A BIODIVERSITY ASSESSMENT OF THE BARENTS SEA ECOREGION

WWF

The Barents Sea Ecoregion

A biodiversity assessment

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"…the Global 200 initiative [is] the most comprehensive strategy to date for the conservation of the world's biodiversity. The Global 200 Ecoregions, representing a wide range of terrestrial, marine and aquatic environments, were selected with a valuable new set of multiple criteria worthy of adoption by other scientists and conservation professionals."

Dr E.O. Wilson, Professor, Harvard University

"The Global 200 map marks an important contribution to the cause of conserving the world's biological diversity. I attach great importance to international action on this issue, for it is a quintessentially global challenge: no country is immune from the effects of biodiversity loss, and no country can do without the benefits of cooperation in combating the threats that we face."

Kofi A. Annan, Secretary-General of the United Nations

"We all agree that time is running out for conserving the world's extraordinary biodiversity. By highlighting the world's urgent conservation priorities, the Global 200 analysis is an invaluable tool for the international community that can help set priorities for conserving the world's most distinctive and outstanding terrestrial, marine and freshwater ecoregions."

James D Wolfensohn, President of the World Bank

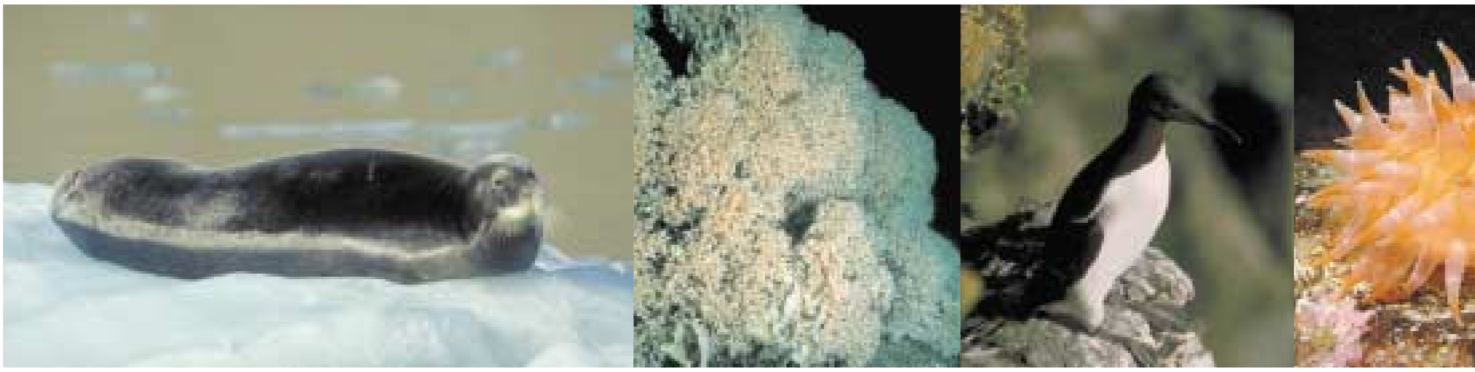
PREFACE

This assessment of the biodiversity of the Barents Sea Ecoregion is part of a major initiative launched by the World Wide Fund for Nature, the Ecoregion Conservation (ERC) strategy. The basis for this strategy is the increasing recognition that nature conservation as well as sustainable use of natural resources is best managed on large scales, based on as complete ecological units as possible. Both natural processes and many threats to biodiversity operate on larger scales than single sites, and traditional nature management approaches and small conservation areas have too often proven to be insufficient to protect the biodiversity in a region. Ecoregion conservation aims toward nature management on a scale that 1) coincides to a large degree with the scale at which natural ecological processes in the area operate; 2) deals with the full range of biodiversity; and 3) enables us to deal with threats on several levels. To reach our goal of maintaining biodiversity for future generations, WWF considers it vital that cooperation is sought with as many partners as possible and that information about biodiversity is made available to all stakeholders and users of natural resources.

The Biodiversity Assessment of the Barents Sea Ecoregion presents comprehensive information about organisms living in both the Russian and Norwegian part of the Barents Sea, including their abundance, distribution and conservation needs. It is the first time that this information is assembled in one report and priority areas for biodiversity conservation have been identified for the Barents Sea as a whole.

The information has been gathered from a multitude of sources in Russia, Norway and elsewhere, and many people have assisted in its making. Besides the participants at a biodiversity workshop held in St. Petersburg in 2001 (see list p. 81, we would particularly like to thank the staff of the WWF Arctic Programme Coordination Office, the marine staff of WWF-Norway, Vassily Spiridonov at the WWF-Russian Programme Office in Moscow, Petra Wahl for valuable information about the Russian oil industry, Karl-Birger Strann for guidance to seabird literature, Bjørn Frantzen for sharing his knowledge about shipping activities and Salve Dahle and Akvaplan-Niva for housing the Barents Sea project office in the Polar Environment Centre in Tromsø. Special thanks must be given to the very helpful staff of the Norwegian Polar Institiute's Library. A most influential source of help and inspiration at the onset of this project was the work done by Margaret Williams and her collaborators in the Bering Sea ecoregion, while Kjell Are Moe and Pål Prestrud provided valuable comments to the manuscript.

The report aims toward a broad group of users, managers, and students of biological and other resources in the Barents Sea. When citing literature in the text, we have therefore given preference to review articles and reports, before specialized scientific literature. Scientists may find this a bit backwards, but hopefully they will also find a satisfying number of references to original works and other scientific literature. Reference to unpublished material has been kept to a minimum, but in some cases this has been unavoidable. Russian readers may notice a bias toward western and Norwegian sources. Translating Russian texts has been one of the obstacles to a more



complete assessment of the biodiversity of the Barents Sea ecoregion, an obstacle we have hopefully been able to tackle to a reasonable extent through extensive consultations with Russian scientists. The alert reader will also notice a number of inconsistencies in the text with reference to geographical names. English names have been used as a general rule, but Norwegian and Russian names have also been spread - intentionally - in the text, tables and maps, as the reader will often find them in other literature about the region.

The Biodiversity Assessment of the Barents Sea Ecoregion draws a picture of an area with extraordinary biodiversity values. Among its most spectacular features can be mentioned the world's highest density of migratory seabirds, some of the richest fisheries in the world, diverse and rare communities of sea mammals and the largest deep water coral reef in the world. While these resources have supported human communities for centuries, growth and expansion of infrastructure, industrial activity and resource exploitation is increasingly threatening to undermine the very basis for biological diversity and production in the ecoregion. It is our hope that this assessment will contribute to increased awareness of the riches of the Barents Sea and to a long-term and a holistic management that balances human development with the needs to protect biodiversity. With wise management and pro-active planning it is still possible to ensure that the marine ecosystem of the Barents Sea continues to function with all its richness.

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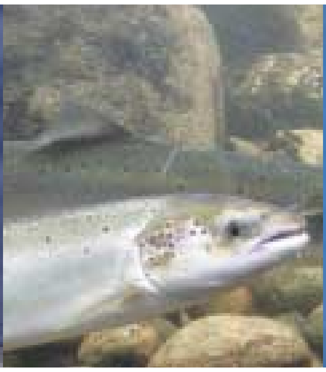

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Figures with placenames may need a small overview of Russian and Norwegian words and map abbreviations:

Guba = bay
Mys = M. = point, cape.
Ostrov(a) = O(-va) = island(s)
Polyustrov = P-ov = peninsula
Proliv = sound, strait
Zaliv = fjord, bay
C. = cape
Pen. = peninsula

Bukta = bay
Fjord, fjorden = fd. = fiord
Kapp = point, cape
Neset = point, cape
Odden = point, cape
Pynten = point, cape
Tangen = point, cape
Vågen = bay
Øy, øya(ne) = island(s)

Appendices

The appendices are available at www.wwf.no/core/barents/index.asp or upon request to WWF-Norway

EXECUTIVE SUMMARY

The Barents Sea has extraordinary biodiversity values. Its shallow structure, inflow of warm Atlantic water, and nutrient-rich upwelling support enormous concentrations of plankton, rich benthic communities, huge concentrations of migratory seabirds, some of the world's largest fish stocks as well as a diverse community of sea mammals. The Barents Sea is one of the most productive oceans in the world and one of the most biologically diverse regions within the Arctic. Nowhere else do warm ocean currents reach as far north as in the Barents Sea, and many species live on the limits of their distributional ranges. The Barents Sea still enjoys a high degree of naturalness and represents one of Europe's last large, clean and relatively undisturbed marine ecosystems.

The Barents Sea ecoregion covers 2.2 million km^2 in the transition zone between European boreal and arctic nature. It stretches north to the Arctic Ocean from the coasts of northern Norway and northwestern Russia. It includes the Northeast Atlantic and Arctic shelf seas north of the Arctic Circle, the White Sea, the western part of the Kara Sea and the waters surrounding the arctic archipelagos of Svalbard, Franz Josef Land and Novaya Zemlya.

This report assembles, systemizes and organises new and existing information on biodiversity in the Barents Sea ecoregion. It describes the ecology of the organisms and their vulnerability to major threats. It maps valuable habitats for seabirds, plankton, ice edge organisms, benthos, fish and marine mammals and identifies overall priority areas for conservation in the Barents Sea. For the first time, comprehensive data on biodiversity and priority areas for conservation for the Barents Sea as a whole is presented in a report.

Ocean currents and the Polar Front. The average ocean depth in the ecoregion is between 200 and 300 meters. Large areas with depths of less than 50 meters are found in the Pechora and Kara Seas and the Spitsbergen bank. From the south, the Norwegian coastal current and the Atlantic current carry warm water into the Barents Sea while from the north, cold arctic water flows to the south and west. Warm and cold water masses meet at the Polar Front, which stretches as a natural and dynamic biogeographic limit eastward in a changing pattern from south of Svalbard.

Plankton. Relative warm and nutrition-rich Atlantic water rises to the surface in the meeting with cold water at the Polar Front. When the ice melts in spring and summer, a very stable and nutritious environment with plenty of sunlight is created in the upper layers of the water column. As a result, the retreating ice edge becomes the scene of a rapidly developing phytoplankton bloom. The species diversity of this sweeping band is moderate, but production is very high. The blooming usually propagates northwards following the ice edge from May until August. It is followed by a bloom of zooplankton, which in turn feeds pelagic fish, benthos, sea birds and most of the rest of the marine ecosystem. Similar conditions and primary productivity are observed in the polynyas. In the arctic ice, ice fauna living in the ice or in the water immediately below the ice exploit a specialised and productive flora of ice algae.

Benthic organisms. The Barents Sea holds a very diverse benthic flora and fauna compared to other arctic seas, and stands out even when compared to northern temperate seas. More than 2500 benthic invertebrate species have so far been described in the Barents Sea, in spite of limited study efforts. There is a trend towards decreasing diversity to the east. Deep-water coral reefs are found at 40-500 m depth along the Norwegian coast. More than 400 coral reefs have been observed and they may cover an area of 1,500-2,000 km^2. In 2002, the Røst Reef, the world's largest cold-water coral reef, was discovered outside of Lofotoen. The kelp forests found in a continuous belt along the rocky coastline of Norway and the northern Kola Peninsula are another feature of interest, covering several thousand square kilometres. Both corals and kelp forests are rich in benthic species and serve as important nursery areas for several species of fish. More than 600 species have been observed associated with a single coral reef. Large colonies of sponges and scallops can be found on the many shallow banks, while shrimps are common in the central Barents Sea at depths of 100 meters or more. The high diversity and productivity on the seafloor is an important premise for the rest of the marine ecosystem. While scientist have sampled and mapped large parts of the seafloor on the Russian part of the Barents Sea, little mapping has been done on the Norwegian side. The comparison of data from different parts of the Barents Sea is complicated by the use of different methodologies.

Fish. The ecoregion holds about 150 fish species of 52 families. North Atlantic boreal and arctic-boreal species predominate, and two-thirds of the species are found only in the western part of the ecoregion close to the limit of their distribution range. The highest number of species occurs in the six families Gadidae, Zoarcidae, Cottidae, Pleuronectidae, Salmonidae and Rajidae. The ecoregion holds some of the largest fish stocks in the world, including Norwegian-Arctic cod, capelin, spring spawning herring and polar cod. Species like capelin and polar cod are key species in the marine ecosystem, representing an important link between the high plankton production and the other trophic levels of the food web. Some stocks, like Norwegian-Arctic cod, herring and capelin are migratory and uses large parts of the Barents Sea in different parts of their life cycle. Others, like redfishes, wool fish, Greenland halibut, tusk and ling are normally stationary and their distribution is related to certain water and seafloor conditions. Most of the Norwegain Arctic cod spawns outside Lofoten in January-April. The herring spawns outside the Norwegian coast south of the ecoregion in the spring, while the haddock has an important spawning area along the southwestern shelf edge. The eggs and larvae of these species are transported by currents to nursery areas in the southern and central Barents Sea. The capelin spawns in shallow waters along the coast of Finnmark and the western part of the Kola

Peninsula. The larvae and eggs of the polar cod drifts from the spawning area south of Novaja Zemlya to the nursery area in the northern Barents Sea. The east coast of Svalbard seems to be another important spawning site for polar cod. The Atlantic salmon spawns in the rivers running into the Barents Sea from the south. While some of the commercial species have received a lot of research attention, less is known about the ecology of the many non-commercial species.

Marine mammals. Twelve species of large cetaceans, five species of dolphins and seven pinniped species have been recorded in the ecoregion. Polar bears are another mammal closely associated with the marine environment. Most of the whales are long-distance migrants, as only three species - white whale (beluga), narwhal and bowhead whale - are permanent high Arctic residents. Historically, all of the large whales in the ecoregion have been hunted, the northern right whale to extinction. Even after 80 years of protection, only scattered individuals of bowhead whale survive near the ice edge. Today, the minke whale is the only whale species being hunted in the ecoregion, and only in limited numbers. Harp seal is the marine mammal that exists in the highest numbers in the ecoregion, with an estimated population of two million individuals. It feeds in the open ocean and in spring huge numbers gather on the sea ice at the entrance to the White Sea to give birth. Walrus, ringed seal and bearded seal are found in highest densities around the northern archipelagos of Svalbard, Franz Josef Land and Novaja Zemlya, while gray seals and harbor seals are commonly found along the southern coasts of the ecoregion. The walrus population totals approximately 2,500 animals and is experiencing a positive development after it was protected in 1954. The present number of polar bears in the ecoregion is estimated at 3,000-5,000. Important denning areas include Svalbard, Franz Josef Land and Novaja Zemlya and very high den densities are found on Hopen and Kong Karls Land. The Barents Sea ecoregion is the only place in the world where the polar bear is protected in its entire natural habitat. The current population status of most marine mammal species is not known, as only the minke whale, polar bear and harp seal receive a reasonable degree of research attention.

Marine birds. More than 40 species of marine birds breed along the coasts of the Barents Sea, many of them in spectacular colonies housing millions of birds in the breeding season. Large fish stocks, vast amounts of krill and other large zooplankton, constitute the basis for some of the largest seabird aggregations in the world. The largest seabird colonies are found on the west coast of Svalbard, on Bjørnøya, and along the north Norwegian coast. Of regular colonies in the ecoregion housing more than 1,000 pairs, Svalbard holds approximately 130, Novaya Zemlya 45, Franz Josef Land 30-40, Norway 41, and the Kola Peninsula 14. Of the White Sea colonies, 33 are registered as possibly holding more than 1,000 breeding individuals. In total, the summer population in the Barents Sea ecoregion exceeds 20 million individuals. Four seabird species - kittiwake, Brünnich's guillemot, little auk and puffin - make up nearly 85% of all breeding seabirds in the region. Significant shares of the global populations of king eider, Steller's eider, Yellow-billed loon and arctic tern live in the Barents Sea. When the seabirds breed in the spring they search for prey in the waters surrounding their colonies. As the edge of the ice moves south in the winter, large numbers of seabirds move to the southwestern part of the Barents Sea. Many birds, in particular auks, spend the winter in open sea, while large numbers of common eider gather in the coastal areas of Finnmark and Kola. Shallow coastal areas are important moulting and resting areas for ducks, geese and waders, and these occur in high numbers along the Kola Peninsula, the White Sea and the Pechora Sea after the breeding season. Many seabirds are highly specialised top predators and are particularly vulnerable to declines in prey stocks. Even today, scientists have relative limited knowledge about the ecology of many species of seabirds in the ecoregion and their distribution during winter.

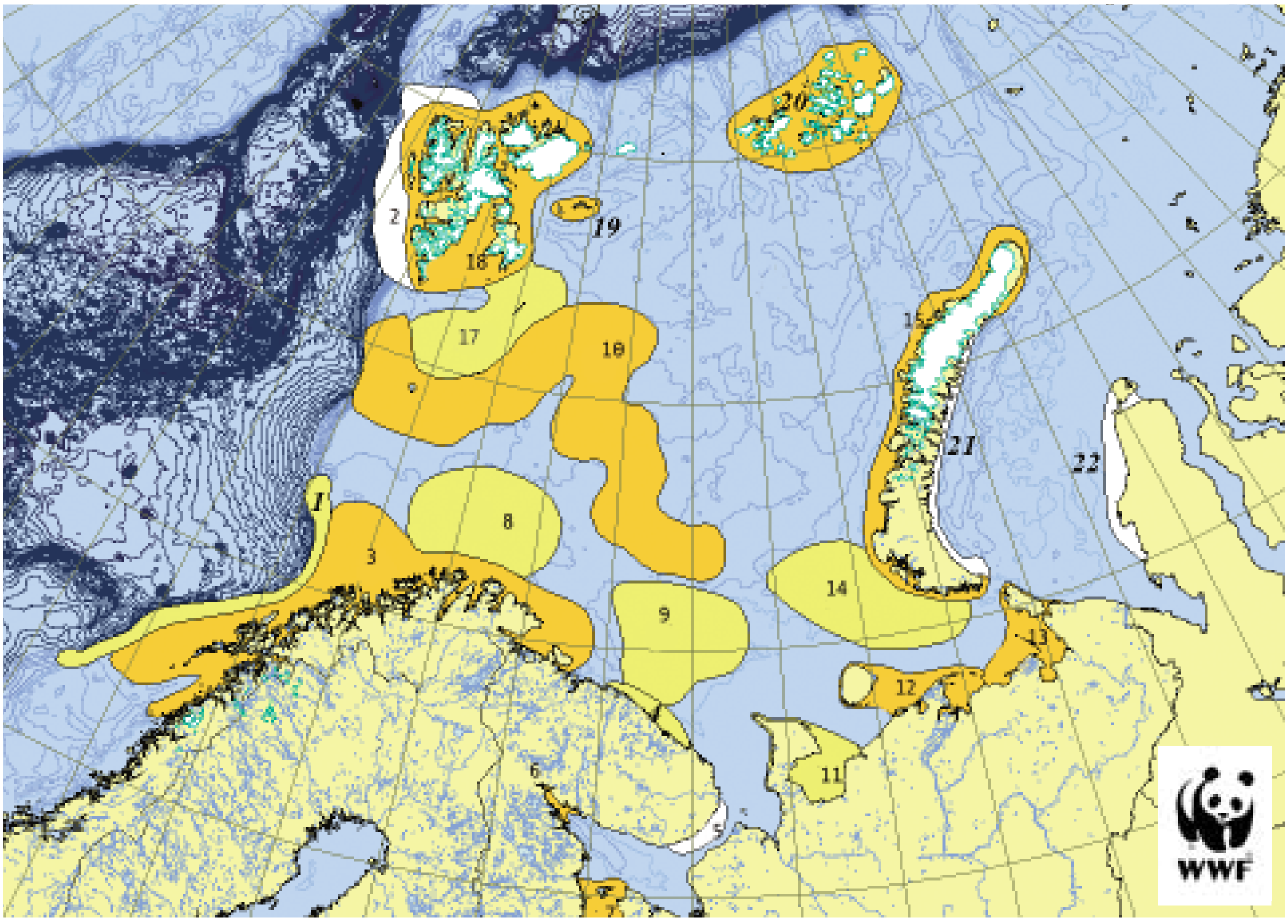
Identifying priority areas for conservation

WWF invited more than 30 leading biologists from Russia and Norway to identify areas of particular importance for the maintenance of biodiversity in the ecoregion. First the ecoregion was divided into ecologically sensible subregions using biological, biogeographic and oceanographic criteria. Then the experts nominated areas of high conservation value for *plankton, benthos, fish, seabirds* and *marine mammals* within each subregion and for the ecoregion as a whole. The following criteria were used when nominating priority: a) naturalness; b) representativeness; c) high biological diversity; d) high productivity; e) ecological significance for species; f) source area for essential ecological processes or life-support systems; g) uniqueness; and h) sensitivity.

The maps with the nominated priority areas for each of the five thematic groups are given in figures 4.1 – 4.6.

In order to identify overall priority areas for biodiversity conservation, data from the five thematic priority groups were combined to produce an overall priority map. A high degree of overlap indicates that an area is valuable for several aspects of biodiversity, and that it should be given particular attention and priority. The workshop participants assessed whether the overall priority map gave sufficient credit to all areas of high importance for sustaining productivity and biodiversity in the ecoregion. Finally, the experts ranked the areas according to their overall conservation value.

The assessment provides a detailed description of each of the priority areas, with a focus on conservation values, current resource use and threats.



Priority areas for biodiversity conservation in the Barents Sea Ecoregion. Dark yellow – very high priority, yellow – high priority, white – priority. Numbers refer to name of the area: 1 = South-western shelf edge; 2 = North-western shelf edge; 3 = Norwegian coast and the Tromsø bank; 4 = Murman coast; 5 = The funnel; 6 = Kandalaksha Bay, 7 = Onega Bay; 8 = North Cape bank; 9 = Banks off Murman coast; 10 = The Polar Front; 11 = Kanin Peninsula and Cheshskaya Bay; 12 = Western Pechora Sea; 13 = Eastern Pechora Sea; 14 = Southeast Barents Sea; 15 = The coast of western and northern Novaya Zemlya: 16 = Ice edge (not on the map); 17 = Spitsbergen bank; 18 = Svalbard coast; 19 = Kong Karls Land; 20 = Franz Josef Land; 21 = Eastern Novaya Zemlya coast; 22 = Eastern Kara coast. The ice edge is not included in the map due to its fluctuating nature, although it is among the most spectacular features of the arctic seas and is given high priority.

Current and potential threats to biodiversity in the Barents Sea ecoregion

In spite of deep scars left by the whalers in the 17th and 18th centuries and the impacts of ongoing activities, in particular fisheries, the Barents Sea is among the cleanest and most undisturbed oceans in the world. At the same time, it is the most accessible region of the Arctic, and human activities are quickly expanding to even the most remote areas of the ecoregion. More than anything else, the planned production of the ecoregion's vast hydrocarbon resources is likely to change the economic and geopolitical situation of the Barents region profoundly. An increasing share of Russia's oil exports is being shipped through the ecoregion and oil companies are investing heavily to fast-track oil and gas development. In a few years, the Barents Sea may find itself at the heart of the production and transportation of a significant part of Russia's oil exports to the West. This fast-moving development, in combination with other important and growing threats to biodiversity, represents a serious challenge to the environment and living resources in the Barents Sea. This report provides updated information on the most important current and potential threats to the ecoregion's biodiversity.

Overfishing. In the past overfishing has led to declines of fish species, changes in marine food webs and fisheries crisis in the Barents Sea. The ecoregion is one of the main scenes of commercial fisheries in the world, and fisheries are probably the single activity currently affecting the Barents Sea's biodiversity to the largest degree. In addition to declines in targeted fish stocks such as capelin and cod, fisheries also directly affect other fauna. Bycatch is a serious threat to several species of fish and seabirds, and bottom trawling has devastating effects on benthic communities, such as corals and sponges. In addition, fisheries may have dramatic implications for organisms in other trophic levels as they often affect the abundance and distribution of key species of the ecosystem. Almost as a rule quotas are set significantly higher than recommended by scientists.

