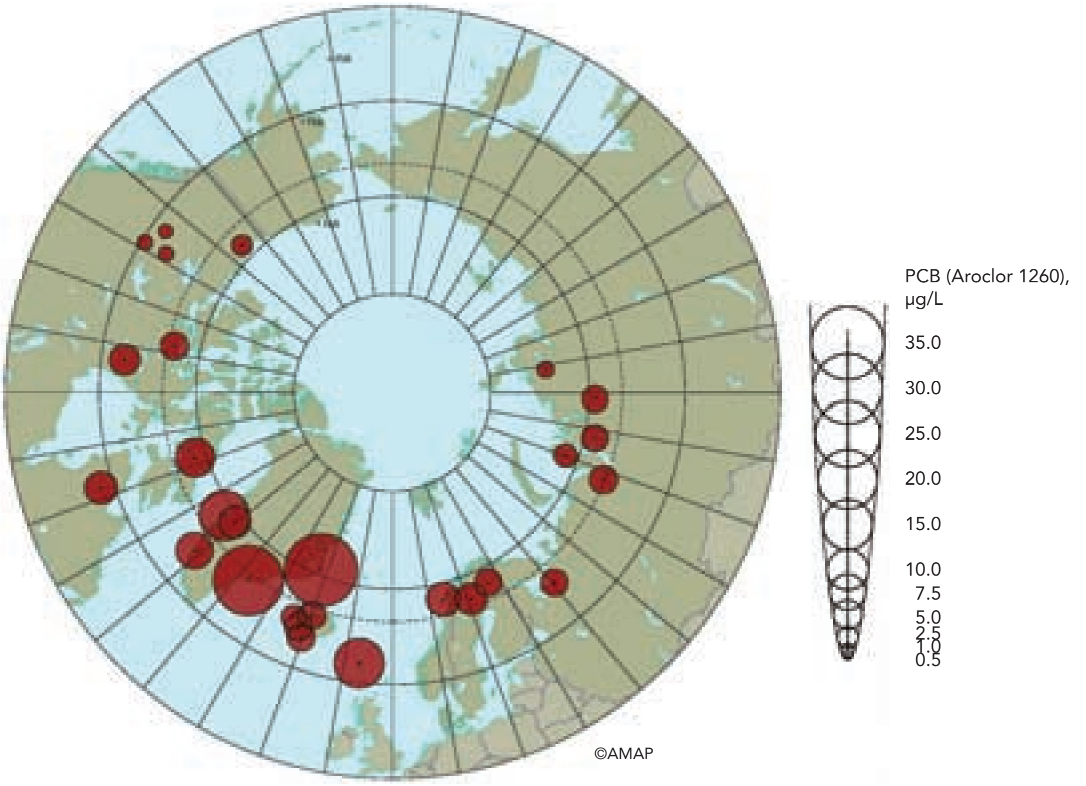
Source: AMAP, 2002.



PCB levels in the blood of women of reproductive age. Percentage of samples exceeding public health levels for concern and action.

Source: AMAP, 2002.

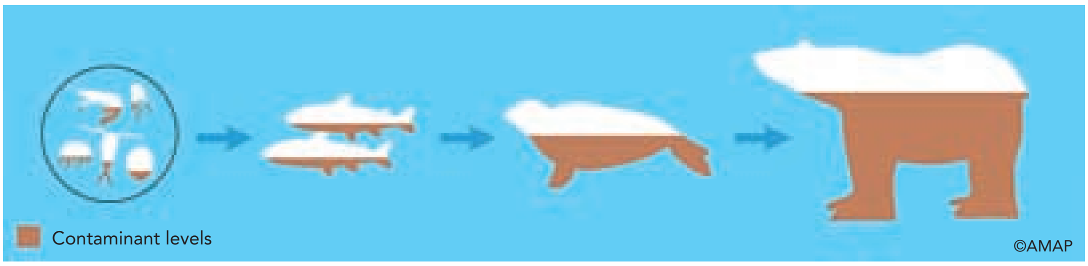
Figure 4.4 **PCB contamination in Arctic people**



Levels of PCB in maternal blood samples collected in different regions of the Arctic. Highest levels are found in communities that depend on traditional diets that include marine mammals.

Source: Canadian Department of Indian and Northern Affairs, 1997.

Figure 4.5 **Build up of contamination in Arctic animals: biomagnification**



Biomagnification occurs when contaminant levels are increased with each step in the food web. Predators consume the contaminants stored in their food (prey). As these predators, in turn, become food for the next level of predators, the concentration of contaminants accumulates at each step. Table 1 shows how levels of toxaphene are biomagnified through the Arctic marine food web.

Source: Bidlemen *et al.*, 1989; Hargrave *et al.*, 1993.

Table 1 **Biomagnification of toxaphene in the Arctic marine food web**

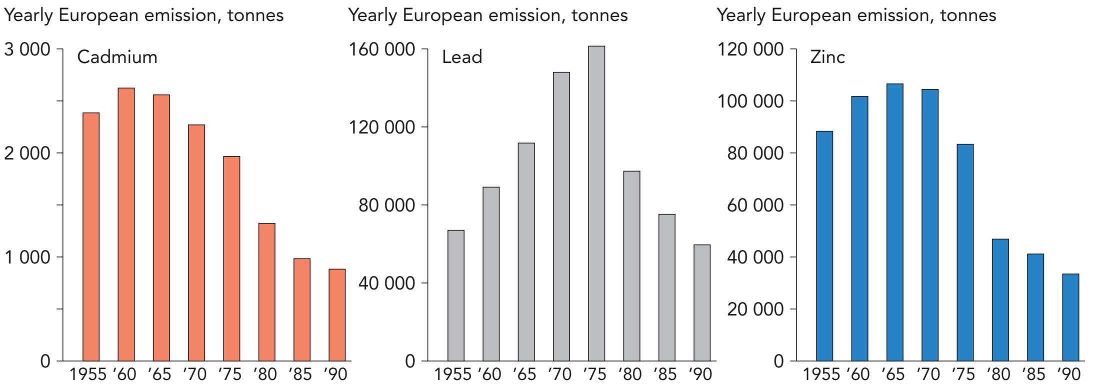
Compartment	Concentration (wet weight)
Air	0.0007 ppb (parts per billion)
Snow	0.0009–0.002 ppb
Sea water	0.0003 ppb
Zooplankton	3.6 ppb
Arctic cod muscle	14–46 ppb
Arctic char whole body	44–157 ppb
Ringed seal blubber	130–480 ppb
Beluga blubber	1 380–5 780 ppb
Narwhal blubber	2 440–9 160 ppb

4.3. Decreasing emissions of some metals

Emissions of lead, zinc and cadmium, among other metals, have decreased over the last 40 years globally. This is not entirely attributable to direct action to curb emissions, but is often a consequence of a combination of factors, including development of improved technology, and changes in the way society and industries operate. For example, reduced metal emissions to the atmosphere from the Russian Federation after 1990 were associated with the collapse of the former Soviet Union and the resulting disruption of Russian industrial activity.