Climate change. The Barents Sea is likely to be the scene of quick changes due to global warming. Almost all climate models project substantial warming and increases in precipitation for the Arctic in the coming decades. Small changes in temperature may cause large changes in arctic ecosystems, and the list of possible effects of global warming on the Barents Sea is long. Reduced sea ice cover is a likely consequence already being observed. As warming occurs and sea ice melts, species composition will change. The seasonal distribution, ranges, patterns of migration, nutritional status, reproductively and ultimately the abundance and balance of species will be altered. Extinctions of species dependent on sea ice or particularly sensitive to changes in sea temperatures are not unlikely.

Petroleum development. Petroleum development will pose a major threat to the natural riches of the Barents Sea eco-region. Large gas resources are known in the Barents Sea and new oil deposits are likely to be found in the near future. The first offshore development in Norway is the Snøhvit gas field, which will begin production from 2006, while the Prirazlomnoye oil field in Russia may be producing already by 2005. Oil and gas development may result in discharges of drilling chemicals, radioactivity and produced water, and will certainly result in habitat destruction and a risk of medium to large oil spills through blowouts, pipeline leaks, when loading to tankers or other accidents. Oil spills in the sea ice, in polynyas or along the ice edge will have particularly dramatic consequences. The existing oil spill preparedness and response system in the region is of little effect, particularly in rough weather. Petroleum development will also bring along infrastructure development and changes in the way of life of indigenous peoples and local communities.

Ship transport. Shipping in and through the ecoregion is expected to increase substantially in the ecoregion over the coming years, perhaps by as much as a factor of ten by 2020. This is due not only to the development of new petroleum fields in the Barents Sea, but also because transport of petroleum from existing inshore fields will be shifted from pipelines to ships. If existing plans to build a pipeline to the Kola Peninsula are realised, the Murmansk area will have one of the world's largest oil terminals by 2010. In addition, the possible opening of the "Northern Sea Route" for commercial traffic and the development of the "Northern Maritime Corridor" may result in increased ship traffic through the ecoregion. An accident with a ship containing oil, radioactive waste or other hazardous cargo could have devastating effects on both biodiversity and industries. The coastline in the ecoregion is among the most hazardous in the world, with rough weather and innumerable islands, skerries and rocky shallows. In addition to accidents, both operational discharges and illegal dumping of oil to the sea is a widespread practise in shipping, giving rise to a number of chronic pollution problems. The introduction of alien species via ships' ballast water is another major environmental problem. With increased shipping, in particular exports of high-density cargoes, the volume of ballast water discharged into the Barents Sea will increase manyfold.

Long-range pollution. The combined effects of ocean currents, atmospheric transport and river drainage result in the Barents Sea being a "sink" for long-range pollution, such as heavy metals, PCBs and other persistent organic pollutants (POPs). Pollution levels generally increase as one goes higher up in the food chains. The effects are most pronounced in marine mammals and seabirds, but diet-related differences in toxic levels have been found even among ice amphipods. There is strong evidence that current mercury exposures in the Arctic already represent a health risk to people and biodiversity. In birds and mammals mercury is known to cause nerve and brain damage, weight loss and reduced reproduction. POPs are known to affect the reproduction of birds, fish and mammals, to weaken several parts of their immune systems, to cause brain damage and to decrease bone density. POP levels in both polar bears and glaucous gulls are far higher in the Barents Sea ecoregion than in any other part of the Arctic. If not significantly reduced, toxic emissions may have (and probably already do have) serious consequences on species living in the Barents Sea ecoregion.

Radioactivity. The Kola Peninsula may represent the largest potential nuclear threat to the environment in the world. It has the world's highest density of nuclear reactors, many of them inside rusting decommissioned nuclear submarines. The area contains large quantities of liquid and solid radio-active waste and spent nuclear fuel, often stored in run-down and unsecured facilities. Russia is also considering importing nuclear waste from Europe, as well as to facilitate transport from Europe to Japan via the Northern Sea Route. In both cases, radioactive material will be shipped along the Norwegian and Russian coasts. At the moment, however, the only measurable radioactivity in the area comes from one country outside the ecoregion: The United Kingdom. Technetium 99 from the Sellafield nuclear reprocessing plant has been recorded since 1998 in Norwegian waters, and has reached as far north as Svalbard. Although relatively little is known about the long-term effects on the marine environment of low-dose, chronic exposures of radioactivity, it is thought that arctic terrestrial ecosystems are particularly vulnerable to releases of radioactivity.

Aquaculture. The aquaculture industry is expected to grow rapidly on both the Norwegian and Russian sides of the Barents Sea. Governments and industry in both countries show great interest in increasing the production of farmed fish and molluscs. The expansion of the aquaculture industry gives rise to two overriding concerns: The intrusion of fish farms into vulnerable marine and coastal areas, and the overall sustainability of an industry that depends on large catches of wild fish to feed farmed fish. Poorly managed and regulated aquaculture can have severe negative impacts through the release of excessive nutrients, chemicals and pathogens, as well as escapees of farmed fish. In Norway, farming of salmon and rainbow trout is an important industry, providing jobs and income in rural and Northern areas. However, environmental issues, like observed increase in sealice infestestions, can have serious impact on local stocks of Arctic charr, seatrout and salmon. Also, high numbers of escaped fish raise concern in areas where wild Atlantic salmon has its natural habitat. Growth in the aquaculture sector is expected to come from new, marine species, such as cod, and little is known about possible environmental effects.

Introduction of alien species. While the probability of an alien species surviving and reproducing in the Barents Sea is low, the potential consequences on biodiversity and industries can be enormous and irreversible. Alien species may affect their new environment in several ways: Native species can be displaced or eliminated; interactions between native species may be disrupted; hybridization with native species can result in loss of genetic diversity; and new parasites or diseases may accompany the alien species. The Kamtchatka king crab, which was released by scientists on the Kola coast in the 1960s, has spread westwards and is now found in vast numbers throughout the southern part of the Barents Sea and as far north as Svalbard. The population probably numbers more than 15 million individuals. The king crab is known to alter benthic communities and to consume capelin eggs, but it is unknown how and to what extent it affects the native fauna in the Barents Sea. Another introduced crab species, the snow crab, has so far had a limited distribution in the Barents Sea. However, in 2003 the first observations were made outside the coast of Finnmark, indicating that it is spreading westward faster than previously expected. Among several pathways for alien species in the marine environment are ballast water, aquaculture, bait, trade, research escapes and fish processing plants.

Conservation first

Meeting this growing number of challenges will require a long-term view and a holistic approach that balances protection and development. Only a comprehensive environmental agenda shared by all stakeholders can ensure the long-term integrity of the Barents Sea ecosystem. Such an agenda must be based on existing bi- and multilateral institutions, common goals and indicators for environmental status and agreed and well-monitored environmental standards for activities.

Protection of a representative set of natural habitats is vital to any attempt to conserve biodiversity in a region. Marine protected areas (MPAs) are necessary to secure the survival of key species, ecosystem components, and processes that are important to and representative of the ecoregion. A network of MPAs should be established in the Barents Sea before new or expanded industrial development takes place in order to provide buffer zones for marine organisms, build resilience and safeguard a set of representative marine areas for future generations to study. A network of MPAs will not only benefit conservation, but also communities, by protecting renewable natural resources that will be the basis for long-term, sustainable development and businesses by providing predictability for investors, developers, governments and other stakeholders.

With very few exceptions, none of the protected areas in the ecoregion have been designed particularly with marine life in mind. There is virtually no overlap between present conservation areas in the Barents Sea ecoregion and the priority areas identified in this report. Today, none of the most vulnerable areas or important ecosystem processes has any protection at all. The priority conservation areas identified in this assessment are therefore natural starting points when planning a future network of MPAs in the Barents Sea ecoregion.

Towards a conservation strategy for the Barents Sea ecoregion

When addressing the variety of threats on a regional scale it is clear that setting aside valuable and vulnerable areas will not be enough to ensure the protection of biodiversity in the Barents Sea ecoregion. In addition, a series of long-term global, regional and local mitigation measures must be developed and enforced. Future management of the Barents Sea ecoregion should be based on the principles of ecosystem-based management, to ensure that no activities threaten important ecosystem processes or components.

It is our hope that information in this assessment will enable policy-makers, natural resource managers and other stakeholders to improve decision-making and to take the necessary steps to conserve the biodiversity of the Barents Sea. With wise management and pro-active planning it is possible to ensure that the Barents Sea continues to function with all its richness, despite the growth and expansion of infrastructure, industrial activity and resource exploitation.

This biodiversity assessment is part of WWF's Global 200 approach to protect the most valuable components of Earth's biodiversity, and it will form the basis for the further development of WWF's Barents Sea Ecoregion Programme. WWF will develop conservation strategies and implement a series of activities and projects in order to contribute to safeguarding the natural riches of the Barents Sea ecoregion for future generations.

КРАТКОЕ СОДЕРЖАНИЕ

Баренцево море исключительно ценно в отношении биологического разнообразия. Его относительная мелководность, приток теплых атлантических вод, богатый питательными веществами апвеллинг обеспечивают существование огромного количества планктона, богатых сообществ бентоса, одних из крупнейших в мире запасов рыбы, а также разнообразных популяций морских млекопитающих, поддерживают высокую концентрацию морских и околоводных перелетных птиц.

Воды Баренцева моря являются одними из наиболее биологически продуктивных полярных вод в Мировом океане. Нигде более на земном шаре южные океанические течения не достигают таких высоких широт, как в Баренцевом море. Динамичность окружающей среды, гидрологический Полярный фронт, сезонный ледовый покров и постоянно присутствующая кромка морского льда определяют высокую биологическую продуктивность моря. Многие атлантические виды живут здесь на северной границе, а арктические – на южной границе своего распространения. Баренцево море все еще не сильно затронуто человеческой деятельностью и представляет собой одну из последних больших, чистых и сравнительно неповрежденных морских экосистем Европы.

Экорегион Баренцева моря охватывает часть северо-восточной Атлантики, Баренцево, Белое моря и сопредельные части Карского моря с островами, архипелаги Шпицберген (Свалбард), Земля Франца-Иосифа и Новая Земля (примерно 2,2 миллионов километров морской акватории), материковые побережья губерний Финнмарк, Тромс и Нордланд в Норвегии, Мурманской, Архангельской области, республики Карелия, Ненецкого и Ямало-Ненецкого автономного округов в России.

Этот отчет собирает воедино, систематизирует и представляет известную и самую новую информацию о биологическом разнообразии в регионе Баренцева моря. Он содержит описания экологии организмов и их уязвимости к различного рода угрозам. В него также включены карты распространения колоний морских птиц, планктона, организмов, живущих во льдах, рыб и морских млекопитающих и идентифицированных по всему региону приоритетных районов для сохранения биологического разнообразия.

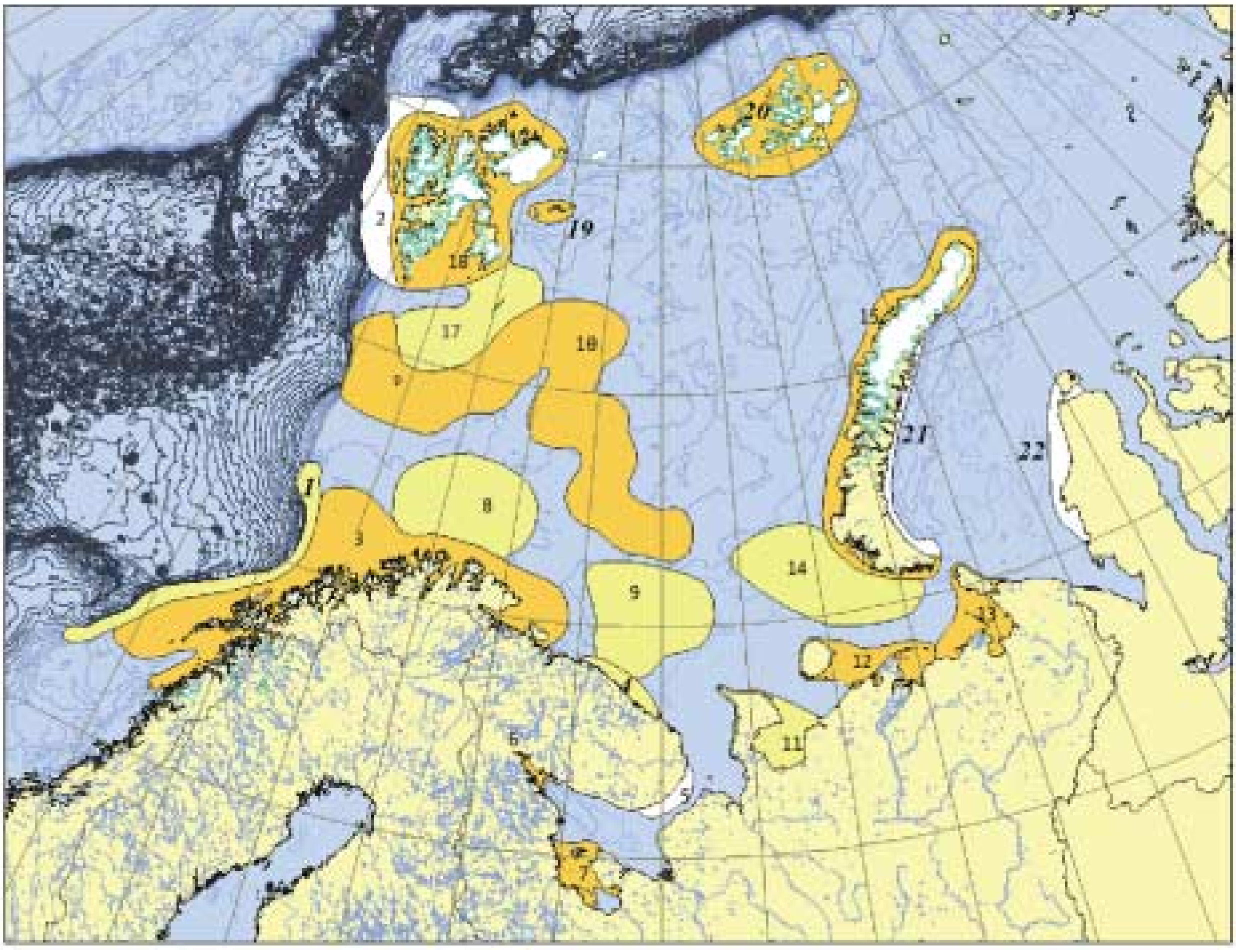
Океанские течения и Полярный фронт. Средняя глубина моря в Баренцевом регионе колеблется между 200 и 300 метрами. Обширные мелководные участки с глубиной менее 50 метров находятся в Печорском и Карском морях и на Шпицбергенской банке. С юга прибрежное Норвежское течение и Атлантическое течение приносят в Баренцево море теплые воды, в то время как с севера холодные арктические воды текут в западном и южном направлениях. Теплые и холодные течения встречаются в зоне Полярного фронта, который тянется как природная динамичная граница в восточном направлении и особенно изменчив к югу от Шпицбергена.

Планктон. Относительно теплые и богатые питательными веществами атлантические воды, встречаясь с холодными водами, поднимаются на поверхность в зоне Полярного фронта. Во время весеннего и летнего таяния льда создается устойчивый и богатый питательными веществами поверхностный слой воды, куда проникает достаточное количество солнечного света. В результате, отступающий край льда становится областью быстрого возникновения такого явления как «цветение воды». Видовое разнообразие этого волнообразно перемещающегося очага развития фитопланктона невелико, но продуктивность очень высока. Как правило, он распространяется в северном направлении, следуя за кромкой льда с мая по август. За ним следует образование зоны, богатой зоопланктоном, который, в свою очередь, является кормом морских рыб, бентоса, морских птиц, а также большинства других животных морской экосистемы. Похожие условия и продуктивность наблюдаются в полыньях. В арктическом льду фауна, живущая непосредственно в воде, в нижней поверхности льда или в самой толще льда, использует богатую продукцию ледовых водорослей.

Бентос. Баренцево море населено многообразной донной флорой и фауной, разнообразие которой превосходит не только разнообразие бентоса остальных арктических морей, но и фауны и флоры умеренных вод Северного полушария. В Баренцевом море известно более 2500 видов морских беспозвоночных. Наиболее разнообразен бентос на западе Баренцева моря, на востоке региона разнообразие снижается. Примечательны глубоководные коралловые рифы, которые найдены на глубине 40-50 метров вдоль побережья Норвегии. Обнаружено более 400 коралловых рифов. Возможно, их общая площадь составляет 1500-2000 квадратных километров. В 2002 году в районе Лофотенских островов был открыт риф Рест – самая большая в мире холодноводная коралловая постройка. Заросли ламинарии тянутся длинным поясом вдоль скалистого берега Норвегии, Кольского полуострова и Карелии. Коралловые рифы и келпы, заросли бурых водорослей, обеспечивают убежище многим видам донных животных и рыб. На одном только рифе найдено более 600 видов морских организмов. Большие колонии губок и скопления морского гребешка встречаются на мелководье, тогда как северная креветка образует большие скопления в центре моря на глубине более 100 метров. Высокое разнообразие и продуктивность на дне моря являются важной предпосылкой для развития остальной морской экосистемы. В то время как ученые исследовали и нанесли на карту большие участки морского дна в российской части Баренцева моря, лишь немногие участки норвежской части моря исследованы биологами. Сравнение данных по бентосу различных участков Баренцева моря затруднено из-за использования различных методов исследований.

Рыбы. В регионе Баренцева моря обитает около 150 видов рыб из 52 семейств. Преобладают северо-атлантические и арктическо-бореальные виды, две трети из которых можно встретить только в западной части Баренцева моря. Лидируют по числу видов шесть семейств: тресковые, камбаловые, бельдюговые, бычки-керчаки, лососевые и скаты, морские лисицы. В экорегионе находится одно из крупнейших в мире скоплений рыбы, представленное арктo-норвежскую треской, мойвой, полярной треской и откладывающей весной икру сельдью. Такие виды как мойва и сайка являются ключевыми для морской экосистемы. Они представляют собой связующее звено между высокой продуктивностью планктона и последующими звеньями пищевой цепи. Некоторые популяции рыбы, например, норвежско-арктическая треска, сельдь и мойва мигрируют, используя большие участки Баренцева моря в различные периоды их жизненного цикла. Другие популяции, такие как морской окунь, зубатка, гренландский палтус, менек, живут на постоянных участках, и их размножение связано с конкретными районами моря и условиями морского дна. Большинство особей аркто-норвежской трески откладывает икру недалеко от Лофотенских островов с января по апрель. Сельдь нерестится у берегов Норвегии на юге экорегиона весной, а у пикши важный район нереста – юго-западная граница морского шельфа. Икра и мальки этих видов переносятся течениями к местам обитания на юге и в центре Баренцева моря. Мойва мечет икру на мелководье вдоль берега Финмарка и западной части Кольского полуострова. Потомство сайки дрейфует от районов нереста у южной оконечности Новой Земли до мест нагула в северной части Баренцева моря. Восточный берег Шпицбергена является другим важным участком нереста полярной трески. Семга нерестится в реках, впадающих в Баренцево море с юга. Ряд промысловых видов рыб исследован достаточно хорошо, об экологии многих некоммерческих видов известно гораздо меньше.

Морские млекопитающие. В экорегионе отмечены двадцать видов больших китов, пять видов дельфинов и семь видов ластоногих. Белые медведи, млекопитающие отряда хищных, тесно связаны с морской средой, и их можно условно считать морскими животными. Большинство китов совершают протяженные миграции, и только три вида – белуха, нарвал и полярный кит, являются постоянными обитателями Арктики. Исторически на всех больших китов в регионе производилась охота, что привело к почти полному уничтожению полярного кита. Даже после восьмидесяти лет охраны лишь отдельные представители этого вида встречаются вблизи границы постоянных льдов. Малый полосатик – единственный на сегодня вид, чей весьма ограниченный промысел ведется в экорегионе. Гренландский тюлень, морское млекопитающее, достигающее очень высокой численности. Его популяция по некоторым оценкам насчитывает 2 миллиона особей. Это животное кормится в открытом океане, а весной огромные стада гренландских тюленей собираются для воспроизводства потомства на морских льдах около входа в Белое море. Морж, кольчатый тюлень и морской заяц обитают вокруг северных архипелагов Шпицберген, Земля Франца Иосифа и Новая Земля, а серый тюлень и нерпа обычно встречаются у южных берегов Баренцева моря. Популяция моржа насчитывает около 2500 особей, при этом отмечается ее рост с тех пор, как она была взята под охрану в 1954 году. Современная численность популяции белого медведя в экорегионе составляет 3500 – 5000 животных. Медведицы залегают в берлоги и дают потомство на Шпицбергене, Земле Франца-Иосифа, Новой Земле и, особенно, на островах Хопен и Земля Короля Карла. Баренцевоморский регион – единственная обширная область на земле, где белый медведь охраняется на территории всего своего местообитания. Современное состояние популяций большинства морских млекопитающих в регионе не известно, поскольку лишь малые полосатики, гренландские тюлени и белые медведи учитываются более или менее регулярно.



Приоритетные районы для сохранения биоразнообразия Баренцевоморского экорегиона.
Темно-желтый цвет – исключительно приоритетный, желтый – высоко приоритетный, белый – приоритетный.
Соответствующие названию района номера: 1 – юго-западный участок шельфа; 2 – северо-западный участок шельфа; 3 – норвежское побережье и банка Тромсо; 4 – побережье Мурмана; 5 – горло Белого моря; 6 – Кандалакшский залив; 7 – Онежский залив; 8 – банка Норд Капа; 9 – банки у побережья Мурмана; 10 – Полярный фронт; 11 – Канин Нос и Чешская губа; 12 – западное Печорское море; 13 – восточное Печорское море; 14 – северо-восточное Баренцево море; 15 – западное и северное побережья Новой Земли; 16 – кромка льда (не изображена на карте); 17 – банка Шпицбергена; 18 – побережье Шпицбергена; 19 – Земля Короля Карла; 20 – Земля Франца-Иосифа; 21 – восточное побережье Новой Земли; 22 – восточное побережье Карского моря.
Кромка льда не изображена на карте по причине ее сильной изменчивости. Несмотря на это, положение кромки льда является одной из наиболее впечатляющих особенностей арктических морей, и ей придается высокая приоритетность.

Морские птицы. В районе Баренцева моря гнездится более 40 видов морских птиц, многие из которых живут впечатляющими колониями, насчитывающими миллионы особей. Большое количество рыбы, криля и зоопланктона составляет основу поддержания этих скоплений морских птиц, одних из крупнейших в мире. Самые многочисленные колонии располагаются на западном побережье Шпицбергена (примерно 130 колоний), на острове Медвежий, Новой Земле (45 колоний) и вдоль северного побережья Норвегии (40 колоний), Кольского побережья (14 колоний) и Земле Франца-Иосифа (30-40 колоний). На Белом море 33 постоянные колонии насчитывают более чем по 1000 размножающихся особей каждая. Среди наиболее многочисленных видов можно назвать тупика, тонкоклювую и толстоклювую кайр, люрика, моевку, серебристую и морскую чаек, численность которых составляет более 85% всех гнездящихся в регионе птиц. В регионе Баренцева моря обитает и значительная часть мировых популяций таких видов как обыкновенная гага, гага-гребенушка, малая гага и арктическая крачка. Во время гнездования птицы добывают пищу вблизи своих колоний. По мере смещения кромки льда на юг зимой, скопления морских птиц перемещаются в западную часть Баренцева моря к югу от Полярного фронта. Многие птицы, в частности, чистиковые, проводят зиму в открытом море, в то время как обыкновенные гаги собираются в прибрежных районах Финмарка и Кольского полуострова. Прибрежные мелководные участки – это важнейшие места линьки и отдыха уток, гусей и куликов, которые после окончания гнездового периода, собираются огромными стаями по берегу Кольского полуострова, побережьях Белого и Печорского морей. Многие морские птицы являются высоко специализированными хищниками, замыкающими собой пищевые цепи. Поэтому они особенно чувствительны к сокращению своей кормовой базы. Даже сегодня экология многих видов морских птиц региона изучена недостаточно, особенно мало знают ученые о распределении птиц во время зимнего периода.