Figure 4.6 **Atmospheric emissions of heavy metals from Europe**

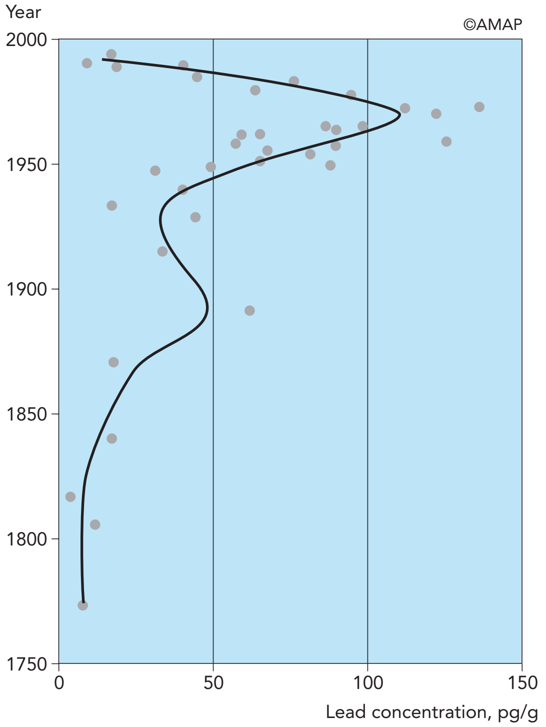
Source: AMAP, 1997.



Reductions in atmospheric emissions of cadmium, lead and zinc have been achieved over the past three to four decades. These are reflected in Arctic contaminant records such as ice cores.

Figure 4.7 **Lead concentration in Greenland ice core**

Source: AMAP, 2002.



Lead concentrations in a Greenland ice core show increases during the industrial period, but decreases since the early 1970s, coinciding with the introduction of unleaded gasoline in North America and subsequently in Europe.

When unleaded petrol was introduced, it was generally perceived to be an environmental action targeting lead pollution. This is another example of where a decrease in metals emissions occurred that was to a certain extent incidental. Installing catalytic converters in cars was done mainly to reduce hydrocarbon pollution. As catalysers require unleaded petrol for their operation, lead emissions therefore also dropped. As a consequence, lead deposition in the Arctic decreased. However, increased levels of the metals used in the catalysers — platinum, palladium and rhodium — have now been found in snow and ice in Greenland. Not much is known about the effects of these metals.

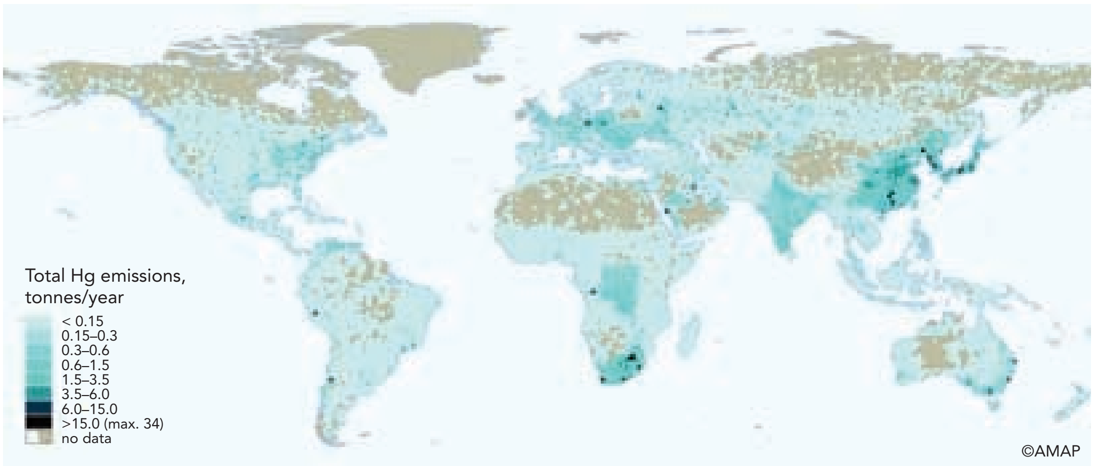
4.4. Mercury an increasing threat

Europe and North America have reduced their mercury emissions over recent years. However, increases in Asian emissions have largely offset the impact of these reductions. The result is simply that the environmental pressure has been transferred to another part of the globe (Figure 4.8).

Recent studies in the Arctic have associated enhanced mercury deposition with a set of photochemical reactions that occur after polar sunrise, a process that more than doubles the annual mercury deposition that would otherwise occur (AMAP 2002, Lindberg *et al.,* 2001, Lu *et al.,* 2001). The mercury is also delivered from the atmosphere in a highly reactive — and potentially more bio-available — form. This phenomenon is most intense during the spring peak in productivity, which creates ideal circumstances for mercury to enter the food web.

Source: AMAP, 2002.

Figure 4.8 **Global emissions of mercury to the air**



Global anthropogenic emissions of mercury to the air from different continents in 1995.

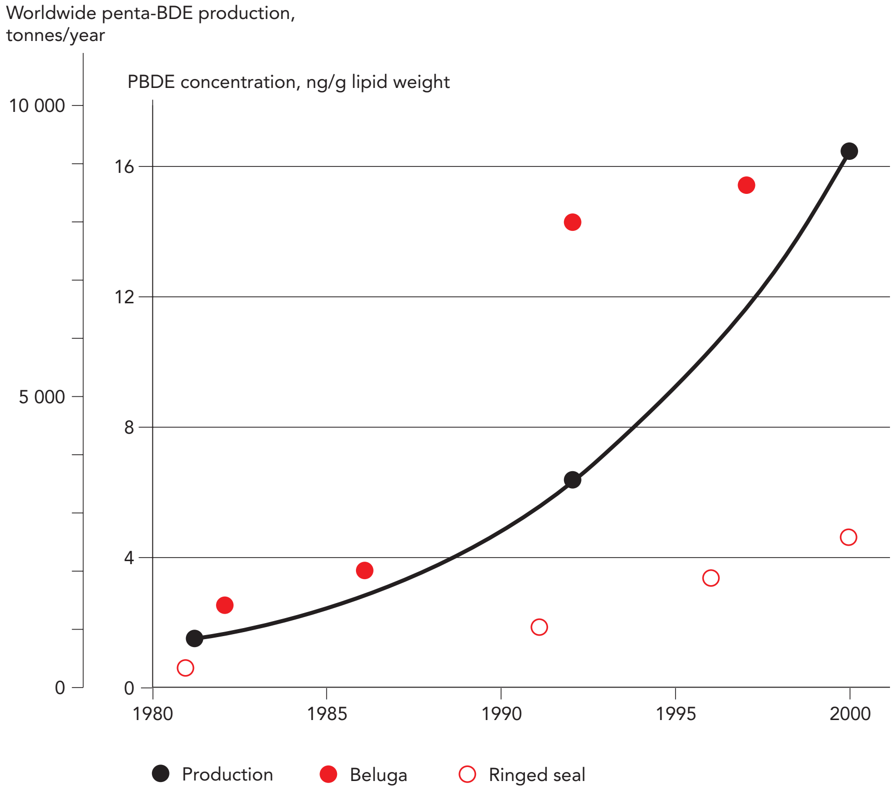
4.5. New chemicals appearing

A great variety of new chemicals are constantly being introduced into European consumer markets, often as replacements for substances being phased out. Not all of these chemicals are truly new, some having been in use for several decades. However, methods for identifying and quantifying many of these substances in the environment are only just becoming available.