Выделение приоритетных для охраны районов

WWF пригласил более 30 ведущих биологов из России и Норвегии выделить районы особой важности для поддержания биологического разнообразия региона. Вначале территория региона была разделена на экологически значимые субрегионы на основе биологических, биогеографичесчких и океанологических критериев. Затем эксперты выделили районы высокой природоохранной ценности в отношении *планктона, бентоса, рыб, морских птиц и млекопитающих* в пределах каждого субрегиона и в регионе в целом. Использовались следующие критерии: а) ненарушенность; б) представительность; г) высокое биологическое разнообразие; д) экологическая значимость для видов; е) важность для поддержания необходимых экологических процессов или системы жизнеобеспечения; ж) уникальность; и) чувствительность.

Карты предлагаемых приоритетных для охраны биоразнообразия районов по пяти названным тематическим группам представлены на рис. 4.1 – 4.6.

Для определения общей приоритетности районов данные по пяти группам организмов были совмещены на общей карте. Высокая степень наложения указывала на ценность участков по всем аспектам биологического разнообразия и на то, что накладывающиеся районы должны стать приоритетными для природоохранной работы. Участники совещания оценили насколько общая карта приоритетных районов репрезентативна в отношении биоразнообразия региона и отражает наиболее продуктивные его участки. В заключение эксперты проранжировали выделенные районы по их общей природоохранной ценности.

В отчете приводится детальное описание каждого приоритетного района с особым вниманием к его природоохранной ценности, современным видам природопользования и угрозам для биоразнообра-зия.

Существующие и потенциальные угрозы для биоразнообразия Баренцевоморского экорегиона

Несмотря на глубокие шрамы, оставленные китобойным промыслом в 17 и 18 веках, а также воздействие текущей хозяйственной деятельности, в особенности, рыболовства, Баренцево море является одной из самых чистых и ненарушенных морских экосистем в мире. В то же время данный регион является самым доступным в Арктике, и человек проникает все в более и более удаленные области региона. Больше чем какая-либо другая деятельность планируемое освоение гигантских ресурсов углеводородов экорегиона может значительно изменить экономическую и геополитическую ситуацию в Баренцевоморском регионе. Доля российского нефтяного экспорта, проходящего через регион, постоянно увеличивается, и нефтяные компании активно инвестируют в форсированное развитие нефтегазового комплекса. Через несколько лет Баренцево море может оказаться в центре добычи и транспортировки значительной части российского экспорта нефти на запад. Такое быстро продвигающееся развитие в сочетании с другими важными и растущими угрозами биоразнообразию представляет серьезный вызов окружающей среде и биоресурсам Баренцева моря. Данный отчет содержит современную информацию о наиболее важных текущих и потенциальных угрозах для биоразнообразия экорегиона.

Перевылов. Перевылов привел к уменьшению количества видов рыбы, изменениям в морских пищевых цепях, а также к кризису рыболовства в Баренцевом море. Экорегион является одной из ведущих мировых арен коммерческого рыболовства. Интенсивное рыболовство, по всей вероятности, представляет собой единственный вид деятельности значительно влияющий на биоразнообразие Баренцева моря на данный момент. Помимо сокращения запасов таких промысловых видов рыбы, как треска и мойва, рыболовство также воздействует и на другую фауну. Прилов представляет серьезную угрозу для нескольких видов рыб и морских птиц, а траление дна оказывает разрушающий эффект на донные сообщества, такие как кораллы и губки. Кроме этого, рыболовство может серьезно воздействовать на организмы других трофических уровней, так как они часто определяют численность и состояние ключевых видов экосистем. Как правило, квоты на вылов устанавливаются гораздо выше квот, рекомендованных учеными. Другая тенденция заключается в том, что растущий флот рыболовных траулеров требует постоянного снабжения рыбой для погашения кредитов и не обладает достаточной гибкостью, чтобы сократить выловы в условиях уменьшающихся запасов рыбы.

Изменение климата. Баренцево море может стать сценой быстрых изменений, связанных с глобальным потеплением климата. Практически все климатические модели предсказывают значительное потепление и увеличение количества осадков в Арктике в последующие десятилетия. Небольшие изменения температуры могут вызвать большие изменения в арктических экосистемах. Список потенциальных эффектов глобального потепления на Баренцево море очень длинный. Уменьшение площади ледового покрова является вероятным последствием, наблюдаемым уже в наши дни. По мере потепления и таяния ледового покрова будет меняться видовая структура сообществ. Сезонное распределение, размеры, характер миграций, статус питания, репродуктивность и, вероятно, частота и баланс видов изменятся. Не исключено исчезновение видов, зависящих от распределения морского льда или особенно чувствительных к изменениям температуры морской воды.

Нефтегазовое развитие. Нефтегазовое развитие будет представлять главную угрозу природным богатствам региона Баренцева моря. Крупные месторождения газа уже открыты в Баренцевом море, и есть вероятность того, что в ближайшем будущем будут найдены новые залежи нефти. Примером первого развития на шельфе является месторождение газа Снохвит в Норвегии, начало добычи на котором запланировано на 2006 год, в то время как добыча на российском месторождении нефти Приразломное может начаться уже в 2004 году. Нефтегазовое развитие может привести к сбросу буровых растворов и химических веществ и, несомненно, приведет к нарушению местообитаний, а также создаст риск возникновения разливов нефти в результате взрывов и утечек нефтепроводов, утечек во время погрузки нефти на танкеры, а также других происшествий. Нефтяные разливы в морских льдах, в полыньях и вдоль кромки льда будут иметь особенно драматичные последствия. Существующая система реагирования и ликвидации нефтяных разливов является малоэффективной, особенно в тяжелых погодных условиях Баренцевоморского региона. Освоение углеводородов также принесет с собой развитие инфраструктуры и изменения в образе жизни коренных народов и местного населения.

Судоходство. Перевозки в пределах и через экорегион возрастут значительно в Баренцевом море в ближайшее время, возможно, в 10 раз к 2020 году. Это случится не только по причине освоения новых месторождений углеводородов в Баренцевом море, но также из-за того, что перевозки углеводородов с существующих месторождений на материке будут осуществляться в большей степени морскими судами, а не нефтепроводами. В случае реализации существующего плана строительства нефтепровода на Кольский полуостров Мурманск будет иметь один из крупнейших нефтеналивных терминалов в мире к 2010 году. Помимо этого возможное открытие Северного Морского Пути для коммерческого судоходства и развитие Северного Морского Коридора может привести к увеличению потока судов в экорегионе. Авария судна, перевозящего нефть, радиоактивные отходы или другие опасные грузы, может иметь разрушительный эффект как для биоразнообразия, так и для промышленности в регионе. Многие нефтеналивные терминалы не обладают достаточными средствами защиты, а побережье экорегиона является одним из самых сложных по судоходным и погодным условиям в мире, с многочисленными островами, шхерами и каменистыми отмелями. Помимо аварий, сбросы во время обычных технических операций и незаконный слив нефти в море, весьма распространенные в судоходной практике, приведут к росту количества постоянных проблем связанных с загрязнением. Появление и расселение видов-вселенцев, привносимых балластовыми водами судов, представляет собой еще одну из главных экологических проблем. При увеличении судоходства, в особенности экспорта с использованием крупнотоннажных танкеров, объем балластовых вод, сбрасываемых в Баренцево море, увеличится во много раз.

Дальний перенос загрязнения. Комбинированное воздействие океанических течений, атмосферного переноса и стока рек приводит к тому, что Баренцево море является «сточной канавой» для долгоживущих загрязнителей, таких как тяжелые металлы, поливинилхлориды и другие стойкие загрязняющие вещества. Уровень загрязнения обычно увеличивается при переходе по пищевым цепям. Загрязнению более всего подвержены морские млекопитающие и птицы, хотя обусловленные типом питания повышенные уровни токсичности обнаруживаются даже среди обитающих во льду амфипод. Существует достоверное доказательство того, что современные уровни концентрации ртути в экорегионе уже сегодня представляют собой риск для здоровья людей и биоразнообразия, вызывая нарушения мозга и нервной системы, приводя к потере веса и снижению репродуктивности. Стойкие органические загрязнители известны своей способностью влиять на репродуктивность птиц, рыбы и млекопитающих, ослаблять их иммунную систему, вызывать нарушения в функционировании мозга и уменьшать плотность костей. Исходя из того, что концентрация стойких органических загрязнителей в белых медведях и серых чайках является выше в Баренцевоморском регионе, чем где-либо в Арктике, можно заключить, что регион получает больше долгоживущих загрязнителей, чем другие районы. Без значительного снижения уровня токсических эмиссий они могут привести (и возможно уже привели) к серьезным последствиям для живущих в экорегионе Баренцева моря видов.

Радиоактивность. Кольский полуостров представляет собой наибольшую потенциальную ядерную угрозу для окружающей среды в мире. Полуостров имеет самую высокую плотность ядерных реакторов, множество из которых находится в отслуживших свой срок ржавеющих атомных подводных лодках. В данном районе находится большое количество жидких и твердых радиоактивных отходов, а также использованного радиоактивного топлива, которые часто хранятся в полуразрушенных и неохраняемых хранилищах. Россия также рассматривает возможность ввоза радиоактивных отходов из Европы наряду с осуществлением перевозок из Европы в Японию по Северному Морскому Пути. В обоих случаях радиоактивный материал будет перевозиться вдоль побережья Норвегии и Мурмана. В данный момент, однако, единственная умеренная радиоактивность исходит от страны, находящейся за пределами экорегиона, – Великобритании. Технеций-99, поступающий с завода переработки радиоактивных отходов Селафилд, обнаруживается в норвежских водах с 1998 года, достигая северной оконечности Шпицбергена. Несмотря на то, что в данный момент известно достаточно мало о долгосрочных эффектах воздействия на морскую среду радиации в малых дозах, известно, что арктические наземные экосистемы особенно уязвимы к воздействию выбросов радиоактивности.

Аквакультура. Ожидается, что аквакультура будет быстро развиваться как в норвежской, так и в российской частях Баренцева моря. Правительство и промышленные круги в обеих странах выражают заинтересованность в повышении уровня производства выращиваемых на фермах рыбы и моллюсков. Экспансия промышленности аквакультуры дает повод для возникновения ряда опасений. Прежде всего, они связаны с внедрением рыбных ферм в чувствительные морские и прибрежные районы, а также с общей устойчивостью этой промышленности, зависящей от больших уловов дикой рыбы, необходимой чтобы накормить разводимую на фермах рыбу. Плохо управляемая и регулируемая аквакультура может иметь тяжелые негативные последствия посредством сбросов больших количеств питательных веществ, химикатов и болезнетворных организмов, а также при непроизвольном выпускании выращиваемой рыбы.

Интродукция видов-вселенцев. В то время как вероятность выживания и воспроизводства видов-вселенцев в Баренцевом море является низкой, потенциальные последствия для биоразнообразия могут быть огромными. Виды-вселенцы могут воздействовать на окружающую среду несколькими путями: аборигенные виды могут быть замещены или уничтожены; взаимодействие между видами может быть нарушено; гибридизация с аборигенными видами может привести к потере генетического разнообразия; новые паразиты или болезни могут появиться вместе с чужеродными видами. Камчатский краб, выпущенный учеными на побережье Кольского полуострова в 60-х годах прошлого века, распространился на запад и сейчас обнаруживается в огромном количестве во всей южной части Баренцева моря, доходя до Шпицбергена. Популяция краба насчитывает 10 миллионов особей. Камчатский краб известен своей способностью видоизменять бентосные сообщества и потреблять икру мойвы, при этом до сих пор не известно, в какой степени он наносит ущерб аборигенной фауне Баренцева моря. В 2003 году были проведены первые наблюдения в акватории вблизи побережья Финмарка, показавшие, что краб распространяется на запад быстрее, чем предсказывалось ранее. Среди путей проникновения видов-вселенцев в морскую среду можно выделить следующие: балластовые воды, аквакультура, использование приманки в рыболовстве, торговля, непроизвольное распространение исследовательских экземпляров и рыбоперерабатывающие заводы.

Охрана прежде всего

Для того чтобы во всеоружии встретить растущее число вызовов необходим долгосрочный взгляд и глобальный подход, уравновешивающий охрану и развитие. Только всеобъемлющая повестка дня, разделяемая всеми заинтересованными лицами, может обеспечить долговременную целостность экосистемы Баренцева моря. Такая повестка дня должна быть основана на существующих институтах, общих целях и индикаторах экологического состояния, а также на согласованных и хорошо контролируемых экологических стандартах хозяйственной деятельности.

Охрана репрезентативного набора природных местообитаний – жизненная необходимость при любых попытках сохранить биологическое разнообразие в регионе. Создание морских охраняемых акваторий является насущной потребностью для обеспечения выживания ключевых видов, компонентов экосистем, а также процессов, важных для экорегиона и широко представленных в нем. Сеть особо охраняемых морских участков должна быть создана прежде, чем случится новое или ускорится существующее промышленное развитие с целью обеспечения буферных зон для морских организмов, повышения их стойкости и сохранения репрезентативной сети морских охраняемых участков для изучения будущими поколениями. Сеть охраняемых морских участков будет способствовать не только охране природы, но и населению через охрану возобновляемых природных ресурсов. Это в свою очередь будет служить основой для долгосрочного устойчивого развития бизнеса, обеспечивая предсказуемость для инвесторов, промышленни-ков, правительств и других заинтересованных лиц.

Не принимая во внимание несколько исключений, ни одна их охраняемых территорий в экорегионе не была создана именно для сохранения морской среды. На данный момент фактически не существует наложений существующих охраняемых районов в Баренцевоморском регионе с приоритетными областями, выделенными и данном отчете. Сегодня ни одна из наиболее уязвимых областей и ни один из важнейших экосистемных процессов не имеет какого-либо охранного статуса. Приоритетные для охраны районы, представленные в этом отчете, являются точками отчета при будущем планировании сети охраняемых морских участков в регионе Баренцева моря.

На пути к созданию концепции охраны Баренцевоморского экорегиона

Рассматривая различные угрозы на региональном уровне, становится понятно, что сохранения ценных и уязвимых районов не будет достаточно для обеспечения полноценной охраны биоразнообразия региона Баренцева моря. Кроме того, серия долгосрочных глобальных, региональных и локальных мер по минимизации потенциальных эффектов должна быть разработана с большей тщательностью и впоследствии усилена. Будущая система управления Баренцевоморским регионом должна основываться на принципах управления на экосистемной основе, нацеленного на обеспечение того, что любая деятельность не угрожает важным экосистемным компонентам или процессам.

Мы надеемся, что информация, содержащаяся в данном отчете, даст лицам принимающим решения, менеджерам природно-ресурсной сферы и другим заинтересованным лицам возможность улучшить процесс принятия решений и предпринять необходимые шаги для сохранения биоразнообразия экорегиона Баренцева моря. С помощью мудрого управления и превентивного планирования возможно гарантировать то, что экосистема Баренцева моря будет функционировать, сохраняя свои богатства, несмотря на рост инфраструктуры, промышленную деятельность и добычу ресурсов.

Данная оценка биоразнообразия является составляющей подхода WWF к сохранению наиболее ценных компонентов биоразнообразия Земли – Global 200. Данный подход будет служить основой для дальнейшего развития программы WWF в Баренцевоморском экорегионе. WWF будет разраба-тывать стратегии охраны, а также осуществлять ряд проектов и мероприятий для того, чтобы внести свой вклад в сохранение для будущих поколений природных богатств региона Баренцева моря.

Harp seal pup. Photo: WWF-Canon / Chris Martin Bahr

1. INTRODUCTION - THE FRAMEWORK

A sea of opportunities

The Barents Sea is one of the most biologically diverse and productive marine ecosystems within the Arctic. Its shallow and nutrient rich waters support huge concentrations of plankton, the world's highest density of migratory seabirds, some of the richest fisheries in the world as well as diverse communities of sea mammals and benthic organisms. The biodiversity and biological productivity of the Barents region has been, and still is, of great importance for both the local and national economies of Norway and Russia.

Yet the biodiversity of the Barents Sea is facing several serious challenges. The ecosystem is already affected by human activities such as over-harvesting of resources, shipping, aquaculture, pollution, tourism, climate change and introduced species. In the near future large-scale exploitation and transportation of fossil fuels are likely to play a major role in the political, economic and environmental development in the region.

Large hydrocarbon resources have already been discovered in the Barents Sea, new deposits are likely to be found in the near future and oil from fields further east will increasingly be shipped out from northwest Russian harbors. In this new and fast-moving political situation, it will be a huge challenge to safeguard the region's wildlife and invaluable natural resources for future generations. Living and renewable resources will remain the only basis for long-term, large-scale sustainable production. For centuries, these resources have been the main source of jobs and income in the region, and when the oil is gone we must be sure that they can continue to sustain the communities of the region.

The Barents region is unique in that it now stands at a crossroads most other regions passed decades ago. While economic development will continue to drive increased demands on the Barents Sea's limited resources, we can still choose how to move forward sustainably. In many other parts of the world the opportunities to balance conservation with development have already been lost. With wise management and pro-active planning it is possible to ensure that the Barents Sea continues to function with all its richness, despite the growth and expansion of infrastructure, industrial activity and resource exploitation.

A Biodiversity Assessment of the Barents Sea Ecoregion is part of WWF's strategic approach to conserve Earth's biodiversity. The approach, which we call ecoregion-based conservation, recognizes that some areas of the world have extraordinary biodiversity values, and that conservation is best managed on a large scale and within as complete ecosystem units as possible. WWF has selected the Barents Sea as a high priority ecoregion due to its extraordinary biodiversity values.

In order to protect the natural values of the Barents Sea we need to know which values it contains and where they can be found. The overarching aim of this assessment is therefore to give a presentation of biodiversity in the Barents Sea: Which species can be found, where are they found, what is the present state of the populations, and which areas are most vital for their continued survival.

It is our hope that the assessment will contribute to increased awareness of the riches of the Barents Sea and to a long-term and a holistic management that balances human development with the need to protect biodiversity.

Amphipode. Photo: Erling Svensen

The Global 200 Ecoregions and the global conservation challenge

Life on Earth - plants, animals, and people - is an interdependent complex. Its balance is threatened by the accelerating loss of species caused first and foremost by the loss of natural habitats through human actions. Once the quantity and quality of intact habitats falls below a critical level, the prospects for the species that depend upon them are bleak. At a certain stage, so are those of human beings. All of us ultimately depend on the ecosystem services provided by the countless species of our biosphere.

Human actions affect natural habitats in various ways. Major direct impacts often include infrastructure development and the expansion of industries, agriculture or fisheries to new areas. Key indirect impacts include the consequences of the introduction of new species, the effects of global warming caused by the build-up of greenhouse gases in the atmosphere, and the impacts of toxic substances on wild species and ecosystems. Each day the impacts of industrial development are reaching more and more remote areas, leaving no ecosystem on the planet totally intact and undisturbed.

Conservation of biodiversity - the variety and variability of the millions of species that live on Earth - is not an optional choice in national or regional development plans; it must be a key component of them. These facts of life - the critical importance of biodiversity and the need to integrate conservation into broader social and economic policies and programmes - are now well recognized by the international community, as demonstrated, for example, by the ratification of the Convention on Biological Diversity. But it is clear that while we are winning a number of battles, we are still losing the war to conserve biodiversity. We need not only make biodiversity conservation an integral component of development plans in all sectors of government and civil society, but also to coordinate and focus these efforts internationally. The goals of biodiversity conservation are integrally linked to the goals and aspirations of human society.

It is important to conserve biodiversity everywhere, but current trends make this problematic. At the very least, we should make sure that we conserve representative examples of each of the many distinctive expressions of life. To help guide this undertaking, WWF scientists have identified the most outstanding regions for each of the world's diverse terrestrial, freshwater and marine habitats. These are the "Global 200 Ecoregions".

What is the Global 200?

The Global 200 Ecoregions are derived from a comparative analysis of biodiversity data leading to a selection of the most outstanding examples of each of the world's diverse terrestrial, freshwater and marine "ecoregions." The central concept of the Global 200 is simple: by conserving a comprehensive representation of the world's habitats, we can conserve the broadest range of the world's species and most endangered wildlife, as well as the ecological and evolutionary processes that maintain the web of life. Hence, the Global 200 analysis targets representative ecoregions from every major habitat as the centrepiece of a global biodiversity strategy. Such a strategy must also tackle global threats such as overfishing, forest loss, global warming and the freshwater crisis. As well as the more familiar terrestrial habitats, the Global 200 highlights outstanding examples of freshwater and marine ecosystems. This is critically important because the threats to aquatic biodiversity are even greater than the threats to plants and animals on land. Also, at the higher taxonomic levels, marine organisms display much greater diversity than their land-based relatives: out of a total of 33 animal phyla, 32 are found in the sea, and almost half are exclusively marine.

Although an estimated 50% of all species occur within a single major habitat type (tropical rain forests), the other half of all species are found elsewhere in the world's land, freshwater and marine habitats. To conserve those species, we must conserve a full representation of the world's diverse ecosystems. And even though species loss in the rainforest is cause for concern, other unique habitats are disappearing even faster. Tropical dry forests, temperate zone freshwater streams and grasslands, and other major habitat types are being converted and degraded at a rate similar to or even surpassing most rain forests. Other less biologically diverse areas are also critical components of a global strategy. Tundra, tropical lakes, arctic oceans, mangroves, and temperate broadleaf forests all are unique expressions of biodiversity. Although they may not support the rich communities seen in tropical rainforests or coral reefs, they contain species assemblages adapted to distinct environmental conditions and reflect different evolutionary histories. To lose examples of these assemblages, and the ecological processes together with the evolutionary phenomena they contain, would represent an irreparable loss to mankind and the Earth, with incalculable consequences for future generations.

What needs to be done?

We need to be strategic about where we focus international conservation efforts in order to conserve the broadest possible range of biodiversity. We must also consider how we implement conservation – our efforts have to be on a scale and of a nature capable of addressing the underlying causes as well as the symptoms of biodiversity loss. As WWF's response to the first of these two critical questions, the Global 200 turns the spotlight on those ecoregions of the world which deserve greater attention because of their representative biodiversity values. WWF's response to the second question focuses on ecoregion conservation (ERC), a broad-based approach that is based on the securing of representative and viable networks of protected areas, and building these into the development plans of the region in a way that addresses the underlying causes of biodiversity loss.

What is an ecoregion?
Ecoregions are distinct ecosystems of regional extent. Specifically, ecoregions are relatively large units of land or water containing a geographically distinct assemblage of natural communities sharing a large majority of their species, dynamics, and environmental conditions. At the species level, ecoregions represent the area within which one would expect to find the great majority of individuals for a defined species, or the large proportion of its sub-populations. Ecoregions function effectively as conservation units at regional scales because they encompass similar biological communities, and because their boundaries roughly coincide with the area over which key ecological processes most strongly interact.

The methodology for selecting the Global 200
The Global 200 Ecoregions synthesize the results of regional analyses of biodiversity across the continents and oceans of the world, completed in collaboration with hundreds of regional experts and by conducting extensive literature reviews. The Global 200 Ecoregions were chosen from outstanding examples of each terrestrial, freshwater, and marine major habitat type (MHT). MHTs describe different areas of the world that share similar environmental conditions, habitat structure, and patterns of biological complexity, and that contain similar communities and species adaptations. Thirteen MHTs were identified in the terrestrial realm, three in the freshwater realm, and four in the marine realm. Each MHT was further subdivided by biogeographic realm (e.g. Nearctic, Indian Ocean, Palearctic) in order to represent the unique faunas and floras of the world's continents and ocean basins. Finally, ecoregions that represent the most distinctive examples of bio-diversity for a given MHT were identified within each biogeographical realm. Only the biodiversity value of ecoregions sharing the same MHT were compared because the relative magnitude of parameters such as richness and endemism varies widely among them. For example, comparing the richness of tree species in ecoregions classified as tropical moist forests to tree diversity in desert or grassland regions would be misleading.

The guiding principle for the selection of the Global 200 Ecoregions is that of "representation." Up to now, this concept has generally been applied locally or regionally. The Global 200 analysis applies it at the global scale by including representative ecoregions of every MHT within each continent and ocean basin. Among ecoregions of comparable biological distinctiveness in the same MHT and the same biogeographical realm, those with relatively more intact habitats based on assessments of their conservation status are included.

Other globally important examples of biodiversity – such as hydrothermal vent communities, pelagic ecosystems, and cave and groundwater biotas – have not yet been adequately mapped to allow their inclusion in the Global 200 analysis. Although the Global 200 aims to represent all major habitat types, like any effort to identify priorities it does not address all aspects of biodiversity conservation. Thus, the Global 200 analysis does not explicitly target hemispheric-scale ecological phenomena, such as migrations of birds, marine mammals, sea turtles, or fish. Highly endangered species will also continue to require targeted conservation efforts. More detailed, fine-scale maps and other analyses are essential to identify and conserve core areas for biodiversity both within Global 200 Ecoregions and elsewhere.

The selection process for The Global 200 includes the following steps:

1. Ecoregions were stratified by realm (terrestrial, freshwater, and marine).
2. The resulting groups of ecoregions were divided and grouped into their major habitat types (MHT).
3. Each MHT was further subdivided by biogeographic realm (e.g. Nearctic, Indian Ocean) in order to represent unique faunas and floras of different continents or ocean basins.
4. Within each biogeographic realm, ecoregions representing the most distinctive examples of biodiversity for a given MHT were selected, using the following criteria:
   (a) Species richness
   (b) Levels of endemism
   (c) Higher taxonomic uniqueness (e.g. unique genera or families of relict species or communities, primitive lineage)
   (d) Unusual ecological or evolutionary phenomena (such as large-scale migrations)
   (e) Global rarity of the major habitat type (e.g. Mediterranean forest, shrublands and woodlands, an MHT that occurs in only five parts of the world and yet hosts more than one-fifth of all known plant species on Earth).

Within each MHT and biogeographic realm, ecoregions were classified by their biological distinctiveness at one of four levels: globally outstanding, regionally outstanding, bioregionally outstanding, or locally important.

Selection of marine Global 200 Ecoregions

As on land and in freshwater, the marine Global 200 Ecoregions have been defined as areas encompassing similar biological communities and over which key ecological processes occur. Marine ecoregions delineated under the Global 200 analysis are nested within a biogeographically based framework. The analysis includes representation of major marine habitat types from each of the five major marine biogeographic realms: Atlantic Ocean, Indian Ocean, Pacific Ocean, Arctic Ocean, and Southern Ocean. Deep sea pelagic ecoregions are not currently included in the analysis as they are as yet insufficiently mapped at the global scale.

The identified ecoregions represent the most distinctive examples of biodiversity for each major habitat type, based on the concept of Large Marine Ecosystems developed by Sherman and Alexander (1986). These are large regions, often over 200,000 km^2, that are characterized by distinct bathymetry, hydrography, productivity and trophically linked populations (Sherman et al. 1990).

The Global 200 Marine Ecoregions include the hugely diverse coral communities of New Guinea and the Moluccas; the unique marine vertebrate assemblages of the Antarctic Peninsula and the Galapagos; the major barrier coral reef areas off Australia, Central America and New Caledonia; and areas of high endemism such as the Marquesas (in the South Pacific), Nansei Shoto (in Southern Japan), and Southern Australia. Due to its high primary production, exceptional biodiversity values and clean and relatively intact ecosystem, the Barents Sea has been selected as one of WWF's priority marine ecoregions.

The ocean currents and the dispersal patterns of larvae and many adult animals mean that patterns of biodiversity and ecological processes in the oceans do not conform to national boundaries or territorial seas. As has been recognized for many years, this means that ecoregion-based conservation and other large-scale conservation approaches are essential for successful management of marine resources. At the global level, the UN Regional Seas Programme has identified a number of marine regions (e.g. Northeast Atlantic, Mediterranean, South Pacific, Caribbean, etc.) where regional frameworks are being developed, often within the context of a regional treaty or agreement. The Global 200 and the approach of ecoregion-based conservation can be used to contribute to such large-scale regional efforts.

The boundaries of ecoregions are derived from regional analyses of biodiversity patterns undertaken by WWF's Conservation Science Program and others. They are based on an assessment of the original extent of the ecoregions prior to marked human interventions during the course of the last few hundred years. These assessments were made in collaboration with hundreds of regional experts and included extensive literature reviews.

Ecoregion conservation (ERC)

The Global 200 turns the spotlight on those ecoregions of the world that deserve greater attention because of their extraordinary biodiversity values. Ecoregion conservation is an attempt to help provide the means for conserving these values. ERC addresses large temporal and biogeographical scales, and focuses on both socio-economic and biological processes and dynamics at these scales. ERC aims to secure lasting conservation for species, habitats and ecological processes, and to create a solid basis for sustainable development. It involves developing biodiversity action plans that bring together the best available ecological and socio-economic information with full stakeholder participation and effective partnerships. This allows the design of appropriate policy and management interventions at all levels – from international trade policies to site-specific nature management, and community development projects.

ERC begins with a planning process that includes a reconnaissance phase and the development of a biodiversity vision based on a lengthy temporal scale (at least 50 years) and on large biogeographical scales. It requires up-to-date, accurate biological, social, cultural, political and economic data and information (where these are not available, it may require predictive modelling and best guesses). ERC is fundamentally about using this information to help stakeholders at various scales (local, regional etc.) within an ecoregion secure a consensus on how to achieve both sustainable development and sustainable conservation – providing for the full expression of biodiversity and the full functioning of ecosystems while also meeting other human needs and aspirations.

Convergence with other global biodiversity analyses

The Global 200 has its own key focus and rationale, as do other global biodiversity analyses aimed at helping prioritize international conservation efforts. But there is a remarkable degree of agreement on the biogeographical priorities for conservation, based on these global assessments, and a high proportion fall within the Global 200.

Hotspots - Myers/Conservation International

This is probably the best known of all global priority-setting analyses to date. First introduced by Myers (1988, 1990) and extended by Conservation International (1998), the hotspots approach originally focused exclusively on threatened areas of high plant endemism. Virtually all of the hotspots fall within the Global 200.

Endemic Bird Areas of the World
BirdLife International has mapped every bird species with a restricted range of less than 50,000 km^2. The areas where these maps overlap define avian centres of endemism – endemic bird areas are good indicators of high biodiversity and hence represent priority areas for conservation.

Centres of Plant Diversity
A key objective of this IUCN/WWF analysis was to identify which areas of the world, if conserved, would safeguard the greatest number of plant species. A total of 234 sites of global botanical importance were selected, based on plant species richness and endemicity. The great majority fall within Global 200 Ecoregions.

Biodiversity: Its meaning and measurement

The term "biodiversity" is commonly used to describe the number, variety and variability of living organisms. It has become a widespread practice to define biodiversity in terms of genes, species and ecosystems, corresponding to three fundamental and hierarchical levels of biological organisation (WCMC 1995).

Genetic diversity is the heritable variations within and between populations of organisms. Genetic diversity is essential to survive under changing conditions. It is genetic variation that enables natural evolutionary change to occur. Some genes, in particular genes that control fundamental biochemical processes, are strongly conserved across different taxa and generally show little variation. Other genes vary greatly even within local populations, reflecting adaptations to specific local conditions.

Species diversity refers to the variety of living species. It is measured by species richness (number of species in a defined area), species abundance (relative numbers among species), and taxonomic or phylogenetic diversity (genetic relationship between different groups of species). Every species places special demands on its surroundings. The living space of a species is called its habitat, and species diversity generally increases as ecosystem diversity, or the diversity of habitats, increases Species diversity is the most commonly used expression for biological diversity. Species are the primary focus of evolutionary mechanisms, and the evolution and extinction of species are the principal agents governing biological diversity in most senses. Species cannot, however, be recognised and enumerated with total precision, and the definition of a species may differ considerably between groups of organisms.

Species diversity is not evenly distributed globally. The richness is concentrated in the equatorial regions of the earth and decrease as one moves to more polar regions. The highest taxonomic diversity is found in marine ecosystems. Representatives of 32 of the 33 known animal phyla are found in the world's oceans, while only 17 can be found on land.

Ecosystem diversity relates to the variety of habitat communities, ecological processes and the diversity of habitats occurring within each ecosystem type. Ecosystem diversity is harder to measure than species or genetic diversity because the boundaries of communities and ecosystems are elusive.

Ecological processes
In an ecosystem, organisms live in close interaction with abiotic factors and the organisms and non-living surroundings influence each other. Ecological processes are the result of the interactions among species and between species and their environment.

Important ecosystem processes are, among others, production (the transformation of solar energy to biomass through photosynthesis), decomposition (the breakdown of organic materials by organisms in the environment), geochemical cycles (the movement of energy, water, and other chemical elements through living organisms and the physical environment) and evolution (the change in the frequency of alleles within a gene pool from one generation to the next) (WRI, 2003; Miller 1989).

Different species play different roles in the ecosystem and support different processes. For example, some organisms are decomposers while others are primary producers. In this way ecologists say that different species fill different ecological niches. The ecological niche of a species can be very complex as a species through its various life-stages may live in different habitats and occupy various niches.

No simple relationship exists between biodiversity and important ecological processes. Nor is there a simple relationship within any given ecosystem between a change in its biodiversity and the resulting change in the system's processes. Instead, the outcome depends on which species and ecosystem are involved. For example, the loss of species from a particular region may have little effect on net primary productivity (or even lead to an increase) if competitors take its place in the community. In other cases, however, the loss of certain species (so-called keystone species) from an ecosystem could have severe impacts on important ecosystem processes (WRI 2003).

Marine biodiversity in the Arctic
Although the Arctic's oceans have relatively few species compared to warmer waters, they contain many species not found elsewhere and many habitats, ecological processes and adaptations are unique (CAFF 2001). These include the bursts of life in spring, organisms living in the sea ice, as well as the physiological features that allow animals to maintain body heat through the arctic winter.

The extreme environmental conditions make the Arctic a pool for genes not found in other ecosystems. Except for studies on subpopulations on polar bears, walrus and some seabirds, there is little knowledge about the genetic diversity of the Arctic. The fact that many species are extremely numerous, and that they appear in several different habitats and niches, indicate however that the genetic diversity within these species could be high.

The relatively low species richness in the Arctic indicates that key ecological functions depend on a few keystone species, rather than several species with overlapping roles. Although species diversity does not always correlate closely with an ecosystem's stability, this could make the system as a whole more vulnerable if key functions are disrupted by changes in distribution or abundance of certain species.

Why conserve biodiversity?
The Earth's genes, species and ecosystems are the product of over 500 million years of evolution. Simplified, one could say there are two main lines of arguments for the conservation of biodiversity; the ethical and the utilitarian. From an ethical perspective it is argued that biodiversity is inherently valuable and has an intrinsic right to exist.

From a utilitarian point of view it is argued that bio-diversity should be protected because ecosystems provide services of actual or potential importance for humanity. Whether we realize it or not, humanity is entirely dependent on biodiversity to survive. Biological resources, including genetic resources, organisms, populations, or any other biotic part of an ecosystem, are renewable and with proper management can support human needs indefinitely. The biological diversity is therefore the essential foundation of sustainable development (McNeely 1994).

The structure of the assessment and the process behind it

This report is part of WWF's ecoregion-based conservation approach in the Barents Sea. Following the principles of ecoregion conservation and the findings in a Reconnaissance Report (Hønneland et al. 1949), WWF decided to develop an assessment of the marine bio-diversity in the Barents Sea Ecoregion. The process of elaborating the Biodiversity Assessment is described in the figure on the next page.

The assessment is based on an extensive review of scientific literature, in addition to consultations with some of the region's most experienced biologists. Because much information about biodiversity in the Barents Sea is fairly old or has not been published, it has in many cases been necessary to rely on personal communications from biologists with long field experience. Of particular importance are therefore the results of a workshop arranged by WWF in St.Petersburg in May 2001 with the participation of leading biologist from various countries, including Russia and Norway (see chapter 4 for list of participants and more details).

The assessment should by no means be considered as a comprehensive description of the natural values of the Barents Sea. As much as an assessment of current and known resources and threats, it should be regarded as a status report of marine research in the Barents Sea. Due to the lack of species-specific data on distribution and abundance for many marine taxa in the Barents Sea, the information presented on maps in this report may in some cases not be very detailed. In some instances it has also been necessary to use approximations of bio-diversity. The process of compiling the assessment has revealed important gaps in our understanding of important ecological processes in the Barents Sea. We therefore strongly urge authorities and scientific institutions to intensify research efforts on the marine ecosystem of the Barents Sea. Further field studies are needed to confirm the exact abundance and distribution ranges of several organisms, and this biodiversity assessment should form a basis for further scientific studies in the region.

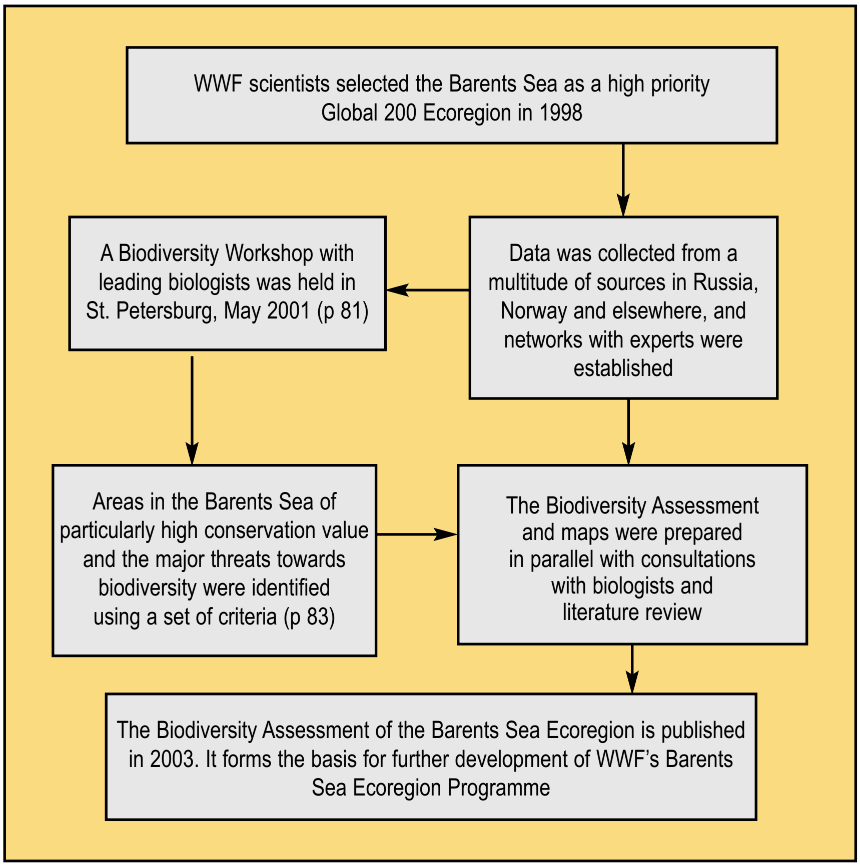
This report nevertheless presents the best available knowledge about biodiversity in the Barents Sea. It is the first time that biodiversity data from both the Russian and the Norwegian parts of the Barents Sea is presented systematically at the ecosystem level. It is also the first time that areas of high biodiversity value have been identified and mapped on this scale. A major effort has been made to make the information in this report easily accessible also to non-scientist, and to present it in a format relevant to policymakers and natural resource managers. It is our intention and hope that this assessment will enable policymakers, natural resource managers and other stakeholders to improve decision-making and to take the necessary steps to protect the riches of the Barents Sea for future generations.

This biodiversity assessment will form the basis for the further development of WWF's Barents Sea Ecoregion Programme. WWF will develop and implement a series of activities and projects in the Barents Sea Ecoregion. The Programme will contribute to raising the public awareness about the biodiversity values of the Barents Sea; to strengthening international cooperation in the region; to keeping environmental issues high on the security, military and energy agendas; to the development of state-of-the art environmental standards; and to implementing ecosystem-based management regimes for the region's natural resources.

On the global level, WWF hopes that the Global 200 analysis will assist the Parties to the Convention on Biological Diversity (CBD) in developing and implementing the National Biodiversity Action Plans and protected area networks mandated by the treaty, and help them work with their regional partner countries and other international processes to build these into regional programmes. WWF also hopes that the Global 200 analysis will assist the Parties to the Ramsar and World Heritage Conventions in ensuring that the full range of habitats is represented within their respective lists of globally outstanding sites, secured under the auspices of these and other key international treaties.

The assessment is divided into six main parts. First, as a background, the conceptual framework for the assessment is described. It includes a presentation of WWF's Global 200 approach, the concept of biodiversity and related initiatives (pp 14-19). From page 22-42 the reader will find a general description of the ecoregion and its biodiversity, which is followed by a description of the major environmental threats the ecoregion is facing (pp 49-76). The fourth part presents the participants at the St. Petersburg workshop and describes the steps taken to identify high-priority areas within the ecoregion (pp 80-97). The fifth section provides a detailed description of the identified sub-regions and priority areas for conservation (pp 100-130). At the end, the report proposes an approach to a balanced development of the Barents Sea Ecoregion based on the findings in this assessement (pp 134-136).

In addition, four appendices are available on www.wwf.no/core/barents/index.asp.
Appendix 1 gives a detailed overview of the largest seabirds colonies in the ecoregion. Appendix 2 provides maps of important localities for polar bears and walrus, while annex 3 shows the distribution of human settlements in the ecoregion. Appendix 4 gives a brief introduction to important international agreements relevant for biodiversity conservation in the Barents Sea.



Flow chart describing the process behind the biodiversity assessment of the Barents Sea Ecoregion

Puffins. Photo: Tore Larsen

2. DESCRIPTION OF THE BARENTS SEA ECOREGION

A productive and fluctuating environment

The Barents Sea ecoregion is situated in the transition zone between European boreal and arctic nature. It comprises the Northeast Atlantic and Arctic shelf seas north of the Arctic Circle, includes the arctic archipelagos of Svalbard, Franz Josef Land and Novaya Zemlya, and ends to the east along the Yamal Peninsula and the 70^{o}E longitude line. To the west and north, the border of the ecoregion follows the shelf edge. In Norway, the ecoregion includes the islands and waters off mainland Finnmark, Troms and Nordland counties as far south as the Arctic Circle, while in Russia it touches on the northern coasts of Kola, includes the White Sea enclosed by the Karelian Republic and the Arkhangelsk Oblast, and continues east along the coasts of Nenets Autonomous Okrug and Yamalo-Nenets Autonomous Okrug. The region is one of the biologically most productive in the world, with a very high plankton production supporting large stocks of fish, dense aggregations of seabirds and a high number of sea mammal species. Nowhere else on Earth do ocean currents from the south reach as far north as in the Barents Sea.

Ocean currents and the Polar Front
The ecoregion covers an area of approximately 2.2 million km^2 water, with an average depth of between 200 and 300 meters. Large areas less than 50 meters deep are found in the Pechora and Kara Seas, as well as on the Spitsbergen Bank. Due to the relatively shallow character of the seas, seafloor topography has a strong influence on the distribution and movement of the water masses. Two main directions of ocean currents are easily identifiable: from the south, the Norwegian coastal current and the Atlantic current carry warm water eastwards into the Barents Sea (occasionally as far as the coast of Novaya Zemlya), while from the north, cold arctic water runs in to the south and west. Both contribute to an approximately counter-clockwise circulation pattern in the Barents Sea. Warm and cold currents meet in a meandering convergence system at the Polar Front, a zone stretching from southwest Svalbard in a shifting

Figure 2.1: The Barents Sea Ecoregion, with some geographical names mentioned in the text. Bathymetric lines are in 100 meter intervals

pattern over the Svalbard, Great and Central Banks. The position of the Polar Front is heavily influenced by bathymetry, and is stable and clearly identifiable in the western Barents Sea, but less so in the eastern Barents Sea. The Kara Sea contains cold arctic water, some of which penetrates the narrow Kara Gate south of Novaya Zemlya and enters the Barents Sea. Influx of nutrient-rich water is limited in the Kara Sea, as it is to a large degree surrounded by land masses and ice.

Due to the large flux of Atlantic water from the south, the Barents Sea is by far the warmest of the circumpolar seas. Its water masses can be separated into four main groups (Lønne et al. 1997). Atlantic water entering from the southwest, penetrating northwards submerged below the lighter arctic water. Atlantic water temperatures vary seasonally and annually between 3.5 and 6.5ºC between the Norwegian coast and Bjørnøya, and its salinity is typically above 35‰. Coastal water has temperatures almost like the Atlantic water, but with a lower salinity (<34.7‰). Along the Norwegian coast, coastal water remains vertically stratified the entire year (unlike the other main water masses), while in the shallow areas around Kolguev Island, stratification is practically non-existent during winter. Coastal water also originates from the White Sea, spreading into the southeastern Barents Sea (Dobrovolsky & Zalogin 1982). Arctic water has both low salinity (34.4 - 34.7‰) and low temperature (below zero). During winter arctic water occupies the upper 150 meters of the water column, while during summer it is covered by 5-20 meters of meltwater (low salinity, 31-34.2‰, and temperatures above zero due to heating from the atmosphere). The meltwater is separated from the arctic water by a distinct transition layer, and is usually found north of the Polar Front. Barents Sea water is formed locally, originating from the transformation of Atlantic water in the deep-water Polar Front area (Dobrovolsky & Zalogin 1982). It is characterized by low temperature and high salinity.

Through the season, a number of larger or smaller temporary eddies form in many parts of the Barents Sea, particularly in transition zones between different currents and water masses. These eddies cause small, passively

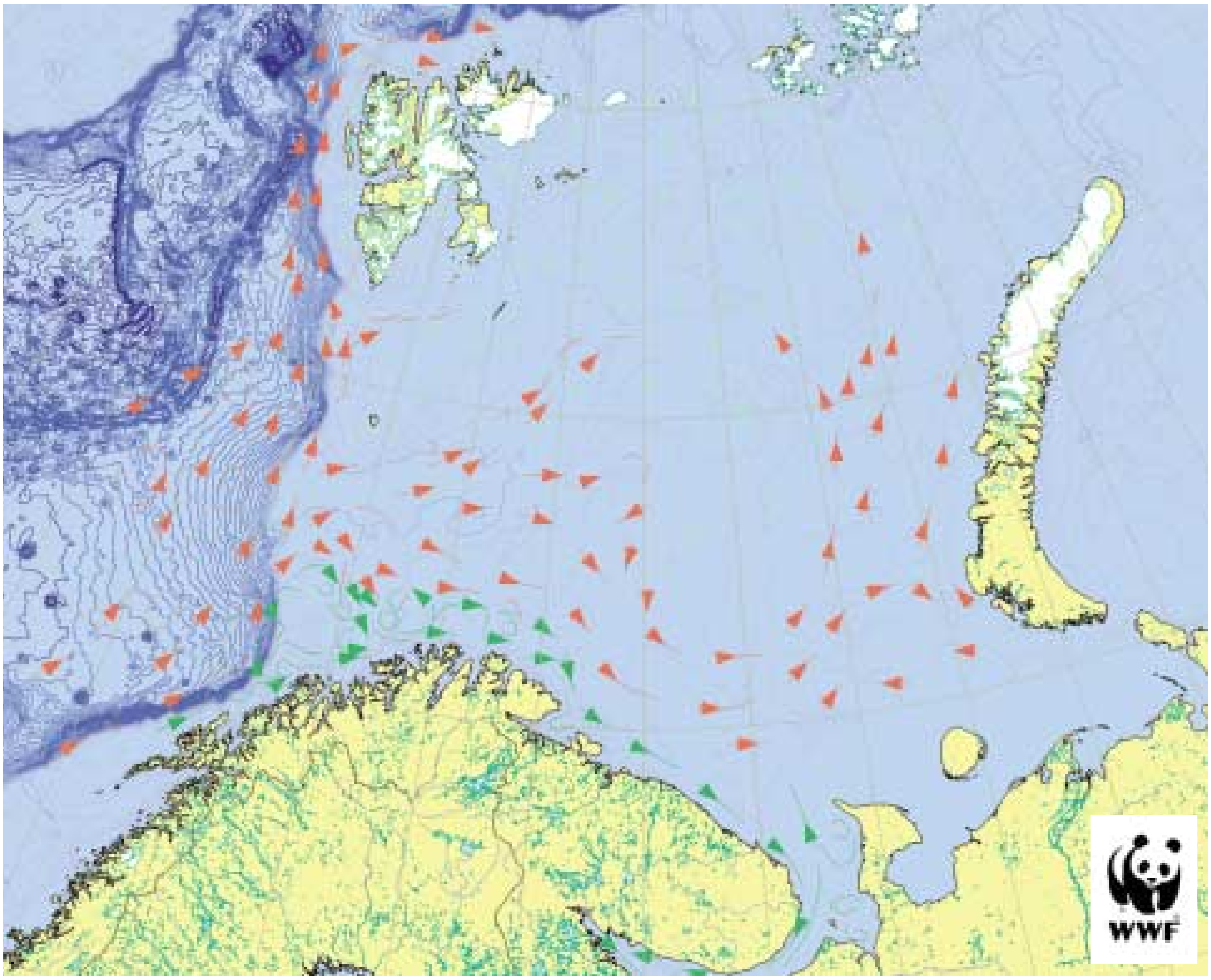


Figure 2.2: Ocean currents (coastal = green, Atlantic = red, Arctic = blue) and the average position of the Polar Front, indicated with a dark green line. After Lønne et al. (1997) and Zenkevitch (1963). (References, see pp.148-151).

drifting organisms like plankton and fish larvae to remain in these areas for long periods of time (Sakshaug et al. 1992). The eddies are particularly well pronounced north of the Norwegian coast, and along the western part of the Polar Front.