Two examples are PBDEs (polybrominated diphenylethers) and PFOS (perfluorooctane sulfonate). PBDEs are used as flame-retardants in furniture and in plastic, e.g. for computer screens; PFOS as a refrigerant and a component in paints. Both chemicals are now beginning to appear in Arctic plants and animals (AMAP, 2002) (Figure 4.9). Their chemical structure is similar to other persistent organic compounds, which leads researchers to suspect they might behave in a similar way in the environment and create similar adverse health effects in animals and humans. Comprehensive studies to investigate such suspicions are still unavailable.

Figure 4.9 **PBDEs in ringed seals and beluga in the Canadian Arctic**

Source: AMAP, 2002.



Comparison of temporal trends of PBDEs in ringed seal and beluga in the Canadian Arctic with estimated global production of penta-BDE over the same period.

4.6. Widespread pesticide contamination

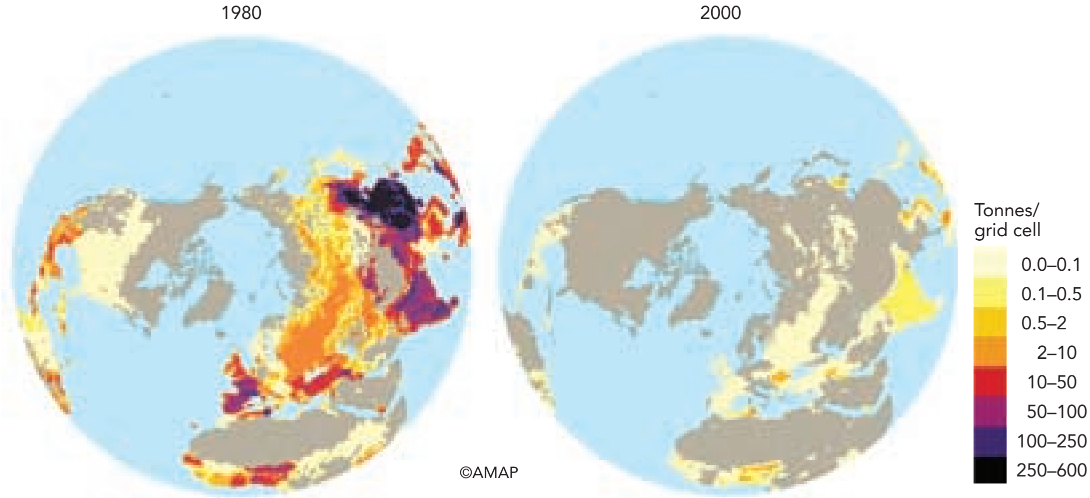
Pesticides, in particular organochlorine pesticides (for example, toxaphene, chlordanes and HCHs (hexachlorocyclo-hexanes)), have been used in farming in Europe and elsewhere since the 1940s, but generally not in the Arctic. However, they have made their way into the Arctic air, water and snow, via air and water pathways, and have been found in animals and humans at levels that give rise to concern.

Several types of organochlorine pesticides have been banned in Europe, or at least more tightly controlled. Agreements, such as the Stockholm Convention on persistent organic pollutants, seek to address such issues globally. Consequently, there is a perception that the use of these harmful POPs is essentially now a developing country issue. However, as recently as 1990, France, Italy and Spain were three of the top ten countries in terms of annual usage of gamma-HCH (lindane, a potent insecticide that is still in use), with France second only to India (Li *et al.*,1996).

Environmental levels of these chemicals are now generally decreasing, but only very slowly. However, due to their massive use in the past, many substances have accumulated in large quantities in environmental reservoirs such as soils and oceans and will continue to be released for many years to come. This is a global problem affecting ecosystems in the Arctic and elsewhere.

Source: AMAP, 2002.

Figure 4.10 **Global reduction of POP emissions**



Emissions of several POPs have been drastically reduced as a result of bans and restrictions that have already been introduced. The map shows estimated emissions of the substances alpha-HCH plus beta-HCH in 1980 and 2000.

4.7. Food is a pathway for human exposure

Traditional foods, in particular those obtained by hunting marine mammals, play a vital cultural and spiritual role in the lives of the Arctic indigenous peoples, as well as being a key source of calories and nutrients. However, this reliance on natural resources means that Arctic indigenous people have little control over their food supplies, as (with the exception of reindeer herding) they usually do not breed, feed or grow the food themselves. The animals they hunt are often long-lived, high in the food web, and have large amounts of fatty tissue, providing plenty of opportunity for environmental contaminants to accumulate (Figure 4.5 and Table 1).

Consequently, indigenous peoples, such as the Inuit of Canada and Greenland, receive higher dietary exposure to contaminants such as PCBs, chlordanes and mercury than any other people on the planet. Moreover, they often do not have the choice of changing to other kinds of foods, as do other people living in the Arctic, or those living elsewhere who benefit from Arctic food resources.

This contrasts with Europe, where the population is essentially fed by an agricultural industry that can control food sources to minimise contamination. Crops are grown and harvested before they have time to take up large amounts of contaminant from the environment. European consumers also have a freedom of choice should concerns about food safety arise, as for example occurred during the Bovine Spongiform Encephalopathy (BSE) or *Mad Cow* disease episode in Britain in the late 1990s, or the scares resulting from dioxin in animal feed (EEA, 2001).

Such choices are not always available to the Arctic indigenous peoples. Imported foods, where available, are often prohibitively expensive, and a shift from traditional to western diets has been shown to result in a higher incidence of obesity, diabetes and cardiovascular diseases in Arctic peoples.

4.8. European radioactivity in the Arctic

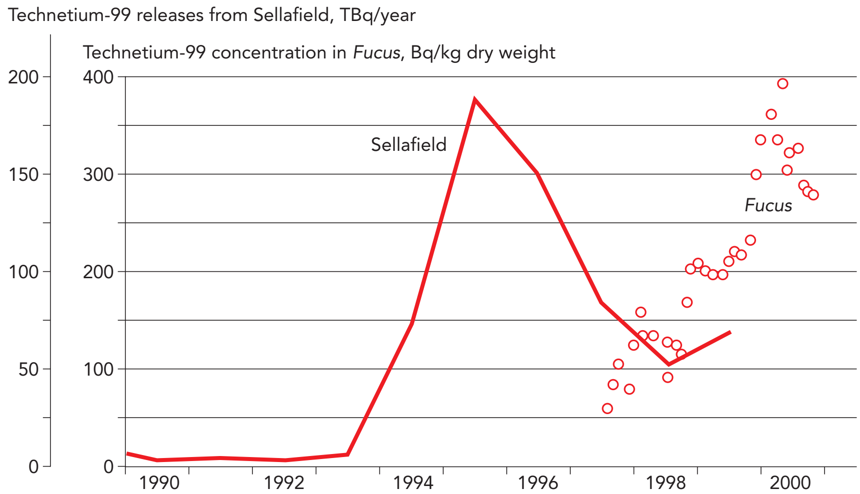
European reprocessing plants are the second largest source of historical radioactive contamination of the Arctic region, exceeded only by fallout from past atmospheric tests of nuclear weapons. The Chernobyl accident is the third largest source, and provides a clear reminder of the potential consequences of using outdated technology and inadequate safety standards in the nuclear industry.