Fluxes, processes and interactions

Dramatic environmental fluctuations are normal in the ecoregion. Wind, weather and the influx of Atlantic water change from month to month and between years, affecting temperatures, the vertical and horizontal distribution of "warm" and "cold" water, and the distribution of ice. Because of these marked fluctuations, and the fact that ecosystems always need some time to adapt to changes, one can say that the Barents Sea is in a constant state of contemporaneous disequilibrium. The environmental conditions give rise to the high productivity of the region, but also to pronounced year-to-year fluctuations. The primary production is conveyed to higher trophic levels through short food chains within relatively simple food webs. This allows for efficient transfer of energy and the support of large stocks of fish, marine mammals and seabirds, but also to strong biological interactions and vulnerability to changes as each link is important. Fluctuations are also caused by species in this environment being close to the limit of their distribution range.

A particularly illustrative example of biological interactions has been presented by Hamre (1994, 1998): In years with high influx of Atlantic water, zooplankton production along the Norwegian coast is likely to be above average, and secures high survival of herring larvae drifting passively northwards with the Norwegian coastal current from the southern spawning sites. The herring larvae sustain the large seabird colonies along the coast, before being sent into the Barents Sea where they mature as important prey for cod and a substantial predator on capelin fry appearing in the southern Barents Sea from the coastal spawning sites in May. The cod also eat adult capelin coming south to the coast to spawn in early spring. Three to four years later, when the rich class of adult herring leave the Barents Sea to spawn after having greatly reduced capelin recruitment, the cod will suffer from lack of both its main prey species. If the stock of juvenile cod increases considerably just as the herring begin to leave the Barents Sea, the cod will have no other option than cannibalism. This may result in the loss of several year-classes of small cod. If, on the other hand, herring recruitment and/or survival fails due to lack of zooplankton in Norwegian waters, this may favour capelin recruitment substantially and eventually result in rich year-classes of cod.

High productivity at the ice edge

The ice edge is a particularly productive part of the ecoregion. In autumn and winter, a vertical mixing of water masses occurs throughout the sea, bringing deep sea nutrients to the surface layers. In spring and summer, melting ice stabilizes the upper 20-30 meters of the nutrient-enriched water column (water of lower salinity remains on top), creating a layer where phytoplankton production is not restrained by vertical mixing of water-masses. As the melting ice edge retreats north, bodies of water with high winter concentrations of nutrients are exposed, creating an environment with stable water, plenty of light and rich in nutrients. This causes an algal bloom to occur in the spring. The algal bloom along the ice edge in the Barents Sea can actually start 6-8 weeks earlier than the algal bloom in the Norwegian Sea (Sakshaug et al. 1992). The retreat of the ice edge during summer means that the "spring bloom" of phytoplankton in the northern part of the Barents Sea may occur as late as July or August. Following the algal bloom is a substantial growth in zooplankton, followed by feeding migrations of plankton-eating fish such as capelin. In the "isolated" Kara Sea, the system is heavily influenced and altered by the massive influx of freshwater from the Ob and Yenisey rivers (on average 1,350 km^3 per year, 2.8 times as much freshwater influx as in the Barents Sea), causing a characteristic thermohaline stratification that inhibits vertical mixing. This prevents nutrient-rich bottom water from reaching the upper, sunlit part of the water column, and halts primary production (Decker et al. 1998, Dobrovolsky & Zalogin 1982).

Polynyas

Icecover in the arctic seas is never absolutely complete, even in winter. Ocean currents, upwellings, wind, and a number of other factors cause areas of open water to occur. These open areas in the sea ice are known as polynyas, and may in some cases be open throughout the year. Studies in other parts of the Arctic have shown that polynyas may attract large numbers of overwintering seabirds and marine mammals, and there is evidence to suggest that they are also of critical importance to some seabirds for reproduction and migration (Sage 1986). Polynyas in the Barents Sea ecoregion are principally of two types: Linear shore leads opening at the edge of the landfast ice – particularly along the southern shore of the Kara Sea (see Heide-Jørgensen & Lydersen 1998) – and wind-driven polynyas opening on the lee side of the arctic islands. Northern winds dominate throughout winter, and recurrent polynyas are found in the Storfjorden area in eastern Svalbard as well as south of Kong Karls Land, Kvitøya and Victoria Island. In Franz Josef Land, polynyas appear both between the islands and on the leeside of the archipelago. The Novozemelskaya polynya along the western shore of Novaya Zemlya is another large recurring polynya. A number of smaller polynyas also open in the archipelagos of the White Sea.

The Barents Sea polynyas can be observed on satellite images, but they have not been subject to closer study. Their role in relation to the ecoregion's biodiversity is therefore not known.

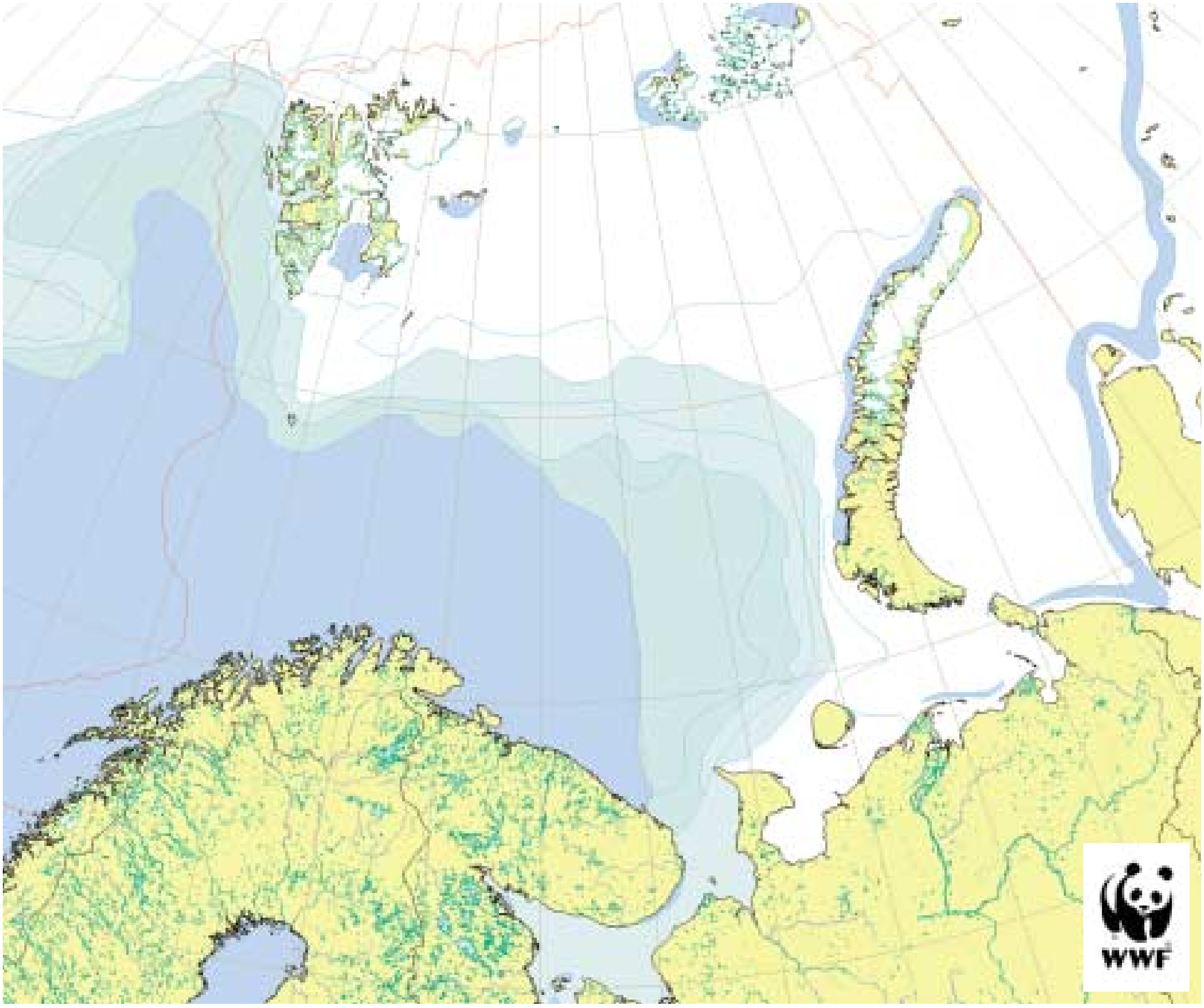


Figure 2.3: Maximum sea ice coverage (March), average values from the period 1971-80. Notice the position of polynyas. (References, see pp.148-151).

Human population

The pattern of human habitation along the coasts of the ecoregion is historically related to fisheries and harvesting of biological resources, with the exception of population centres connected to the bases of the Russian Northern Fleet and some mining. The ecoregion sustains well above one million people, mainly in Murmansk Oblast on the Kola Peninsula. The three northernmost counties of Norway have a total population of approximately 460,000 people, of which it has been estimated roughly that 10,000 are involved in fisheries and 5,000 are employed in fish processing industries. The Russian fisheries and fish processing industry in the region employed some 80,000 people in the 1980s (Hønneland et al. 1999). Total fish catch in the Norwegian part of the ecoregion was 1.35 and 1.1 million in 1997 and 2000, respectively. The value of annual catches were 6 and 6.4 million NOK (Fiskeridirektoratet 2002). In 1997, the catch of the Russian fishing fleet based in Murmansk oblast was approximately 400,000 tons (decreasing sharply from 1.06 million tons in 1991, mainly due to high fuel costs and increased deliveries abroad, see Hønneland et al. 1999). Also tourism and aquaculture are becoming increasingly important industries in the ecoregion.

Indigenous peoples

Two groups of indigenous people live in the ecoregion, the 60-70,000 Sami of northern Scandinavia and the Kola Peninsula, and the ca. 35,000 Nenets of the northern rim of Russia from the White Sea to Yamal. Both are traditionally reindeerherders, fishermen and hunters. While sea mammal hunting is no longer important among these communities, the Nenets have developed their fisheries into an important commercial business (Dallmann & Diachkova 1999). Typical Sami fishing in Norway takes place predominantly in the fjords when adult fish enter to spawn.

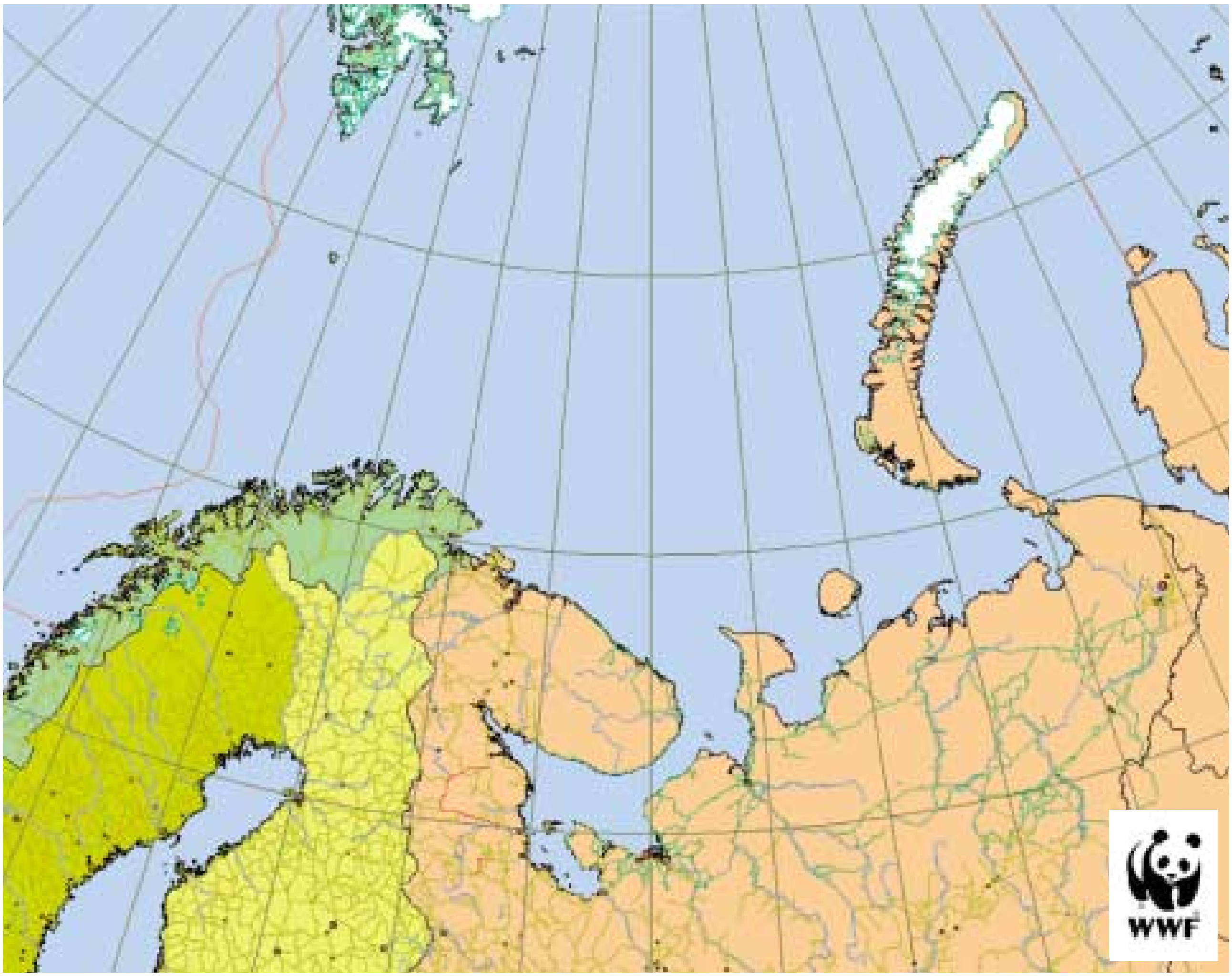


Figure 2.4: Human infrastructure in the areas bordering to the Barents Sea ecoregion, in Norway (green), Sweden (brown), Finland (yellow) and Russia (pink). Roads and paths are indicated (highways=red, primary and secondary roads=brown, tracks and trails in green), as are the biggest settlements and cities.

Benthic organisms

Subpolar shelf seas include some of the most productive patches of the world's oceans, although species richness in a global sense must be regarded as low. The number of macroalgae around Svalbard is, for instance, only one fifth of the 478 species along the Norwegian coast (Rueness 1977). There are 97 species of brown and red algae around Svalbard, ca. 200 species are recorded off the Kola Peninsula and in the White Sea, 158 species are known from Novaya Zemlya, and 55 from the Kara Sea (Makarov & Shoshina 1986, Vozhinskaya & Luchina 1995). However, the Barents Sea holds very diverse benthic flora and fauna compared to other arctic seas, and stands out even when compared to northern temperate seas. According to Sirenko (1998, cited by Brude et al. 1998), a total of 2,499 benthic invertebrate species have been found in the Barents Sea (the delimitation of the Barents Sea here is not clear, it probably does not include the Norwegian coast south of North Cape, and not the White Sea, from which ca. 1,500 species are known). In the Kara Sea, the number is 1,580, and there is an apparent trend towards decreasing diversity to the east: 1,084 species are described from the Laptev Sea, 962 from the East-Siberian Sea and only 946 from the Chukchi Sea. Harsher environmental conditions explain some of this variation, but study effort is probably also important.

Mapping the distribution of benthos in the Barents Sea based on Russian, Norwegian and other sources is complicated by the use of different methodologies. Only recently has it been possible to address international cooperation and standardisation of methods. Russian institutes have sampled and mapped much of the Barents Sea (Brotskaya & Zenkevich 1939, Antipova 1975, Denisenko et al. 1995, Pogrebov et al. 1997), but little work has been done from the Norwegian side. Apart from the Svalbard coast, only a transect from the Storfjord through SE to the Central Bank (Cochrane et al. 1999) and the shallows along the Norwegian coast have been thoroughly examined.

In terms of species richness, marine diversity is positively correlated with four essential factors (Direktoratet for Naturforvaltning 2001): 1) climate and age of the biogeographical region, 2) the number of available habitats, 3) salinity, and 4) the stability of the system. All of these factors put the Norwegian coast in a favourable position within the ecoregion, with its proximity to inflow of warm high-salinity Atlantic water. Unlike most of Europe, the Norwegian coastal zone is also totally dominated by hard-bottom, rocky and stony shores, giving a high number of habitats varying from rock to gravel. In the intertidal zone of Finnmark and Troms counties, more than 150 species and densities of 80,000 individuals per m^2 have been observed (Moe et al. 2001). Hard-bottom habitats are found also in the coastal zone of the Arctic islands, with Svalbard standing out as the archipelago most influenced by Atlantic water. The Russian coast along the southern rim of the ecoregion is characteristically sandy, and although with a very high productivity in places, the species composition is dominated by bivalves. Common in all parts of the ecoregion, however, is the very significant contribution of benthic flora and fauna of the coastal zone to the overall biodiversity of the ecoregion.

Russian long-term studies have shown that the distribution of benthic biodiversity is correlated to the fluctuations of the frontier between Atlantic boreal and arctic water masses, in particular how boreal species spread east in warm periods and vice versa. In the Pechora Sea, the gastropod Margarites costalis was found in 5-30% of the investigated stations in warm periods of the last century, but only in 1.5-11% of the stations in colder periods (Galkin 1991). These fluctuations make it rather difficult to produce maps of benthos distribution in the ecoregion. Biomass distribution also seems to have changed markedly if we compare the maps published by Brotskaya & Zenkevich (1939) and Antipova (1975). Areas of high benthic biomass in the former map (e.g. Spitsbergen Bank and Northern Pechora Sea) are largely absent in the latter. Instead, we find biomass "hotspots" further east, towards Vaigach Island. Antipova (1975) interprets the changes as a general decrease in boreal species caused by falling temperatures in the 1960s. Filtrate feeders, together with bottom deposit feeders, are the most numerous groups, with bivalves dominating greatly in the southeastern part of the ecoregion.

A particular feature of interest in the southwestern part of the ecoregion is the deepwater coral reefs at 40-500 m depth along the Norwegian coast. Although dating as far back as 8,600 years, they have only recently been

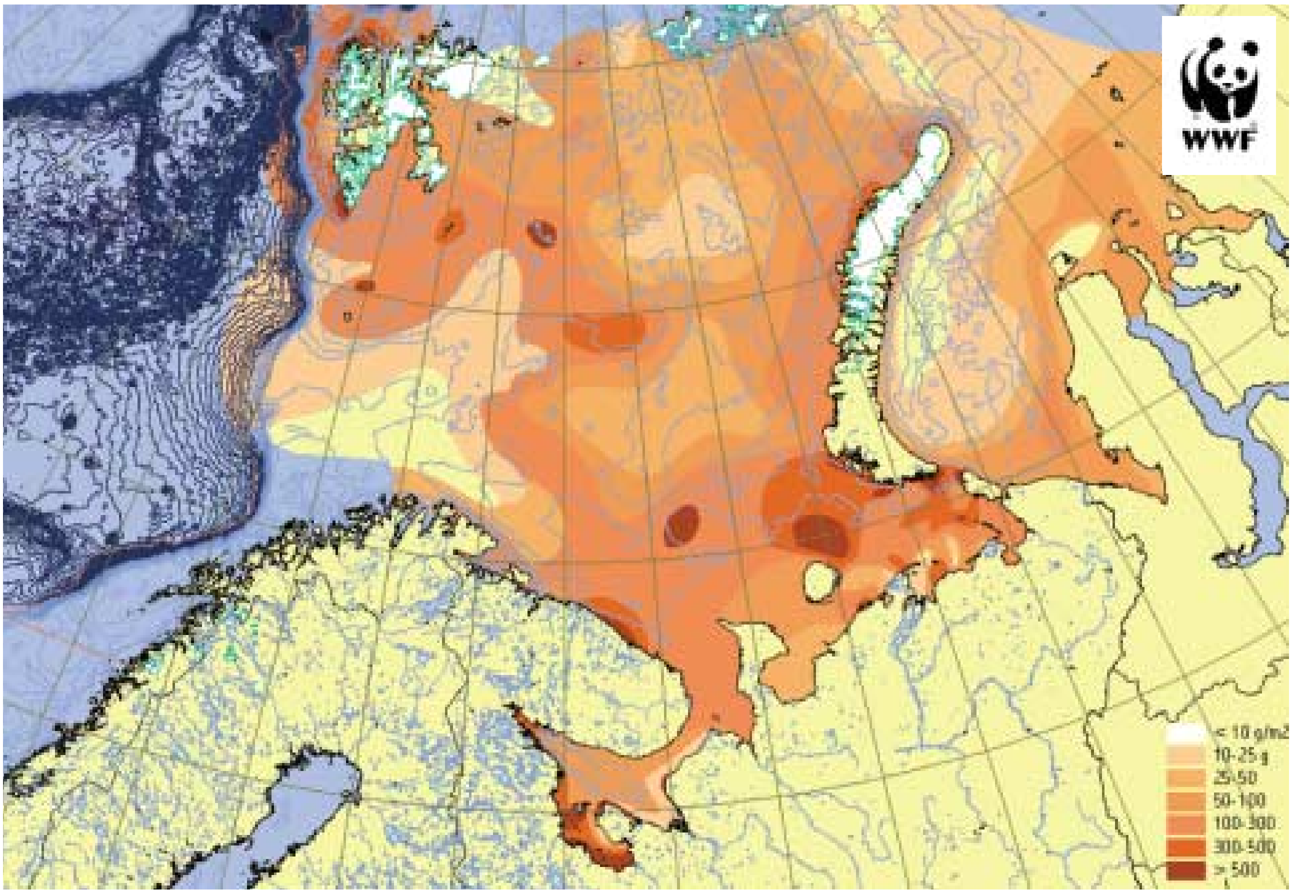


Figure 2.5: A representation of the density of benthic organisms (g/m^2) in the Barents and Kara seas, based on Kiyko & Pogrebov (1997) and Pogrebov et al. (1997). The Norwegian coast was not covered by these investigations. (References, see pp.148-151).

mapped and investigated. Fosså et al. (2000) reports 407 single observations or areas of coral reefs, up to 35 m high and 1 km long, and estimate that they may cover an area of 1,500-2,000 km^2. The dominating coral species is the ahermatypic (without symbiotic green cells) reef-building stony coral *Lophelia pertusa*, with other species associated: the stony coral *Madrepora oculata*, sea trees *Paragorgia arborea* and other gorgonians, soft coral *Capnella spp.*, as well as *Paramuricea placomus*, *Primnoa resedaeformis* and a high number of other animal forms. So far, 614 species have been found on Norwegian coral reefs (Nilsen 2000). They seem to be important nursery areas for fish of several species (Husebø et al. 2002). (See box on next page).

Another feature particular to the southwestern coasts and quite outstanding north of the Arctic Circle is the kelp forests found in a continuous belt along the rocky coastline of Norway and the northern Kola Peninsula. On exposed coasts down to 30 meters, giant kelp (*Laminaria hyperborea*) are found as large "forests" 1.5-2 meters high, covering several thousand square kilometers altogether. The kelp forests are rich in benthic species and are important nursery areas for several species of fish. The distribution of sponges in the Barents Sea is much less studied. Large colonies of godiasponges have been observed outside the coast of northern Norway. Particularly high densities are registered on Tromsøflaket (Føyn et al 2002). Sponges have been known to constitute important habitats for redfish and invertebrates, and are assumed to be of high ecological significance.

Deep-water shrimps (*Pandalus borealis*) are normally found on depths of 100 meters or more. Currents, depth, temperature, salinity and characteristics of the sea floor are decisive for their distribution, and they appear with the highest densities in the southwestern part of the Barents Sea and around Svalbard (Føyn et al. 2002). Shrimps have an interesting life cycle, as they are males the first years of their life before turning into females. Spawning age varies between four and ten years depending on water temperature. Shrimps eat plankton, small benthic organisms and dead organic material and represent important prey for fish species such as cod and Greenland halibut (Føyn et al 2002).

An oasis in the deep Arctic Ocean was discovered on the western continental margin of the Barents Sea in 1995: the first – and so far the only – deep sea vent in the Arctic, the Håkon Mosby mud volcano at 1,250 meters and 72ºN (CAFF 2001). Within a diameter of one kilometer, methane and hydrogen sulfide seep from the ocean floor, supporting chemosynthetic life independent of photosynthesis. Apart from methane-oxidizing bacteria and other bacteria oxidizing waste products, tubeworms, other invertebrates and fish abound. The scalebelly eelpout (*Lycoides squamiventer*) is several hundred times more abundant on the mud volcano than on the surrounding seafloor.

Today less than 10 percent of the bottom of the Barents Sea has been systematically mapped. As a consequence little is known about distribution and abundance of benthic organisms. Scientists also know relatively little about the ecological significance of species rich benthic communities such as sponges and deep-water corals in the Barents Sea, and there is a general need to improve our understanding about interactions between benthic

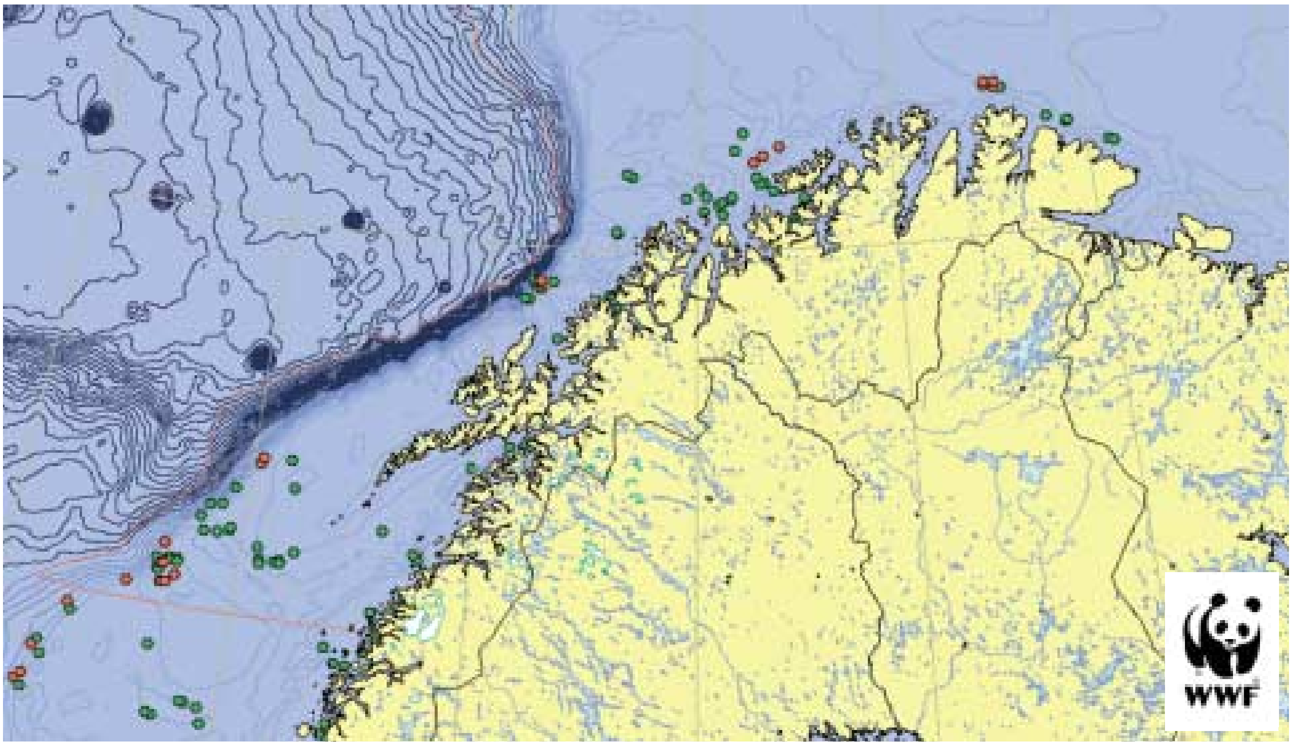


Figure 2.6: The distribution of known (live) deepwater Lophelia reefs, as given by Fosså et al. (2000). Reefs damaged by bottom trawling are marked with red. Newly detected Lophelia reef is marked green with a yellow circle (Institute of Marine Research, May 2002).

THE DISCOVERY OF THE WORLD'S NORTHERNMOST CORAL REEFS

The presence of deep-water corals along the Norwegian coast have been known to science at least since the mid 1700's, particularly in the fjords of mid-Norway. Fishermen from time to time brought corals home, and in 1768 Johan Gunnerus published a description and unmistakable drawing of "Madrepora (Lophelia) pertusa". Not until the age of offshore oil development was however the extent of coral reefs on the Norwegian shelf revealed. In 1982, the oil company Statoil was mapping the seafloor in an area for a potential gas pipeline, when the sonar revealed a 20 meter high cone-shaped structure at 280 meters depth. Initially labelled a possible cold war surveillance installation, a probe was sent down and revealed that the structure was actually a Lophelia reef at 71º North (Hovland & Mortensen 1999)

Since then, more areas of the Norwegian shelf have been mapped, and numerous deep-water reefs have been revealed. As late as May 2002 the Røst Reef was discovered SW of the Røst Archipelago. Measuring approximately 45 x 3 kilometres it is the largest known deep-water coral reef in the world. Similar to most other coral reefs in Norway, the Røst Reef grows in an area with relatively strong ocean currents along the continental break Video recordings made by Remote Operated Vehicles (ROVs) reveal that in spite of the total darkness and cold water, the reefs stand out from their bleak and rather lifeless soft bottom surroundings as colourful oases teeming with life, surrounded by "mosquito swarms" of planktonic crustaceans and small fish.

It is estimated that between 30 and 50 percent of the Norwegian Lophelia reefs have already been damaged or impacted, mainly by bottom trawling (Fosså et. al 2002). To save the reefs for the future Norwegian authorities have recently imposed a series of protective measures. In 2002 Norway took action to protect specific reefs, including the Røst-reef, from harmful bottom trawling. Furthermore, a “National Marine Conservation Plan” is under development to ensure improved protection of corals and other valuable marine habitats. However, because the Nature Conservation Act is restricted to areas within 12 nautic miles of the shore, Norwegian environmental authorities have no legal authority to protect coral reefs in the high seas.

The fact that oil companies have discovered many deep-water coral reefs may not be entirely coincidental. Several reefs have been found on soft bottom, rich in pockholes where hydrocarbon-enriched water seeps out from the layers below. It may be that bacteria blooming in this hydrocarbon gradient represent a parallel to the primary producers found in ecosystems based on photosynthesis. Such hemosynthetic communities are found in deep oceans elsewhere in the world, but so far hard biological evidence is missing for the deep-water reefs. Even in narrow fjords, Lophelia reefs are often found in areas of strong currents. Here, the gradient attracting bacteria is not based on hydrocarbons, but possibly freshwater seeping through the geological layers (Hovland & Mortensen 1999).

organisms and other trophic levels. Without improved knowledge about the distribution and ecology of benthic organisms, it will be impossible to assess how various activities may affect the populations or how biodiversity is best maintained (von Quillfeldt & Olsen 2003).

Plankton

In the upper layers of the water column, the retreating ice edge in spring and summer is the scene of a rapidly developing phytoplankton bloom. The species diversity of this sweeping band is rather moderate, but production is very high. In Atlantic water, the phytoplankton bloom starts in April and peaks in May. In arctic water, the blooming may start even earlier in the melt-water layer, but usually propagates northwards following the ice-melting from May until August.

Cushion star. Photo: Kåre Telnes

THE PLANKTON COMMUNITY OF THE BARENTS SEA

Data from OSPAR Quality Status Report 2000 and Sakshaug et al. 1992 and Pers. com. Cecilie von Quillfeldt (04.07.02)

Phytoplankton: 200-300 species (size range from a few to several hundred micrometers, usually 10-50 mm, fat content usually below 10%, protein 30-50%, carbohydrates 40-60%)

- Diatoms (make up half the species inventory): Most abundant *Chaetoceros socialis*, other common genera *Fragilariopsis* and *Thalassiosira*.
- Naked flagellates: Most abundant *Phaeocystis pouchetti* (single and in colonies)
- Dinoflagellates (many heterotrophic species).

Total biomass during bloom: Coast/shelf 3-400 mg chlorophyll a/m^2
Open sea <100 mg chlorophyll a/m^2
New primary production: Arctic water 50 g C/m^2
Atlantic water 55 g C/m^2
Total annual production in the Barents Sea (1979-1989): 90 g C/m^2

Zooplankton: (size range from a few micrometers (mm) to several cm)

- Copepods: Calanoid cop. (predominantly herbivorous, also heterotrophic microplankton)
  - *Calanus finmarchicus* (dominant in Atlantic water, most numerous zooplankton species), 3-4 mm, winters below 1,000m in Norw. Sea.
  - *Calanus glacialis* (dominant in Arctic region of Barents Sea), 4 mm
  - *Calanus hyperboreus* (dominant in the Arctic Ocean), 6 mm

  Other common species:
  - *Metridia longa* (Atlantic water), 2-3 mm
  - *Euchaeta norvegica* (carnivore feeding on other copepods), 10 mm
  - *Euchaeta glacialis* (as E. norv., feed on a.o. wintering *Calanus spp.*), 10 mm
  - *Pseudocalanus* spp. (mainly Atlantic water), 2 mm
  - *Oithona similis* (most numerous small spp., 0-100 m, omnivore), 1 mm
  - *Microcalanus pusillus* (deep water, 100-200 m, detritivore), 1mm
- Krill (Euphasiidae)
  - *Meganyctiphanes norvegica* (dominant species in Atlantic water, probably not breeding in Barents Sea, carnivore/omnivore), 45 mm,
  - *Thyssanoessa inermis* (dominant in Barents Sea, Arctic/boreal, herbivore)
  - *Thyssanoessa longicaudata* (Atlantic water, carnivore/omnivore)
  - *Thyssanoessa raschii* (southeast shallow seas, herbivore), 20 mm

  All species migrate vertically every day (100-300 m), surface at night
  Annual krill productivity in the Barents Sea: roughly 1.5 g C/m^2
- Amphipods (hyperiid a.)
  - *Themisto abyssorum* (Atlantic water, food: copepods and other plankton)
  - *Themisto libellula* (Arctic water, food: copepods and other plankton), 60 mm
- Jellyfish Cnidarians (medusae)
  - *Aurelia aurita* (common jellyfish, feed on other plankton; coastal)
  - *Aglantha digitale* (dominant medusa, Atlantic and Arctic water), 10-20 mm
  - *Sarsia princeps* (Arctic water, plankton-feeding, rapid bloom)
  - *Euphysa flammea* (Arctic water, as *S. princeps*. common at Polar Front)

  Ctenophora (comb jellies)
  - *Mertensia ovum* (dominating species in Barents Sea, feed on smaller plankton), 80 mm wide (1,000 mm tentacles)
  - *Bolinopsis infundibulum* (Arctic/boreal, not numerous, but hungry), 150 mm
- Arrow-worms
  - *Sagitta elegans* (common in whole area, carnivore (copepods), 20-90 mm
- Molluscs
  - *Limacina retroversa* (planktonic pteropod)
  - *Limacina helicina* (planktonic pteropod, true Arctic species)
- Tunicates

  Appendicularian tunicates (feed on small plankton and bacteria), 1-10 mm

Total zooplankton biomass in the Barents Sea is very variable; 1-20 g dry weight/m^2

In Arctic water, the blooming may start even earlier in the melt-water layer, but usually propagates northwards following the ice-melting from May until August. In general, the bloom in the stratified melt-water region is more intense and limited in time than in the less stratified Atlantic water.

In the Atlantic water the annual primary productivity is about 120 g C/m^2, and in the region to the north of the polar front the annual production is up to 90 g C/m^2. About 50-60% of this is new production. Diatoms dominate during the spring bloom with up to about 108 $cells/m^3$ for the species of largest cells. The flagellate Phaeocystis pouchetii is also a very important species in the Barents Sea, with cell numbers of more than 109 $cells/m^3$ during bloom situations (OSPAR 2000). Zooplankton grazing on the most intense blooms at the ice edge may not be able to utilize the full production, and in that case much phytoplankton will sink ungrazed. Both ungrazed phytoplankton and zooplankton faecal matter contribute to the rich benthic fauna of the Barents Sea, which in its turn feed demersal fish stocks. The pre-dominant herbivore in the Atlantic water south of the Polar Front is the calanoid copepod *Calanus finmarchicus* with a one-year life cycle. The species overwinters below 1,000 m in the Norwegian Sea, although some populations spend the whole year in the shallow Barents Sea. In spite of its dominant role in the ecoregion, advection from the core regions in the Norwegian Sea is very important (OSPAR 2000).

In the cold arctic water, *C. glacialis*, with a two-year cycle, is the main species, while a third species, *C. hyperboreus*, inhabits the northernmost areas. *C. hyperboreus* contains 26 times more stored lipids than the southernmost species (70% of body mass), enabling it to survive in the absence of phytoplankton blooms for a full year. This extremely fatty and energy-rich organism is of vital importance to seabirds and possibly also sea mammals entering the arctic seas in summer (Scott et al. in press).

Krill species are very important south of the polar front. The three small krill species *Thysanoessa inermis*, *T. raschii* and *T. longicaudata* often account for about 45% of the zooplankton biomass, while the large krill *Meganyctiphanes norvegica* usually comprises <5% of the biomass. Krill probably consume a smaller part of the pelagic production than the calanoid copepods, but they constitute a very important link to predators higher in the food chain because they live in dense swarms: Krill is important in the diet of major bird species like little auks and kittiwakes in the breeding season, but even more important predators are capelin and other fish. When the capelin stock declined sharply in the mid 1980s, the standing stock of zooplankton increased notably, and resulted in a major switch in the diet of cod. Sea temperatures also influence zooplankton abundance markedly, as exemplified by biomass variations in the Pechora Bay: In cold years, biomass values average 337.4 mg/m^3, while in warm years values of up to 2,400 mg/m^3 have been recorded (S. Denisenko pers. comm.). In Arctic water, the amphipods *Parathemisto spp*. are important zooplankton. The most important jelly plankton are the cnidarian *Aglantha digitale* and the ctenophoran *Mertensia ovum.*

In general, quantitative knowledge about how different climatic conditions affect plankton production is very limited. According to von Quillfeldt and Olsen (2003), there is an urgent need to improve our understanding about factors controlling the blooming of phytoplankton, the ecological relations between phytoplankton and zooplankton and the potential impacts of changes in the plankton communities on the rest of the marine ecosystem.

Ice flora:	Interstitial species:	Pennate diatoms;	*Gyrosigma spp., Pleurosigma spp., Navicula spp., Nitzschia spp.*
	Under ice species:	Pennate diatoms;	*Fossula spp., Fragilariopsis spp., Navicula spp. Nitzschia frigida* (one year ice)
		Centric diatoms;	*Thalassiosira spp., Bacterosira spp., Porosira spp., Chaetoceros spp.* *Melosira arctica* (two year ice and older)
Ice fauna:	Real ice fauna:	Gammarid amphipods;	*Apherusa glacialis* (one year ice, most numerous) *Onisimus spp.* (two year ice and older, under and in the ice) *Gammarus wilkitzkii* (two year+ ice), 30-40mm
	Sub-ice fauna:	Hyperid amphipods; Fish;	*Parathemisto libellula* Polar cod, *Boreogadus saida*

Source: Sakshaug 1992, Pers. com. Cecilie von Quillfeldt (04.07.02)

Ice flora and fauna

The arctic sea ice holds its own specialized flora and fauna. Ice algae are one-celled organisms found in assemblages on, in, and under the ice; in contrast to phytoplankton their spring bloom is not inhibited by vertical mixing of watermasses, and therefore may start as soon as light conditions improve (February). Depending on the age of the ice, the thickness of the under-ice assemblage may grow to several decimeters. These assemblages are potentially present everywhere in the Barents Sea, although ice older than one year is largely restricted to the northern parts. South of the Polar Front, sea ice melts from below in spring/summer, and by releasing its sea ice flora may contribute significantly to the sedimentation of biological material. The primary production associated with ice is exploited by a set of more or less specialized animals, usually divided in two groups (Sakshaug et al. 1992): sub-ice fauna (living in the water masses immediately below the ice, feeding on ice flora and fauna) and real ice fauna (living on the ice or in water-filled channels in the ice)

Fish

The fish fauna of the ecoregion is relatively species poor, with about 150 species of 52 families (Andriyashev 1954, Sakshaug et al. 1992, Hansen et al. 1996). North Atlantic boreal and arctic-boreal species predominate, and two thirds of the species are found only in the western part of the ecoregion – close to the limit of their distribution range. The highest number of species occur in the six families Gadidae, Zoarcidae, Cottidae, Pleuronectidae, Salmonidae and Rajidae. Many of the other families are represented by only one or a few species. There are no endemic species, but several subspecies with local distribution ranges, mostly anadromous or associated with brackish water (such as the cod found in the relic Lake Mogilnoe on Kildin Island, *Gadus morhua kildinensis*).

Although relatively poor in species, the ecoregion nevertheless holds some of the largest fish stocks in the world. The most numerous species are cod (*Gadus morhua*), capelin (*Mallotus villosus*) and herring (*Clupea harengus*), all of which spawn in millions along the Norwegian coast, and polar cod (*Boreogadus saida*) spawning along the Polar Front in the southeastern Barents Sea and southeast of Svalbard.

The herring spawns along the Norwegian continental shelf (mainly south of the ecoregion), and progeny are advected into the Barents Sea as early juveniles. There are strong interactions between the main fish stocks in the ecoregion, species being eaten by – or eating – each other at different stages of the life cycles, with variations in year-class sizes having marked influence on other components of the ecosystem (Klungsøyr et al. 1995). In years with a rich inflow of warm Atlantic water,

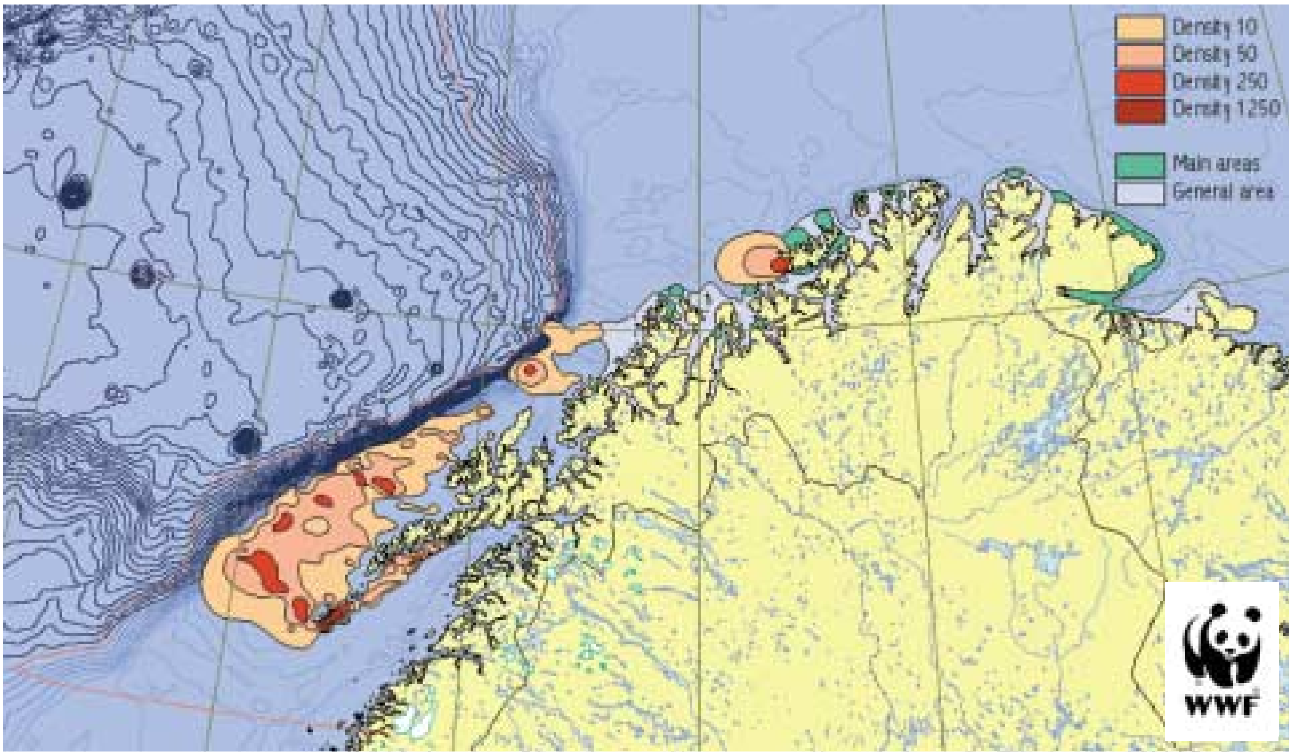


Figure 2.7: Spawning areas for cod (red) and capelin (green/grey). Cod areas are given as acoustic densities of spawning fish in the 1996 season (Korsbrekke 1996), capelin areas are based on information from Sakshaug (1992). (References, see pp.148-151).

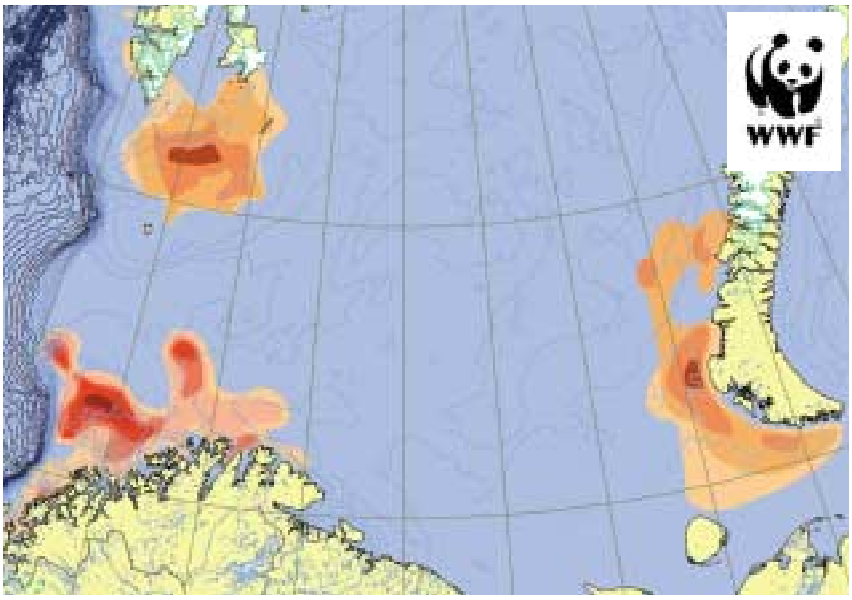


Figure 2.8:
Relative densities of fish larvae in summer, after spawning. Dark colour indicates high densities.