Source: Elisabeth Lie.

Photo: Polar bear tested for contamination

Figure 4.11 **Sellafield radioactivity in northern Norway seaweed**

Source: AMAP, 2002.



The technetium-99 releases from Sellafield are reflected in increased activity levels in Fucus seaweed at Hillesøy, northern Norway a few years later — illustrating the transport of radionuclides from European reprocessing plants to the Arctic Ocean.

Current doses to Arctic inhabitants from these sources are low and well below the International Atomic Energy Agency's (IAEA) guidelines. Releases from European reprocessing plants have been estimated to be associated with an increased risk equivalent to one to two additional cancer deaths in the Arctic. In comparison with other areas, and from what is known today, threats to human health from European radioactivity are probably only a small problem compared to other Arctic concerns. However the risks to the Arctic environment as a whole are less clear, and this issue has to be monitored.

4.9. Threat of nuclear material

Several sites in northwest Russia pose a potential risk for releases of radioactivity into the Arctic. These include the Kola nuclear power plant, various nuclear fuel and waste storage sites, nuclear waste dump sites, nuclear powered icebreakers and several military installations, in particular the Russian Northern Fleet facilities where nuclear submarines are being decommissioned.

The transportation and handling of used nuclear fuel remains a challenge, as neither a long-term disposal option nor a safe means of transportation has been agreed. About 80 % of all used nuclear fuel waste from the Russian Northern Fleet is stored at Andrejeva Bay on the Kola Peninsula. Some leakage has occurred, but the main threat comes from the entire process of handling this fuel, from first use to placement in final storage.

Several other nuclear plants are within 1 000 kilometres of the Arctic. These include one in the Chukotka region of eastern Russia, and other plants in Finland, Sweden and parts of the Russian Federation. They could threaten the Arctic in the event of an accident.

Source: Per-Einar Fiskebeck.

Photo: Andreeva Bay — the main Northern Fleet facility for storing nuclear waste

Northwestern Russia contains a high concentration of potential sources of radioactivity. Nuclear waste disposal, including waste from decommissioned nuclear submarines of the Russian Northern Fleet, is an issue that urgently requires appropriate solutions.

4.10. Increasing transport of oil

The development of new oil and gas reserves in the Barents and Pechora Seas, and increasing development and exports from western Siberia, will likely result in more tanker traffic in the Arctic. In addition, the desire to reduce transit times and costs between Europe and Japan has generated renewed interest in opening up the Northern Sea Route along the northern coasts of Russia (see Figure 3.9). The prospect that sea-ice along this route will decrease as a consequence of climate change has further promoted this idea.

Any increase in drilling, infrastructure and oil tanker traffic will increase the risks to the Arctic environment. A more comprehensive assessment of several of these subjects is due to be completed by AMAP in 2006.

4.11. Actions and policies — Arctic countries working together

In 1991, the eight Arctic countries adopted the Arctic environmental protection strategy (AEPS), under which they agreed to take actions to reduce the threats to the Arctic from pollution, both from sources within and outside the Arctic.

As a direct response to the pollution threats identified by AMAP, the Arctic Council has initiated several projects as part of the Arctic Council action plan (ACAP). The Arctic Council is also responsible for development of the Arctic regional plan of action (RPA) for the protection of the marine environment from land-based sources of pollution, as a component of the UNEP global plan of action (GPA). Together, such initiatives are beginning to tackle issues relating to pollution sources within or close to the Arctic.

However, as most of the pollution in the Arctic originates from outside the region, responsibility and action must extend beyond the local and national levels, and be backed by regional and global initiatives. Close cooperation is therefore especially important between the European Union, Arctic governments, and regional bodies such as the Arctic Council.

4.12. International agreements

In the last few years, the international community has reached agreement on:

- the Stockholm Convention on persistent organic pollutants — in force on 17 May 2004;
- the protocol on persistent organic pollutants to the United Nations Economic Commission for Europe Convention on Long Range Transboundary Air Pollution (UNECE CLRTAP) — in force on 23 October 2003;
- the protocol on heavy metals to UNECE CLRTAP — in force on 29 December 2003.

These conventions have the potential to reduce significantly some of the pollutants that are of primary concern in the Arctic. Public health concerns articulated by Arctic indigenous peoples had a direct impact for the first time on global policymaking for the Stockholm Convention (Downie and Fenge, 2003).

The process of ratification by countries is slow, however, and the conventions do not completely address all the issues. For example, the POP agreements target mainly legacy POPs, which are those that have already been banned or controlled in many countries. The agreements include provisions for extending the conventions to cover additional substances, but it may take several years before new chemicals entering the market are properly considered for inclusion under the conventions. Mercury is not yet covered by any global agreement, only by regional ones, such as the UNECE metals protocol. In the EU, regulations state that new chemicals have to undergo rigorous testing.

4.13. Importance of European actions and policies

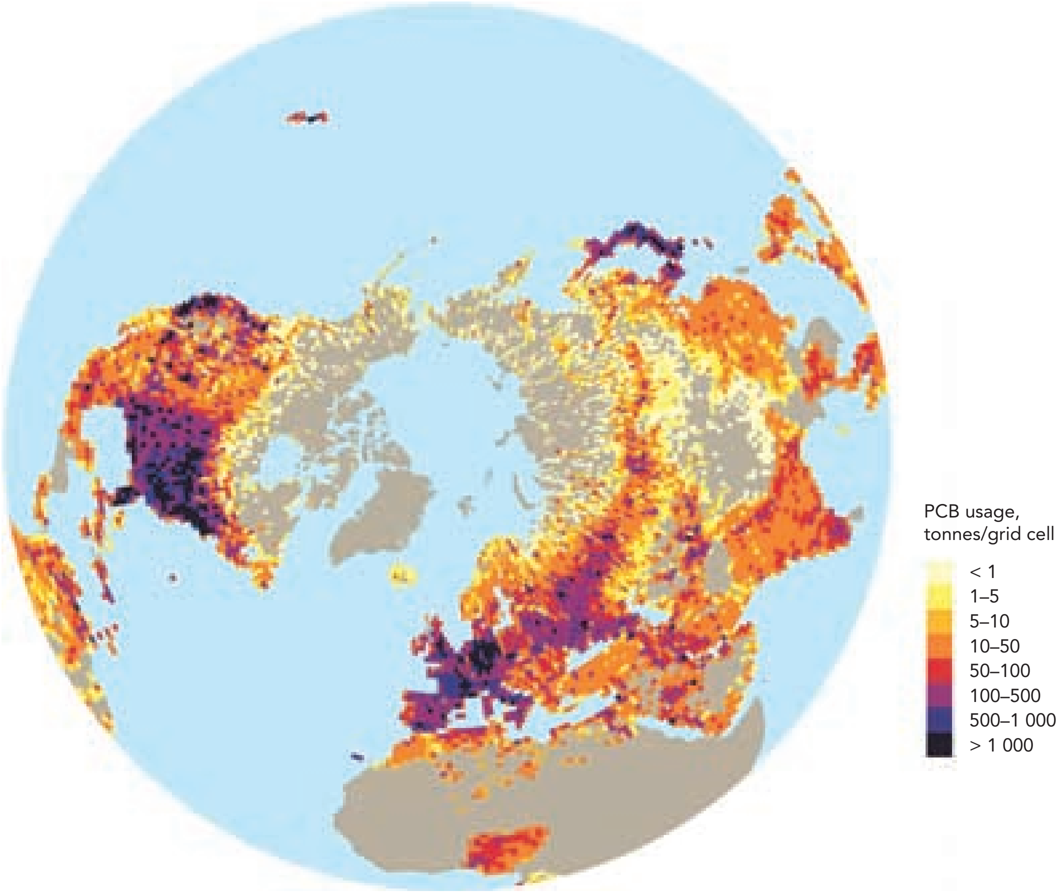
Europe has a vested interest in ensuring that the exploitation of resources outside its boundaries is conducted in an environmentally responsible manner. For example, European demand for seafood caught in the Arctic is high, and appropriate action is needed to ensure a continued supply of high quality, uncontaminated products.

The exploitation of Arctic oil and gas is also driven, to a large extent, by US and European demand, and involves European companies. This development and the associated increase in shipping needs to be managed with appropriate environmental standards and safeguards, or it will result in damage to both the Arctic and to Europe.

In the EU, designing policies from the outset with environmentally sound practices contributes not only to environmental management and protection in Europe, but also helps to ensure that industrial and agricultural activities taking place within its borders do not result in negative impacts on other regions. Much groundwork has already been done. European environmental policies can be expected to have a significant positive impact in reducing contamination in the Arctic. Such policies include those embodied in the water framework directive and air quality directives, and the sixth environment action programme (pesticides strategy) to reduce pollution levels in Europe.

Source: AMAP, 2002.

Figure 4.12 **Estimated PCB usage, 1930–2000**



The industrialised heavily populated areas of Europe are one of the most important sources of contamination reaching the Arctic through long-range transport.

4.14. Europe's engagement in Arctic issues

Some countries and companies in Europe have already recognised that engagement in environmentally sound developments and environmental clean-up efforts can provide new business opportunities. Many possibilities remain for Europe to contribute to projects aimed at reducing or preventing environmental contamination in the Arctic.

Developing policy to deal with Arctic contamination should take into account not only short-term benefits but also the long-term and hidden costs. To date, Arctic remediation projects, such as ACAP (Arctic Council action plan for the elimination of pollution in the Arctic), have been financed mainly by the eight Arctic countries, and by funding bodies such as the Nordic Environmental Finance Corporation (NEFCO). Since the Chernobyl accident in 1986, Europe has begun to support more programmes and remediation projects in the Arctic region, specifically in northwestern Russia.

However, in general, the full scope of pollution issues in the Arctic are not being addressed, and the trend in funding support has been one of decline.

5. The climate is changing the Arctic

The Arctic is a sentinel for climate change. Large areas of sea ice, and the Arctic's role in cold-water mass formation that drives the ocean currents are unique characteristics. They make the Arctic a critical part of the global climate system. Europe, as a major contributor of greenhouse gas emissions — and as a close neighbour to the Arctic — should address climate change by continuing its efforts to bring the Kyoto Protocol into force.

The consequences of climate change include increasing incidence of storms and floods in some parts of Europe, rising sea levels, and changes in the timing and duration of plant growth. The precise impacts of climate change continue to be the subject of much research and debate.

5.1. Particularly sensitive to climate change

Some of the environmental impacts of climate change will become evident in the Arctic sooner than in other regions. This is because of biological and physical characteristics specific to the Arctic, such as the presence of large areas of sea ice cover and permafrost. Warmer temperatures associated with the global greenhouse effect will lead to substantial decreases in the extent and duration of snow and ice cover, and reduced sea ice thickness. Reduced snow and ice cover in turn means that less sunlight will be reflected back into space, increasing temperatures still further.

With warmer temperatures in the Arctic, some bacteria, plants and animals will grow and prosper while other species, for example those that depend on sea ice — such as polar bears that hunt seals on the ice, might disappear from the regions. Some models even predict that by the end of the twenty-first century, climate change warming could result in the Arctic Ocean being ice free in the summer. This would have a significant effect on regional weather patterns, for example by changing the cloud cover and increasing rain and snow amounts.

The rest of the world can monitor climate change impacts in the Arctic to infer how regions such as Europe ultimately may be affected. Natural and human effects on the climate are not easy to separate. However, it is now generally accepted that human activities, such as burning fossil fuels, have resulted in changes in climate and weather patterns and will continue to do so for some time to come.

Europe's climate has changed over time

Europe has experienced extensive natural climate variation in the past. The mountains and hills sculpted in earlier Ice Ages are examples of their potential to change the landscape. More recently in the period of the Little Ice Age from 1450–1850, Europe experienced many harsh winters. Cold and wet summers were characteristic of the last decades of the sixteenth and seventeenth centuries, while the first decade of the nineteenth century saw a climate-induced food crisis in Europe.

Greenhouse gas emissions by European industrial sector

In the EU, emissions of greenhouse gases from the transport sector (which accounted for a fifth of total greenhouse emissions in 2000) increased by 18 % between 1990 and 2000 due to road transport growth in almost all EU Member States.