Cod (red, Norwegian coast): Data from Fossum & Øiestad 1992

Polar cod (orange, Svalbard and Novaya Zemlya): Average values estimated from data in Gjøsæter & Anthonypillai 1995.

(References, see pp.148-151).

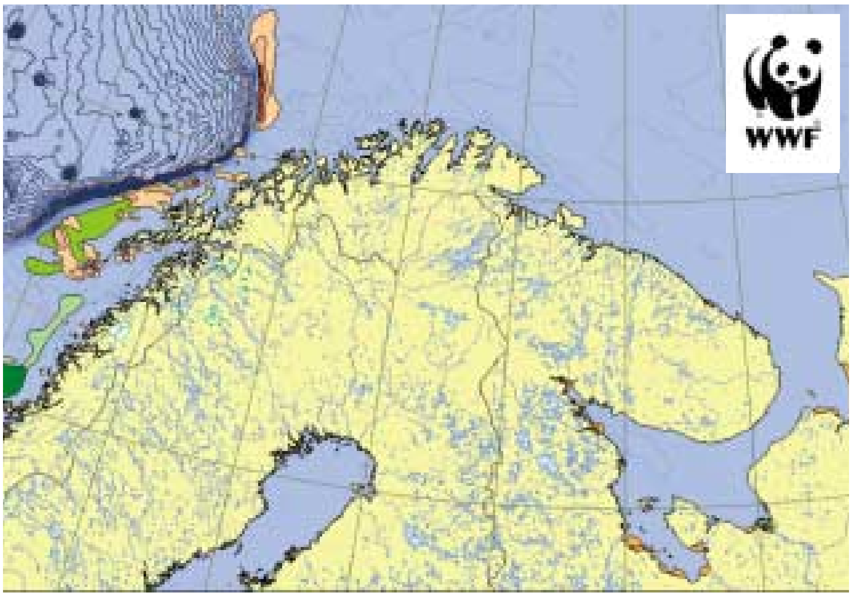


Figure 2.9:
Spawning areas for haddock and herring. Dark colour indicates high densities.

Haddock (red): Acoustic densities, 1996 season (Korsbrekke 1996)

Herring (green): Appr. distribution of spawning fish (Fossum & Øiestad 1992, Fossum 2000)

Herring (orange): White

(References, see pp.148-151).

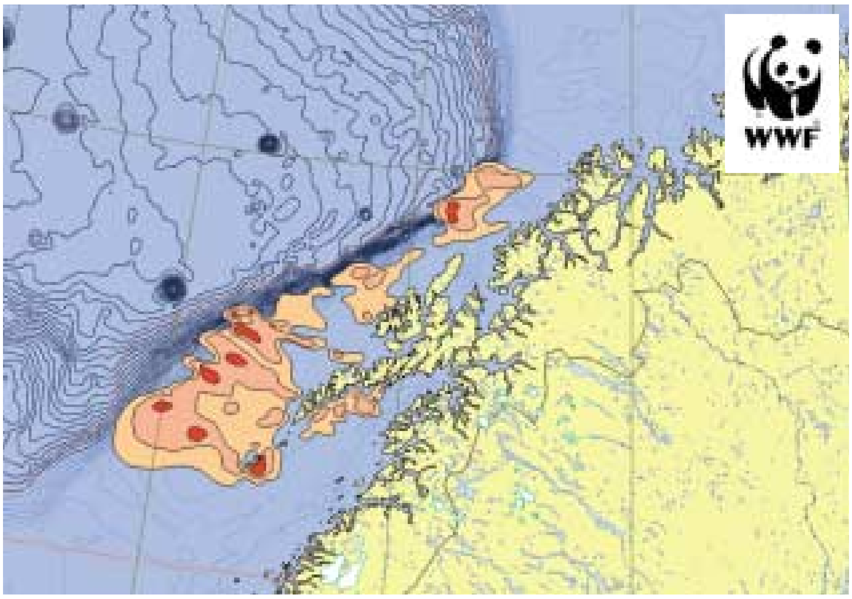


Figure 2.10:
Closeup of the very important spawning area near the Lofoten and Vesterålen archipelagoes, here exemplified by the 1996 spawning distribution of saithe. Dark colour indicates high acoustic density (from Korsbrekke 1996).

(References, see pp.148-151).

COMMON FISH SPECIES IN THE BARENTS SEA

Pelagic:	Capelin (*Mallotus villosus*)	Arctic water during summer feeding, atlantic water in winter and spring
	Arctic cod (*Boreogadus saida*)	Along the Polar Front, into Arctic waters
	Herring (*Clupea harengus*)	Atlantic water
Demersal:	Cod (*Gadus morhua*)	Atlantic water
	Haddock (*Melanogrammus aeglefinus*)	Atlantic water
	Redfishes (*Sebastes spp.*)	Atlantic water
	Saithe (*Pollachius virens*)	Atlantic water
	Sandeels (*Ammodytes spp.*)	Atlantic water
	Greenland halibut (*Reinhardtius hippoglossoides*)	Polar front
	Long rough dab (*Hippoglossoides platessoides*)	Polar front

zooplankton production is sufficient to secure the survival of herring larvae drifting passively northwards with the Norwegian coastal current. Hundreds of billions of four to seven cm long fry reach the coasts of Lofoten and Troms in summer (Anker-Nilssen et al. 2000). Here they sustain the large seabird colonies in the area, before being sent into the Barents Sea where they mature for three to four years as important prey for cod and a substantial predator on capelin. In particular, young herring may eat a lot of capelin fry when these appear in the southern Barents Sea in May. Cod, on the other hand, eat adult capelin coming to the coast to spawn in early spring, but also eat the young herring. When a rich class of adult herring leave the Barents Sea and go south after having greatly reduced capelin recruitment, the cod will suffer from lack of both its main prey species. The cod stock in the Barents Sea had good growth from 1988 to 1993 because of great reduction in fishing pressure and good recruitment (IMR 1999). In 1994 and 1995, the stock of juvenile cod increased considerably just as the herring began to leave the Barents Sea (Hamre 1994, 1999). The decrease taking place after 1993 was probably caused by a combination of higher fishing pressure, lower recruitment and increasing cannibalism (IMR 2002). The whole complex of interactions is strongly influenced by hydrographic conditions.

Feeding migrations of large pelagic fish stocks are closely linked to the seasonal production cycles of zooplankton. The return of *Calanus finmarchicus* from its deep-water wintering areas triggers the herring feeding migrations to the plankton-rich Polar Front. Drifting capelin larvae mainly feed on copepod eggs and nauplii, young capelin feed on *Calanus spp.*, and with age and size, krill and planktonic amphipods become increasingly important (OSPAR 2000). The capelin may also feed on polar cod larvae at the ice edge. The polar cod is a very numerous species, occurring in large schools of millions of fish, and is the dominant species in the eastern Barents Sea. In the different stages of its life cycle, it is a key food item for marine mammals, seabirds and other fish.The relatively small population of White Sea herring spawns in the White Sea and feeds in the southeastern part of the Barents Sea (Føyn et al 2003). Along the eastern shores of the ecoregion, salmonids such as Atlantic salmon (*Salmo salar*) and whitefish (*Coregonus spp.*) are valuable salmonid species for commercial fisheries. Most of these species are anadromous and spawn in the many rivers bordering the ecoregion.

Research efforts on most non-commercial fish species have been limited, and there is little data about the status of most stocks. While we have knowledge about the predator-prey relations for a few species, there is a great need to identify and quantify such relations for many species of fish in the Barents Sea. Von Quillfeldt and Olsen (2003) also highlight the need to know more about nursery areas for species such as cod, Greenland halibut and redfish, as well as factors contributing to mortality for the commercial fish stocks.

Seabirds

Large fish stocks, vast amounts of krill and other large zooplankton, and the amphipods associated with subsurface sea ice constitute the basis for some of the largest seabird aggregations in the world. More than 30 species of seabirds breed in a large number of smaller or larger assemblages.

Data on colonially breeding marine birds are gathered in a common Russian-Norwegian database, developed by the Norwegian Polar Institute (Bakken 2000). The base has 579 "colonies" on record in Svalbard, but a major part of these are quite small (perhaps only temporarily used) and include breeding localities of semi-colonial waterfowl (ducks, geese). The number of registered seabird colonies on Novaya Zemlya is 61, and in Franz Josef Land 87. Of regular colonies in the ecoregion housing more than 1,000 pairs, Svalbard holds approximately 130, Novaya Zemlya 45, Franz Josef Land 30-40, Norway 41, and the Kola peninsula 14. The White Sea colonies are split into their smallest identifiable units in the seabird database, resulting in a total number of 689. Of these, only 33 are registered as possibly holding more than 500 breeding pairs.

In total, the summer population in the Barents Sea ecoregion sums more than 20 million individuals (estimated from data in Anker-Nilssen et al. 2000, see below). Four seabird species (kittiwake, Brünnich's guillemot, little auk and puffin) make up nearly 85% of all breeding seabirds in the region. The areas along the Polar Front, and the Svalbard Bank around Bjørnøya (Bear Island) are the most productive areas in the Barents Sea (Theisen & Brude 1998). Very large seabird colonies (with a total of more than one million individuals present in the breeding season) are found on the west coast of Svalbard, on Bjørnøya, and along the north Norwegian coast. The Kara Sea is characterized by a much lower pelagic and benthic production than the Barents Sea, and seabird colonies are few and small.
In winter, there is a westward shift in seabird distribution in the ecoregion, as birds from Norway and Svalbard tend to move to the northwest Atlantic, while birds from Russian areas move into the western Barents sea (some of them continuing even further west or south) and spend the winter there (Nikolaeva 1996, 1997). Large numbers of fulmars from Svalbard, common guillemots from the Murman coast and Brünnichs' guillemots from Novaya Zemlya are found in Norwegian waters south of the Polar Front in winter, the last two also wintering in the White Sea polynyas. Vast flocks of common, king and Steller's eiders gather in shallow areas along the Norwegian and Murman coasts. Airplane counts indicate around 50,000 wintering eiders in the fjord areas of eastern Finnmark (Systad & Bustnes 1999), and 22,000 Steller's eiders from Varanger eastward along the Murman coast (Nygård et al. 1995).

Estuaries and coastal shallows are important moulting and stop-over sites for waterbirds (ducks, geese, divers) and waders, and the Russian coast from the Ob estuary to the Kola Peninsula holds vast numbers of these birds in the postbreeding and migration periods. Aerial surveys in August-September 1988-2001 have revealed large concentrations of marine ducks, such as flocks of more than 10,000 scoters west of Mys Belkovskiy Nos and more than 25,000 king eiders near Maly Zelenets island south of Dolgiy Island (Isaksen et al. 2000, Krasnov et al. in prep.). A major portion of the world's population of king

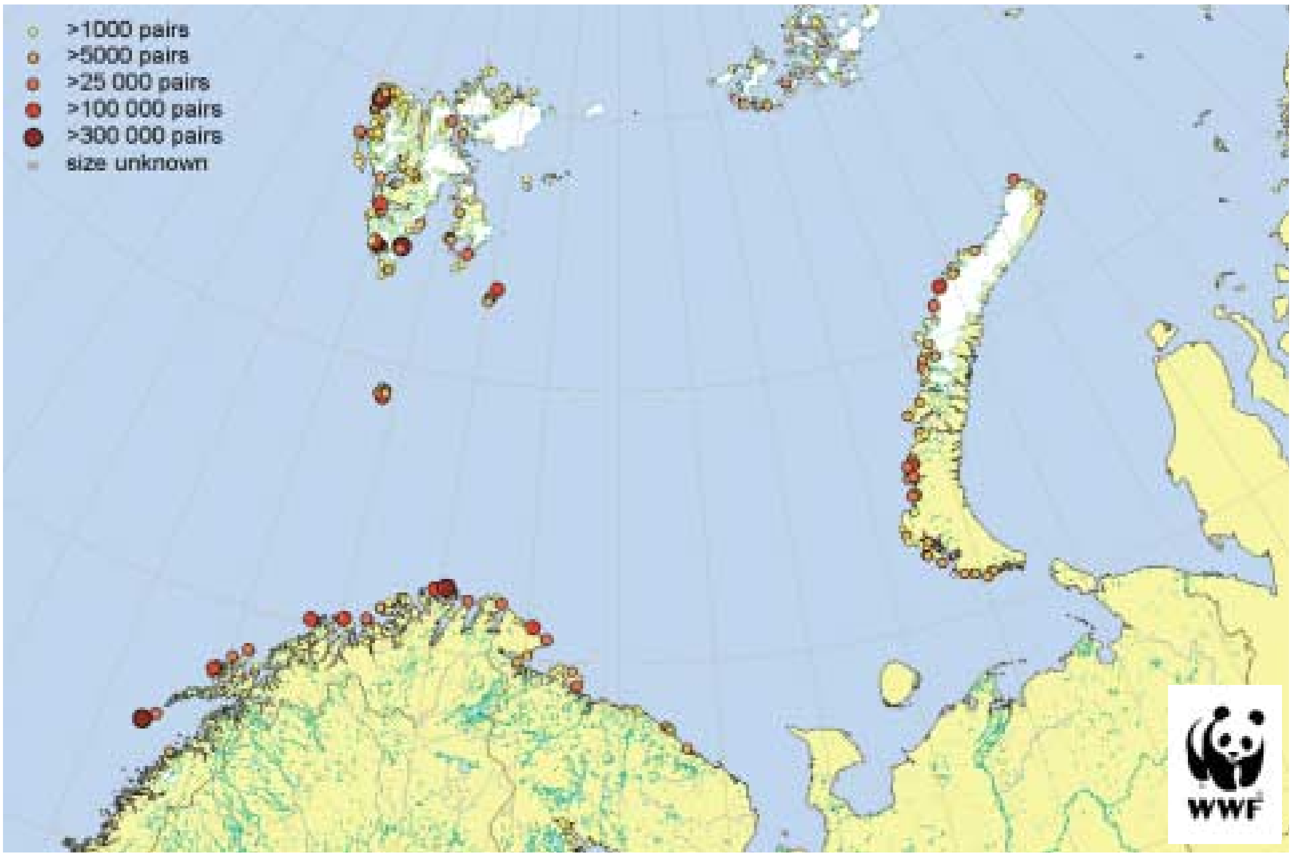


Figure 2.11: Seabird colonies in the Barents Sea ecoregion with more than 1,000 breeding pairs. (References, see pp.148-151).

eiders, Steller's eiders, pomarine skuas and arctic terns occurs in the ecoregion during moulting and migration. In contrast to the situation in the Bering Sea, where the Steller's eider has declined sharply, the Barents Sea has experienced increasing numbers of wintering birds and a trend toward a general western expansion of this species (CAFF 2001).

Our knowledge about the distribution of seabirds offshore is far from perfect, particularly in winter and early spring. This is not only due to the general lack of monitoring programs, but also because of the dynamic character of seabird distribution, related to – among other things – the variable position of the ice edge. In general, however, the major diversity of marine birds is concentrated along the coast of Norway, the Kola Peninsula and the Pechora Sea. These are also the most intensively used areas, together with the western coast of Novaya Zemlya, the western part of the Polar Front around the Spitsbergen Bank, and the ice edge in general. Both the ice edge and the non-freezing waters of the Barents Sea are used by several marine bird species through the year. We know particularly little about the distribution of seabirds in the Barents Sea during winter. Migration routes are poorly mapped and there is a general lack of data on the distribution of seabirds off-shore throughout the year. Population estimates are in some cases based on data that is more than 20 years old. According to von Quillfeldt and Olsen (2003), other important gaps in our knowledge about seabirds in the Barents Sea include the need to improve our understanding of predator-prey relationships and the need to map areas of particular importance for various species.

Common guillemots. Photo: WWF-Canon / Kevin Schafer

Breeding seabird numbers in the Barents Sea Ecoregion

(number of pairs, data from Anker-Nilssen et al. 2000, with updated information from Maria Gavrilo on Kola and the White Sea)

	Norway	Kola	White Sea	Nenets	Svalbard	Franz J. Land	Nov. Zemlya
Fulmar	360-585	-	-	-	100,000-1 mill.	2-3,000	2,500
European Storm Petrel	2,500	-	-	-	-	-	-
Gannet	2,200	16	-	-	-	-	-
Cormorant	6,500	1,100	500	-	-	-	-
Shag	8,800	400	-	-	-	-	-
Eider	50,000	3,800	13,000	3,500	17,000	1,000	25,000
King Eider	-	-	**	**	500	-	**
Arctic Skua	4-8,000	80	<100	**	1,000	**	**
Great Skua	20-30	10	-	2	200-350	-	1
Common Gull	>20,000	200	6,000	-	5	-	-
Lesser Black-backed Gull*	<600	-	1,600	1,000	-	-	-
Herring Gull	100,000	6,000	8,000	-	-	-	-
Glaucous Gull	-	-	-	1,500	4-10,000	500	1,000
Great Black-backed Gull	25,000	4,000	300	1	100	-	1
Kittiwake	487,000	100,000	-	10	270,000	>30,000	40-50,000
Ivory Gull	-	-	-	-	200	2,000	**
Common Tern	2,500	-	-	-	-	-	-
Arctic Tern	20,000	3,000	20,000	**	<10,000	**	**
Guillemot	10-15,000	9,600	-	-	100,000	-	750
Brünnich's Guillemot	1-2,000	4,200	-	-	850,000	25,000	850,000
Razorbill	25-30,000	400	3,200	-	100	-	10
Black Guillemot	30,000	6,000	3,000	**	20,000	3-4,000	6-7,000
Little Auk	-	-	-	-	>1,000,000	250,000	30-50,000
Puffin	2,000,000	6,000	-	-	10,000	-	>100
Total	2,800,000	145,000	56,000	6,000+	2,800,000	315,000	975,000

**including "L. heuglini"*

*** numbers unknown*

In order to calculate the number of seabirds present in the ecoregion in the breeding season, we have made some rough approximations related to the number of non-breeding birds and nestlings. Age at first breeding is relatively high for many of the most numerous species (for instance fulmar and puffin), resulting in a relatively high proportion of non-breeding birds in the colonies. The number of nestlings vary from one among most alcids to six or seven in the eider, but because of the predominance of alcids and gulls in the ecoregion, the average has been set to one per breeding pair.

Breeding pairs:	7,097,000	
Breeding individuals	7,097,000 x 2:	14,194,000
Non-breeding individuals:	20% extra:	2,838,800
Nestlings:	1 per breeding pair:	7,097,000
Total number of seabirds in summer:		24,129,800

Marine bird species of the Barents Sea

Bird species of the Barents Sea ecoregion, of which all or some populations depend on the marine environment for all or parts of the year. The subregions roughly coincide with those in the map on page 55 (1=Norwegian and Murman coast, 2=White Sea, 3=Pechora Sea, 4=Western coast of Novaja Zemlya, 5=Spitsbergen Bank and Svalbard coast, 6=Franz Josef Land, 7=Central Barents Sea, 8=Kara Sea.

Legend:
- ● Summer distribution (breeding season)
- ○ Autumn/winter distribution (moulting and overwintering (winter: roughly November to April))
- ♦ Birds breeding elsewhere present during migration, or occur as regular stray birds *(small symbols: rare, or only present in a very minor part of the subregion)*

Species (English)	*(Latin)* Subregion	1	2	3	4	5	6	7	8
Red-throated diver	*Gavia stellata*	●○	●	●	●	●	●		●
Black-throated diver	*Gavia arctica*	●○	●	●	●				●
Great northern diver	*Gavia immer*	○				•			
White-billed diver	*Gavia adamsii*	•○		•○	●				●
Fulmar	*Fulmarus glacialis*	●○		○	•○	●○	●	○	•
Sooty shearwater	*Puffinus griseus*	♦				♦			
British storm petrel	*Hydrobates pelagicus*	●							
Leach's storm petrel	*Oceanodroma leucorhoa*	●							
Gannet	*Sula bassana*	●							
Cormorant	*Phalacrocorax carbo*	●○	●						
Shag	*Phalacrocorax aristotelis*	●○							
Bewick's swan	*Cygnus bewickii*	•		●	•				
Bean goose	*Anser fabalis*	•	•	●	●				●
Pink-footed goose	Anser brachyrhynchus	♦				●			
Gr. white-fronted goose	*Anser albifrons*	♦	♦	●	●				●
L. white-fronted goose	*Anser erythropus*	♦	♦	♦					♦
Barnacle goose	*Branta leucopsis*	♦	♦	●	●	●			●
Brent goose	*Branta bernicla*	♦	♦	•♦	•	●	●		●
Shelduck	*Tadorna tadorna*	•							
Teal	*Anas crecca*	●	●	●	●	♦			•
Scaup	*Aythya marila*	♦	•	•					
Eider	*Somateria molissima*	●○	●○	●○	●	●	●		•
King eider	*Somateria spectabilis*	○	○	●○	●	●			●
Steller's eider	*Polysticta stelleri*	○	•♦	•♦	•				♦
Long-tailed duck	*Clangula hyemalis*	•○	•	●○	•	●			●
Black scoter	*Melanitta nigra*	•○	•	•○	•	•♦			♦
White-winged scoter	*Melanitta fusca*	•○	•	•○					♦
Red-breasted merganser	*Mergus serrator*	●○	●	●○	•♦				•
Goosander	*Mergus merganser*	•○	•	•	♦				●
White-tailed eagle	*Haliaetus albicilla*	●○	•	●					
Peregrine falcon	*Falco peregrinus*	●	•	•					●

Species (English)	(Latin) Subregion	1	2	3	4	5	6	7	8
Gyrfalcon	*Falco rusticolus*	•○	○	•					•
Oystercatcher	*Haematopus ostralegus*	●	●	●					
Ringed plover	*Charadrius hiaticula*	●	●	●	●	●			●
Golden plover	*Pluvialis apricaria*	●	●	●		♦•			♦
Grey plover	*Pluvialis squatarola*	♦		•					♦
Knot	*Calidris canutus*	♦				•			
Sanderling	*Calidris alba*	♦			♦	•			
Little stint	*Calidris minuta*	•	•♦	●	●				●
Purple sandpiper	*Calidris maritima*	●		•	●	●	●		♦
Curlew sandpiper	*Calidris ferruginea*	♦		♦					♦
Dunlin	*Calidris alpina*	●	•♦	●	●	•			●
Bar-tailed godwit	*Limosa lapponica*	♦	♦	♦					♦
Redshank	*Tringa totanus*	●	♦	•		♦			
Ruddy turnstone	*Arenaria interpres*	●○	•	•	•	•			●
Red-necked phalarope	*Phalaropus lobatus*	●	•	●		•			●
Red phalarope	*Phalaropus fulicarius*				•	●			♦
Pomarine skua	*Stercorarius pomarinus*	♦		●	●	♦			♦
Arctic skua	*S. parasiticus*	●	●	●	●	●	•		♦
Long-tailed skua	*S. longicaudus*	♦		●	●	•			♦
Great skua	*Stercorarius skua*	●		•	•	●			
Sabine's gull	*Larus sabini*					•			
Black-headed gull	*Larus ridibundus*	•							
Common gull	*Larus canus*	●○	●	●		•			
L. black-backed gull	*Larus fuscus*	●	●	•					
Herring gull	*Larus argentatus*	●○	●	•		•			•
Glaucous gull	*Larus hyperboreus*	○	♦	●○	●○	●○	●	○	♦
Iceland gull	*Larus glaucoides*	○							
Gr. black-backed gull	*Larus marinus*	●○	●	•○	•♦	●			
Kittiwake	*Rissa tridactyla*	●○	•	•	●	●○	●	○	●
Ivory gull	*Phagophila eburnea*				○	●○	●		●
Common tern	*Sterna hirundo*	●	•						
Arctic tern	*Sterna paradisaea*	●	●	●	●	●	●		●
Guillemot	*Uria aalge*	●○	○	○	●	●○		○	
Brünnich's guillemot	*Uria lomvia*	•○		○	●○	●○	●	○	•
Razorbill	*Alca torda*	●○	●			•		○	
Black guillemot	*Cepphus grylle*	●○	●○	•○	●○	●○	●		♦
Little Auk	*Alle alle*				•	●○	●	○	♦
Puffin	*Fratercula arctica*	●○	•		•	•		○	

Sources: Anker-Nilssen et al. 2000, Isaksen & Bakken 95, Theisen 97, Theisen & Brude 98, Decker et al. 1998, Strann & Vader 1987, Strann 98, Brekke & Fjeld 1991, Brude et al. 1998, Filchagov & Leonovich 1992, Flint et al. 1984, Strøm et al. 1994, Strøm et al. 1995, Strøm et al. 1997, Norderhaug 1989.