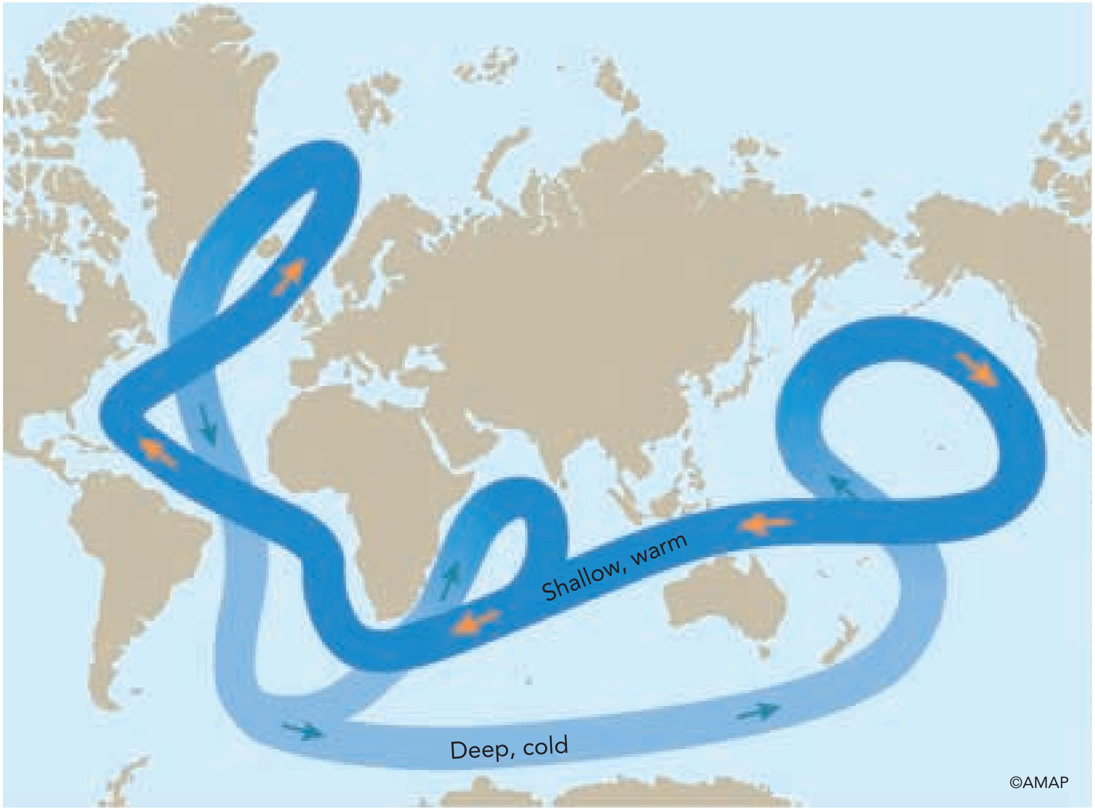
Hydrofluorocarbon (HFC) emissions (1 % of total EU greenhouse emissions) from industrial processes have increased by 66 % as a result of the expanding use of these chemicals as substitutes for ozone-depleting chlorofluorocarbons (CFCs), which were gradually phased out in the 1990s.

The energy sector, including electricity, heat production and petroleum refining, is the largest source of greenhouse gas emissions (26 % of the total). However, this sector has seen carbon dioxide emissions fall by 9 %, partly due to fuel shifts from coal to gas in the UK and other countries.

5.2. Arctic and European currents strongly linked

Source: AMAP, 1997.

Figure 5.1 **Global ocean circulation**



The Arctic plays a fundamental role in the circulation of water in the oceans of the world. When warm, salty North Atlantic water reaches the cold Arctic around Greenland and Iceland and in the Labrador Sea, it becomes denser as it cools, and therefore sinks to deeper layers of the ocean. This process of forming deep water is slow, but takes place over a huge area. Every winter, several million cubic kilometres of water sink to deeper layers, moving water slowly south along the bottom of the Atlantic Ocean.

Climate variation is often associated with oscillations, cyclical shifts in the weather and ocean currents, El Niño, in the southern hemisphere being the best-known example.

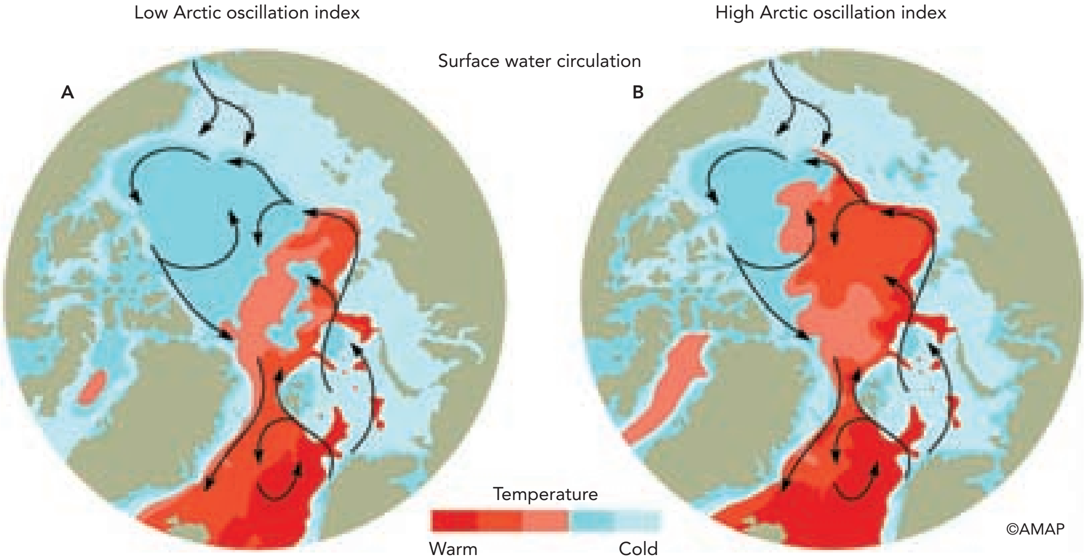
Another, the North Atlantic oscillation, primarily affects weather patterns in Europe, while the Arctic oscillation has its main impact in the Arctic. The North Atlantic and Arctic oscillations are strongly interlinked. Storm frequency and storm tracks, wind, cloud cover, surface water circulation, freshwater discharge and ice drift patterns are all strongly correlated with the Arctic oscillation, and determine the climate in the Arctic. Through its influence on issues such as freshwater discharge, the Arctic oscillation can affect ocean circulation and cold-water mass formation that in turn affect the general temperature of both the Arctic and European regions.

During the 1990s, the Arctic oscillation was extremely high, and the weather associated with low-pressure systems penetrated further north, resulting in higher than normal rainfall and temperatures across western Europe and Scandinavia. This was in marked contrast to the preceding three decades when generally lower Arctic oscillation conditions dominated: higher than average atmospheric pressures over the Arctic led to cold stable conditions in the Arctic as storms were forced to track further south across Europe.

The reason for the extreme high Arctic oscillation conditions in the 1990s is unclear. It could have been a response to global climate change, or a result of natural variability, or a combination of both. Whatever the reason, the 1990s might be an example of what can be expected as the more normal situation in the future (Macdonald *et al.*, 2003).

Figure 5.2 **The Arctic and Atlantic oscillations**

Source: AMAP, 2002.



An exceptionally strong shift to high Arctic and North Atlantic oscillation indices in about 1989 increased the influence of Atlantic water (red) in the Arctic basin. The Atlantic layer currents are relatively fast and move water at a rate of 300–1 600 kilometres per year along the margins of the basin.

Figure 5.3 **Changes of fish species in Arctic waters**

Source: AMAP, 2002.

Possible changes in the distribution of some commercially important fish species that could occur if the seawater temperature increases by 1–2 °C.

The Gulf Stream — a key to Europe's favourable climate

The Gulf Stream, a warm water current that originates in the tropical waters around the Gulf of Mexico, transports vast amounts of heat across the Atlantic Ocean. This heat gives western Europe its temperate climate and keeps the European Arctic Seas ice free as far north as Svalbard. After entering the Arctic, the warm surface current that is the northern branch of the Gulf Stream is cooled and sinks, forming deep cold water current that returns to the Atlantic and drives global ocean circulation. If the temperature in the Arctic increases, and the Arctic Ocean become less salty due to the melting of ice, this circulation pattern may weaken and eventually result in a colder climate in northern Europe, Scandinavia and northwest Russia. Scientific studies have indicated that the Gulf Stream may have weakened in recent years.

5.3. Impacts on Arctic indigenous people

Climate change in the future is expected to happen faster and be more pronounced in extent than has occurred in the last 10 000 years (Bernes, 2002). Changes in Arctic ecosystems will impact the peoples of the Arctic, as changes in the availability of natural resources put pressures on cultures and lifestyles.

As a practical example, if widespread melting of the Arctic permafrost occurs, flooding and subsidence could severely damage existing infrastructure. Repairing or replacing damaged buildings, roads, pipelines, etc. in the remote Arctic is expensive, and new infrastructure development may be needed to cope with life on a waterlogged — as opposed to a frozen — surface.

Indigenous peoples will be the first to experience the impact of climate change. As the environment changes, the indigenous peoples are likely to lose access to large areas of their current hunting grounds, which may affect their food habits.

5.4. Arctic animals and plants threatened

Several million birds migrate to the Arctic each year, and their ability to breed there also determines their abundance at lower latitudes at other times of the year. Conversely, invading land and aquatic species lured to the Arctic by a warmer climate could drive some of the native Arctic species to extinction. Alien species may exploit the foods of local species, thus starving the resident species unless they can adapt quickly to new feeding patterns.

Another consequence is the shrinking of sea ice. This is the primary hunting ground for polar bears. Without sufficient sea ice, the bears will be without access to the crucial seal diet that keeps them alive in the cold.

If forests expand into tundra areas, the lives of animals and plants that are adjusted to the tundra, such as birds and Arctic fox, will also be affected. These animals may decrease in abundance while forest species benefit. Pests may prosper, e.g. such as has been seen in British Columbia and in the state of Washington where pests have killed commercially important trees. Heath and wetland areas are likely to be invaded by grasses, shrubs and trees. Shifts in forest productivity could, however, also be economically important.

More Arctic fish?

One way of predicting what may happen in a warmer world is to look at past experiences. During a period of warming of the North Atlantic seas between 1920 and 1960, a range of marine stocks, from plankton to commercial fish such as cod and herring, increased and expanded their ranges further northward (Vilhjalmsson, 1997; Hylen, 2002). For example, cod fry of Icelandic origin began migrating to Greenlandic waters, resulting in a sizeable cod fishery there in the 1950s and 1960s.

If climate change leads to warmer seas again, then countries like Norway, Iceland and Greenland could possibly look forward to a more lucrative fishing industry. Changing conditions in Arctic freshwater streams and rivers, for example as glaciers melt, could also benefit freshwater and salmon fisheries. Salmon have already migrated into more northerly rivers in Alaska. However, scientists disagree in their predictions about possible ecological consequences from climate change. The heavily fished stocks of today may respond differently from those in the early twentieth century. Climate change could also bring invasions of more alien species, resulting in far reaching changes in ecosystems and food webs with negative impacts on fisheries in the region.

5.5. Climate change affects contamination

Contaminants arrive in the Arctic largely as a result of long-range transport.

During a contaminant's journey to the Arctic, it may spend varying proportions of time in air, soil, water, ice, and food webs or it may become degraded. Each step along the path and every point of transfer can be altered by global change, which for a contaminant may mean dilution, concentration, transformation, bifurcation, shortcut or delay (Macdonald *et al.,* 2003).

As a consequence of climate change, contaminant pathways and their delivery to the Arctic will be affected. It is not possible yet to predict what will happen for any specific contaminant. However, it is likely that some types of Arctic contamination will be enhanced, while other types will be reduced or remain unchanged.

5.6. Climate change in the Arctic

Temperatures have increased on average by two degrees Celsius over the past 40 years in regions of Siberia and North America. Temperature changes vary from place to place, and trends in some areas, such as around west Greenland and Baffin Bay, are of more cooling than warming. Strong seasonal differences have also been observed, with the greatest warming occurring in the winter.

Changes in temperatures are not as large over the oceans and coastal areas because of the large thermal capacity of water, i.e. water's ability to store heat.

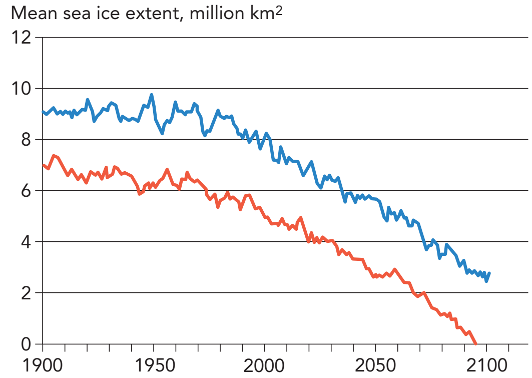
Source: Henning Thing, Danish Polar Photos.

Photo: Glacier at Kangerlussuatsiaq, west Greenland

The light grey zones at each side of the glacier show the former extent.

Source: AMAP, 2002.

Figure 5.4 **Projections of changes in the sea ice cover in the Arctic Ocean**



Model projections of change in sea ice cover for the Arctic Ocean. Annual mean sea ice extent is shown for the northern hemisphere as simulated by two different climate models, which differ in how they treat mixing of the water mass.

Over the last 25 years, Arctic sea ice extent has decreased by approximately 3 % per decade and the duration of autumn/winter and spring/summer decreased by approximately five days per decade (Figure 5.4). Looking ahead, the average temperature may increase by five degrees Celsius at the pole and two to three degrees around the margins of the Arctic Ocean over the next 50–100 years, according to the Intergovernmental Panel for Climate Change (IPCC).

Floods have become very severe in the Lena river and its tributaries in northern Russia, and climate change may have contributed to this. Over the last five years, there have been two extremely severe floods, surpassing all floods of this river since records began. Sixty-two towns and villages were badly affected by flooding in 2001 and the town of Lensk was completely flooded. The direct economic loss was estimated at USD 250 million.

Such costs illustrate the need for awareness and action in water management and policy decision-making. The Arctic monitoring and assessment programme (AMAP) has consequently undertaken, within the framework of the global dialogue of water and climate, the project 'Dialogue on climate change adaptation strategy in water management and flood preparedness at the Lena Basin'. This aims to establish a background to sustainable and sound water management.

Scientist also assign the fact that the tree-line is changing as a sign of climate change. Evidence, such as the greenness index from satellite images, shows that northern forests are expanding (Bernes, 2002).

5.7. Actions and policies

5.7.1. Arctic countries are developing policy through the Arctic Council

The Arctic Council through its AMAP and CAFF working groups has initiated a programme to evaluate and synthesise knowledge about climate variability, climate change and increased ultraviolet radiation, and their consequences in the Arctic.

This Arctic climate impact assessment (ACIA) will also examine possible future impacts on the environment and its living resources. ACIA products will include a peer-reviewed scientific report, a synthesis document summarising results, and a policy document providing recommendations for coping with and adapting to change. This assessment is due to be completed by 2004.

The continued active involvement of the EU to follow and respond to this process is therefore needed. Moreover, given the importance of the Arctic to Europe, both economically and as an indicator of climate change, an expanded research effort in the area should be supported.

5.7.2. International actions are underway to curb climate change

The United Nations Framework Convention on Climate Change (UNFCCC) addresses climate change and its potential consequences. The Kyoto Protocol has been developed under this intergovernmental convention. It sets greenhouse gas reduction targets for all countries in the world on an individual basis. Most industrial nations have signed, with the notable exception of the US (responsible for about 25 % of world greenhouse gas emissions), which has indicated it will not participate. However, if the Russian Federation ratifies the protocol there will be a sufficient number of countries, accounting for a large enough fraction of emissions, for it to enter into force.

The protocol sets reduction targets of 8 % over 1990 levels by 2008–2012 for six greenhouse gases for the EU. The EU has achieved almost half of the Kyoto Protocol targets to date. However, with current trends in a number of the Member States, it is unlikely that the targets will be reached without further action (EEA, 2003). Considerable effort will be required to develop, adopt and implement the required EU and coordinated national policy measures in time.

Nonetheless, progress is being made. Austria, France, the Netherlands, Sweden and the UK have developed EU national programmes. Carbon dioxide taxes are in place in Denmark, Finland, Germany, Italy, the Netherlands, Norway, Sweden and the UK. Also, the UK introduced a national emission-trading scheme in 2002.

The Kyoto Protocol, which has been more than a decade in the making, is still the only global-scale initiative to address human contributions to global climate change. It will not halt the changes in climate already observed or prevent those expected to occur over the coming decades, nor can it affect the natural components of climate change. However, it is a first step towards the further coordinated action that is needed to avoid potentially disastrous consequences in the coming centuries. It is therefore more important than ever that the EU continues its diplomatic efforts to encourage ratification of the protocol so that it enters into effect, and prioritises the actions required to meet negotiated targets.

Moreover, if the EU continues and expands its climate change research with a focus on the Arctic region as an indicator for climate change, this would underline the effectiveness of such measures to the rest of the world.

6. International cooperation: the Arctic Council and the second northern dimension action plan 2004–2006

The Arctic Council, which was established in Ottawa, Canada in September 1996, has a regional identity. Its strength lies in the commitments of Arctic nation governments (Denmark, Finland and Sweden from the EU, and five non-EU members: USA, Canada, the Russian Federation, Norway and Iceland). Indigenous peoples' organisations are also recognised as permanent participants. The Arctic Council's working groups provide scientific assessments and advice on Arctic issues. However, the Council is not a regulatory body, and it has difficulty in addressing controversial issues such as oil, gas and other mineral exploitation, fisheries quotas, forestry, military activities and sustainable use.

The European Council endorsed the second northern dimension action plan in October 2003, on the basis of proposals presented by the European Commission in June 2003. These proposals were developed by the European Commission in close cooperation with EU Member States, partner countries (Norway, Iceland and the Russian Federation) and northern dimension regional bodies — the Arctic Council, the Council of the Baltic Sea States, the Barents Euro-Arctic Council and the Nordic Council of Ministers.

The new action plan addresses the Arctic and Baltic and pays particular attention to crosscutting themes and sustainable development by considering the needs of indigenous peoples living in the High North and in the Arctic.

The Arctic Council (http://www.arctic-council.org)

The Arctic Council is a high level forum providing 'a means for promoting cooperation, coordination and interaction among the Arctic States, with the involvement of the Arctic indigenous communities and other Arctic inhabitants...' The genesis of the Arctic Council was the 'Declaration on the Protection of the Arctic', otherwise known as the Rovaniemi Declaration, signed on 14 June 1991. The Nuuk Declaration of 16 September 1993 broadened this strategy to adopt sustainability as an overarching goal.

The Conference of Parliamentarians of the Arctic region, with delegations from the Arctic states and the European Parliament, is a forum for issues relevant to the work of the Arctic Council. Between conferences, a standing committee carries on the Arctic parliamentary cooperation. There are five working groups under the Arctic Council: the Arctic monitoring and assessment programme (AMAP) (http://www.amap.no); Conservation of Arctic flora and fauna (CAFF) (http://www.caff.is); Emergency preparedness and response (EPPR) (http://eppr.arctic-council.org), Protection of the Arctic marine environment (PAME) (http://www.pame.is); and Sustainable development programme (SDWG) (http://www.arctic-council.org/sdwg.asp).

The northern dimension

The northern dimension process began under the Finnish EU presidency in 1999 and addresses the Baltic and Arctic region. The second northern dimension action plan 2004–2006 has identified key objectives in five broad priority sectors:

1. economy, business and infrastructure;
2. human resources, education, scientific research and health;
3. the environment, nuclear safety and natural resources;
4. cross-border cooperation and regional development;
5. justice and home affairs.

Source: European Commission communication (COM(2003) 343 final).

6.1. Actions and policies — strengthening institutions and capacity

The EU does not have formal observer status in the Arctic Council, but participates in meetings on an ad-hoc basis.

The EU's second northern dimension action plan 2004–2006 is expected to play an important role in developing cooperation with the Arctic Council and other regional bodies with similar mandates, such as the Barents Euro-Arctic Council, the Nordic Council of Ministers and the Council of the Baltic Sea States. The second northern dimension action plan has the potential to address circumpolar and global issues that affect the entire Arctic's resources and environment, although its geographical priority is the Baltic area.

It is particularly important to develop and support projects and programmes that address the rights and needs of indigenous peoples in tackling sustainable use of the Arctic's resources, pollution, biodiversity and climate change. Co-management and community based natural resource management (CBNRM) initiatives have the potential to make important contributions to conservation and the wise use of natural resources.

Universities, such as those in the circumpolar University of the Arctic (http://www.uarctic.org), can play a key role. New interdisciplinary research and associated course programmes are needed that focus on the interactions between social, economic and ecological systems in legal and political contexts, and which address legislation and the roles of the private sector. In education too, indigenous peoples can play a central role in developing appropriate curricula and research agendas.

In general, there is a need to bring Arctic and indigenous perspectives to the attention of key decision-making bodies (Watt-Cloutier, 2003). The Inuit Circumpolar Conference, which represents people in Greenland, Canada, Alaska and the Russian Federation, intends to establish a permanent presence in Washington DC. Along the same lines, consideration could be given to establishing a permanent presence for indigenous peoples in Brussels.

7. Conclusion

The Arctic's unique environment and indigenous peoples are under increasing threat from unsustainable development, pollution and climate change.

However, there are measures to address these problems. Governments, regulators, indigenous peoples and the private sector can work together to manage natural resources and use them responsibly and equitably. International conventions that will limit heavy metal and persistent organic pollutants can be expanded, ratified and implemented. If the Russian Federation accedes to it, the Kyoto Protocol can enter into force and set the scene for further measures to address climate change.

None of these measures are easy, and they will not be accomplished without genuine commitment at all levels. Yet, the European connection to the Arctic is such that this commitment is more than warranted, and the European Union has the potential to play a leading role in catalysing the response of the Arctic nations.

The implementation of the second northern dimension action plan 2004–2006 is the next important step to protect the Arctic environment and the health, welfare and traditional lifestyles of its peoples for future generations.

Source: Thor S. Larsen.

Photo: Icebergs

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