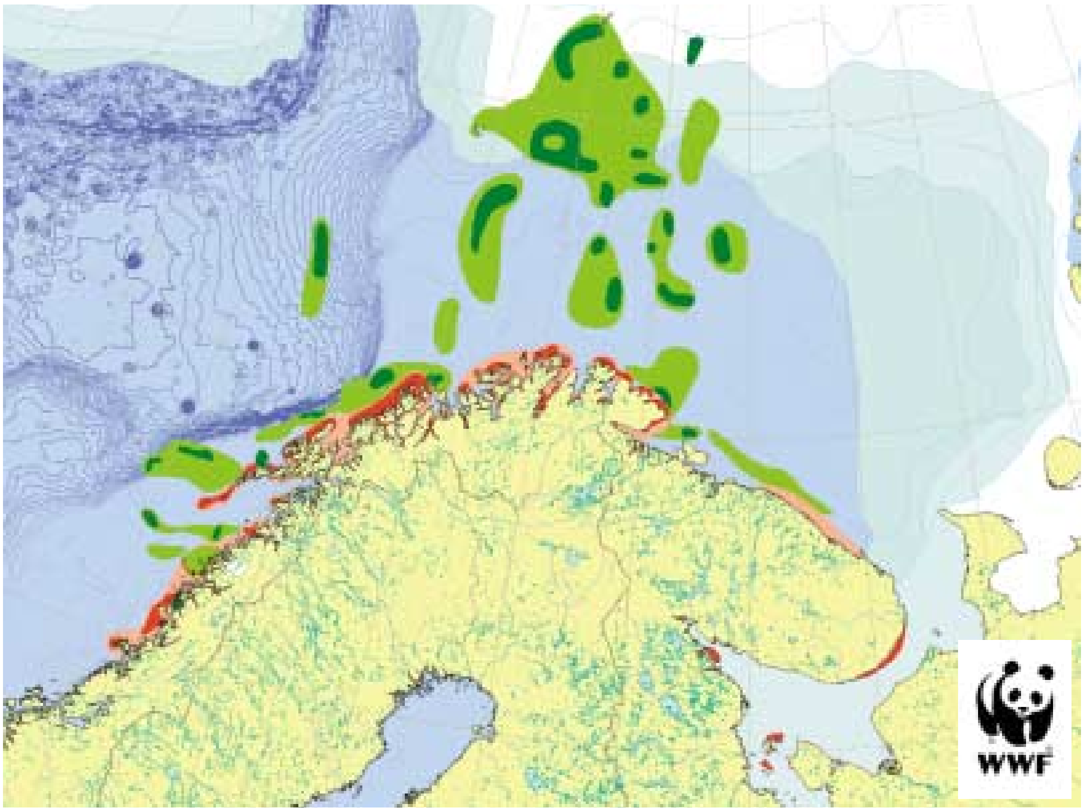


Figure 2.12: Main wintering areas of marine ducks (red) and auks (green). Dark colour indicates high densities. Auk winter distribution is very dynamic, and the map is therefore only suggestive for this group. (References, see pp.148-151).

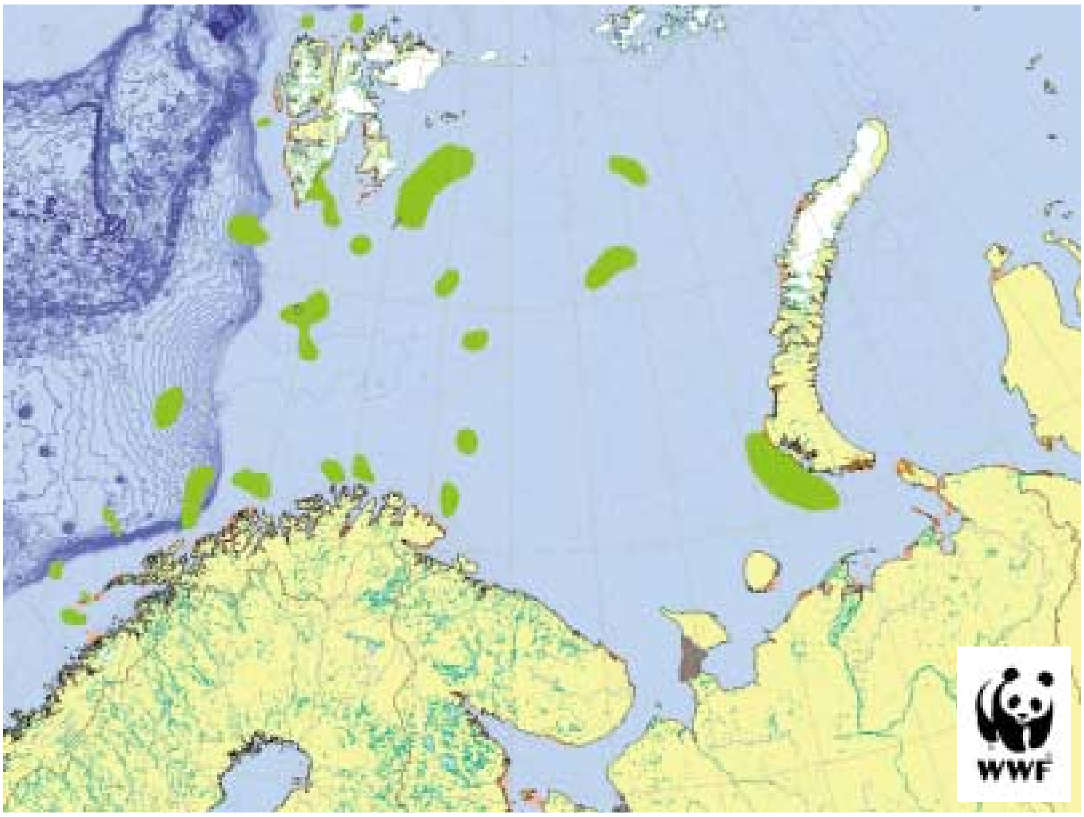


Figure 2.13: Moulting and feeding areas of seabirds and geese. For legend and details, see maps next page. (References, see pp.148-151).

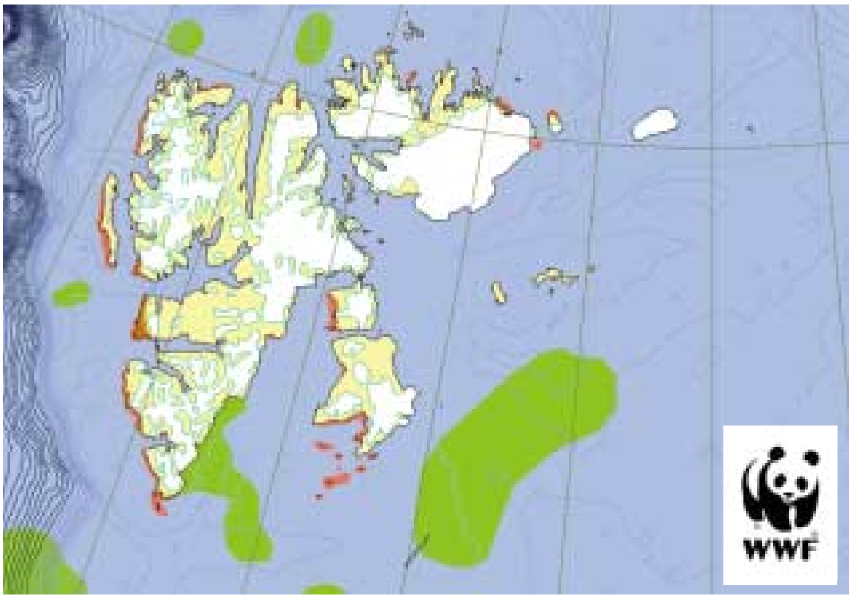


Figure 2.14:
Important moulting and feeding sites for seabirds and geese in the Svalbard area.

Marine ducks = red;

Geese = brown;

Auks = green
(appr. location of moulting concentrations)

(References, see pp.148-151).

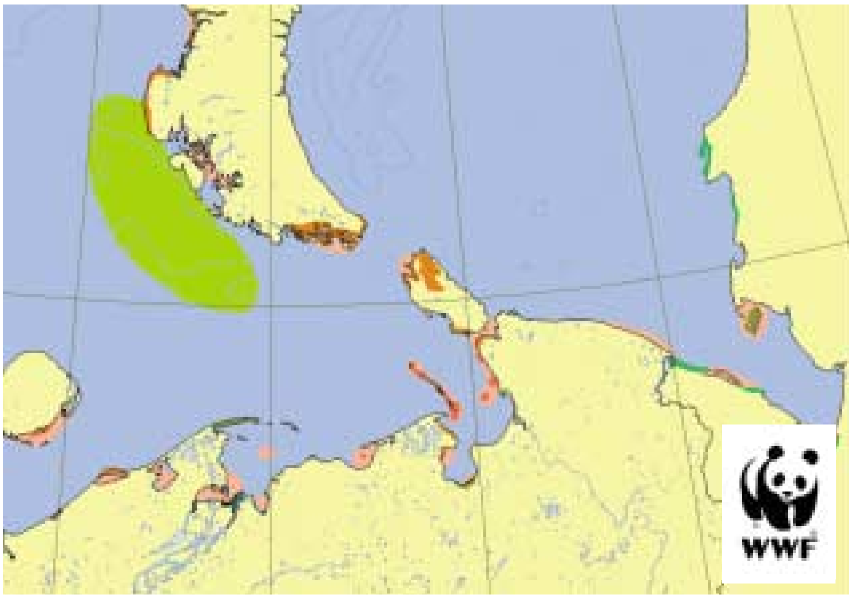


Figure 2.15:
Moulting and feeding sites for seabirds and geese in the southeastern part of the ecoregion.

Marine ducks = red, dark red shows very high concentrations

Geese = brown

Swans = blue

Waders = green

Auks = olive green
(appr. location of moulting concentrations)

(References, see pp.148-151).

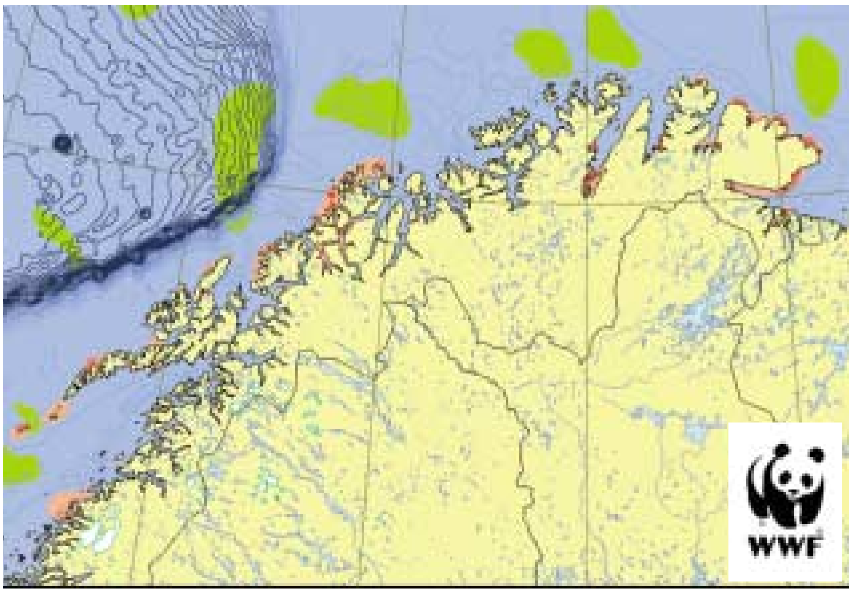


Figure 2.16:
Moulting and feeding sites along the Norwegian coast.

Marine ducks = red, dark red shows very high concentrations

Auks = olive green
(appr. location of moulting concentrations)

(References, see pp.148-151).

Marine mammals

Whales

Twelve species of large cetaceans and an additional five species of dolphins have been recorded in the waters of the ecoregion. Most of these are long-distance migrants, as only three species – white whale (beluga), narwhal and bowhead whale – are permanent high Arctic residents. Historically, all of the large whales in the ecoregion have been hunted, and all of them have been depleted, the northern right whale to extinction. The pre-exploitation (1679) Svalbard stock of the bowhead whale was estimated by Mitchell (1977) to be 25,000 animals, nearly half of the world population at the time. Today only scattered individuals (50-100; Isaksen & Wiig 1995) survive near the ice edge. A recent study based on DNA analysis indicates that pre-exploitation stocks of fin whales, humpback whales and minke whales in the North Atlantic were much more plentiful than previously thought (Standford Report 2003). The current population status of most whale species in the region is not known, as only the minke whale receives a reasonable degree of research attention (the only whaling object today, as it was too small for the "Golden Age" whalers). The minke whale population in the Northeast Atlantic is estimated by Schweder et al. (1997) to be 112,000 animals. According to Sakshaug et al. (1992), 40,000 of these can be found in the Barents Sea in summer, while a more recent estimate by Vikingsson & Kapel (2000) sets this figure alone to 85,000 individuals. Herring and capelin, in addition to krill and cod, represent important prey for the minke whale. The minke whale appears to be very flexible in its choice of diet if there are large fluctuations in the relative availability of prey species. A study carried out in the Barents Sea between 1992 and 2001 indicates that the amount of herring consumed by a relatively stable minke whale population varied from 640 to almost 120,000 tons per year, depending on the size of the herring stock (Lindstrøm & Haug 2002).The resident population of white whale (beluga) in the White Sea has been estimated at 800 individuals (Belkovich 1995), with summer numbers increasing to 2,500-3,000 due to visitors from the Barents Sea. However, the size of the Barents Sea stock is unknown.

Cetaceans in the Barents Sea

Whale species of the Barents Sea ecoregion. The subregions roughly coincide with those given on page 55 (1=Norwegian and Murman coast, 2=White Sea, 3=Pechora Sea, 4=Western coast of Novaja Zemlya, 5=Svalbard Bank and Svalbard coast, 6=Franz Josef Land, 7=Central Barents Sea, 8=Kara Sea).

Legend: ● Summer distribution
○ Winter distribution
❖ Extinct

(small symbols: rare, or only present in a very minor part of the subregion)

	Subregion	1	2	3	4	5	6	7	8
Minke whale	*B.acutorostrata*	●		●	•	●		•◦	●
Sei whale	*Balaenoptera borealis*	•		•					
Fin whale	*Balaenoptera physalus*	•		•	•	•		•	
Blue whale	*Balaenoptera musculus*	●				●		•	
Humpback whale	*Megaptera novaeangliae*	●		•	•	●		●	
N. right whale	*Eubalaena glacialis*						❖		
Bowhead whale	*Balaena mysticetus*				•	•◦	●○	•◦	
White whale	*Delphinapterus leucas*	•	●	●○	●○	●○	●◦	●○	●◦
Narwhal	*Monodon monoceros*				•○	●○	●	•○	•
Sperm whale	*Physeter macrocephalus*	●		•		●		•	
Northern bottlenose	*Hyperoodon ampullatus*	●				•			
Killer whale	*Orcinus orca*	●◦		•	•	●	•	●	
Common dolphin	*Delphinus delphis*	•							
White-beaked dolphin	*L. albirostris*	●		•	•	●		●	
White-sided dolphin	*Lagenorhynchus acutus*	●							
Bottlenose dolphin	*Tursiops truncatus*	•							
Harbour porpoise	*Phocaena phocaena*	●		•	•	●		●	

Sources: Isaksen & Wiig 1995, Hansen et al. 1996, Ridgway & Harrison 1985, Ridgway & Harrison 1989, Sakshaug et al.1992, Brekke & Fjeld 1991

Figure 2.17: Primary distribution range of beluga (white whale). Green=summer distribution.. Darker green=important sites (high concentrations, breeding sites). Grey=wintering area. Dark grey=migration corridors between Kara and Barents Sea. The red spot at Svalbard delineates an important area for narwhal.

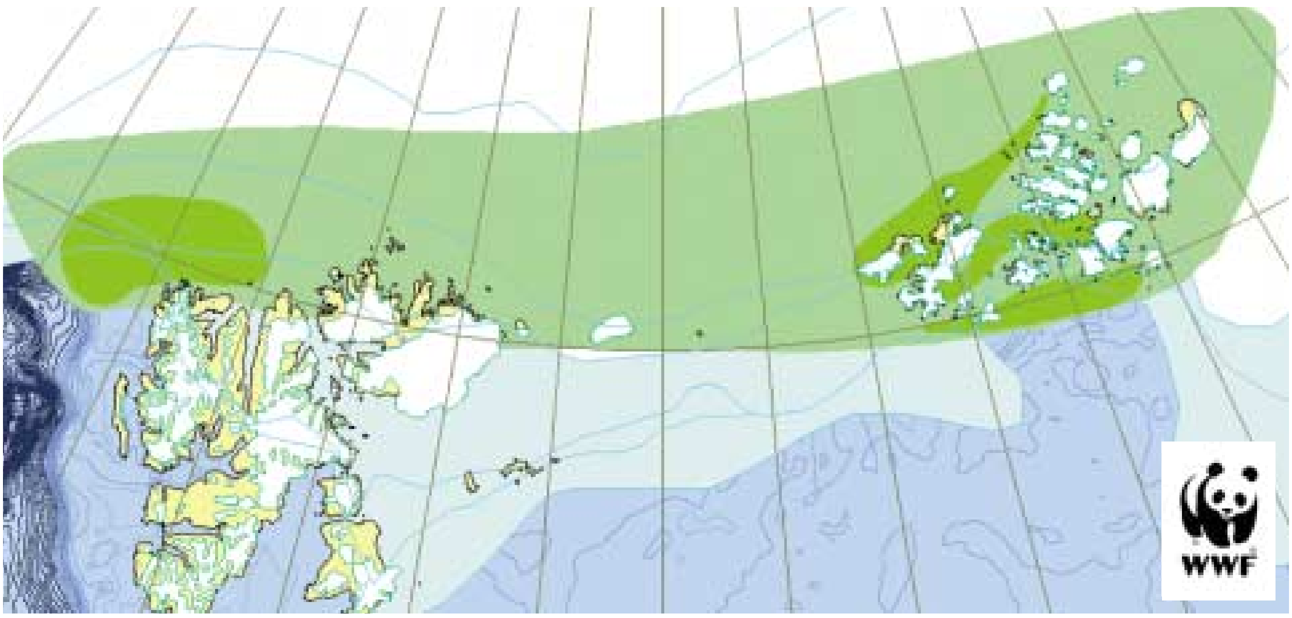


Figure 2.18: General distribution of bowhead whale. Dark colour indicates areas of most frequent distribution.

Seals and walrus

Seven pinniped species are found in the ecoregion. Harvesting of pinnipeds never evolved to an industry the size of whaling, except for two species: the walrus and the harp seal. The walrus was harvested to the verge of extinction in the ecoregion by the 1950s. From an original stock of perhaps 70 - 80,000 animals (Fedoseev 1976, cited in Hønneland et al. 1999), the number of walruses in the ecoregion today is probably around 2,500 (Born et al. 1995). Important breeding and feeding grounds are in the northern archipelagos of Svalbard and Franz Josef Land with a population of around 2,000, while the Pechora Sea is an important wintering area. The southeast Barents Sea and the Kara Sea do, however, also hold a resident population of ca. 700 animals (Goryaev & Vorontsov 2000). The Atlantic walrus is one of three walrus subspecies. The species was protected on Svalbard in 1952 and in Russia in 1956, but there is still considerable concern for the future situation of the species due to increasing activities in shipping and the petroleum industry (Hønneland et al. 1999).

Pinnipeds in the Barents Sea

Walrus and seals of the Barents Sea ecoregion. The subregions coincide roughly with those given on page 55 (1=Norwegian and Murman coast, 2=White Sea, 3=Pechora Sea, 4=Western coast of Novaya Zemlya, 5=Svalbard Bank and Svalbard coast, 6=Franz Josef Land, 7=Central Barents Sea, 8=Kara Sea).

Legend: ● General distribution
(small symbol: rare, or only present in a very minor part of the subregion)

	Subregion	1	2	3	4	5	6	7	8
Walrus	*Odobenus rosmarus*		•	●	●	●	●		●
Bearded seal	*Erignathus barbatus*	•		●	●	●	●	●	●
Ringed seal	*Phoca hispida*	•	●	●	●	●	●	●	●
Harp seal	*Phoca groenlandica*	•	●	●	●	●	●	●	●
Harbour seal	*Phoca vitulina*	●	•	•	•	•			
Hooded seal	*Cystophora cristata*	•				•		•	
Grey seal	*Halichoerus grypus*	●							

Sources: Isaksen & Wiig 1995, Hansen et al. 1996, Hønneland et al. 1999

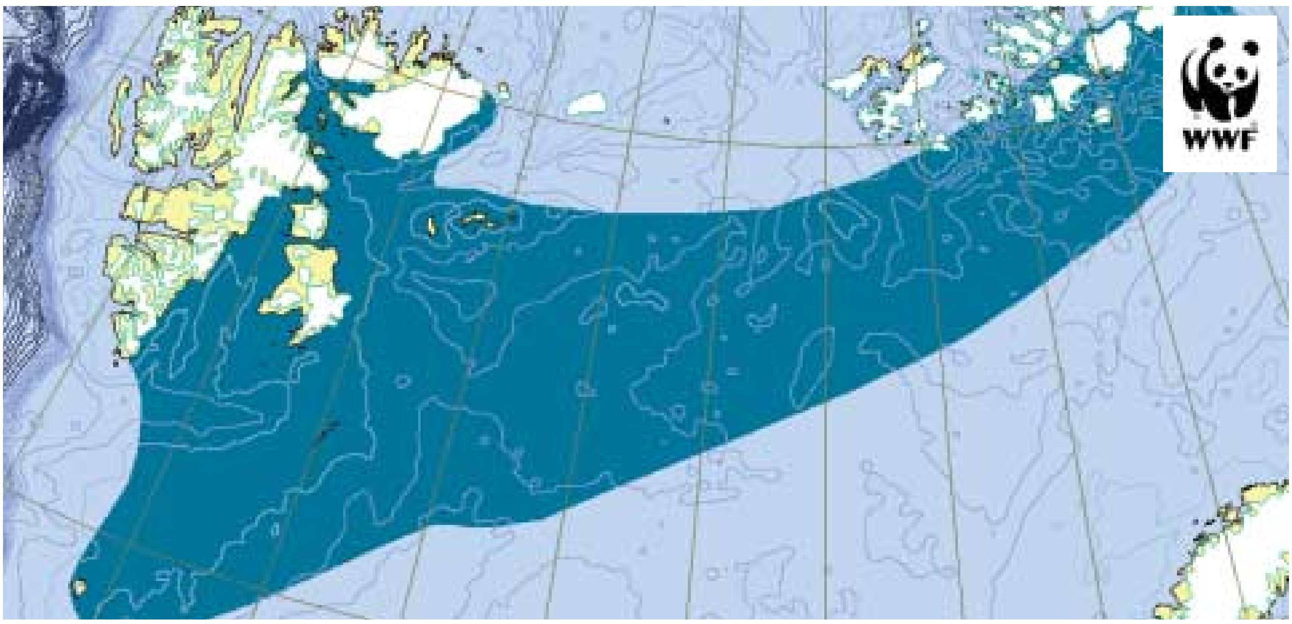


Figure 2.19: Main breeding distribution of the bearded seal (winter/spring). (References, see pp.148-151).

Figure 2.20:
Breeding and moulting areas of harp seal.

The dark green area in the Funnel is the principal breeding site, with extensions to the White Sea and toward the Kanin Peninsula. The lightest colour delineates the larger moulting area.

(References, see pp.148-151).

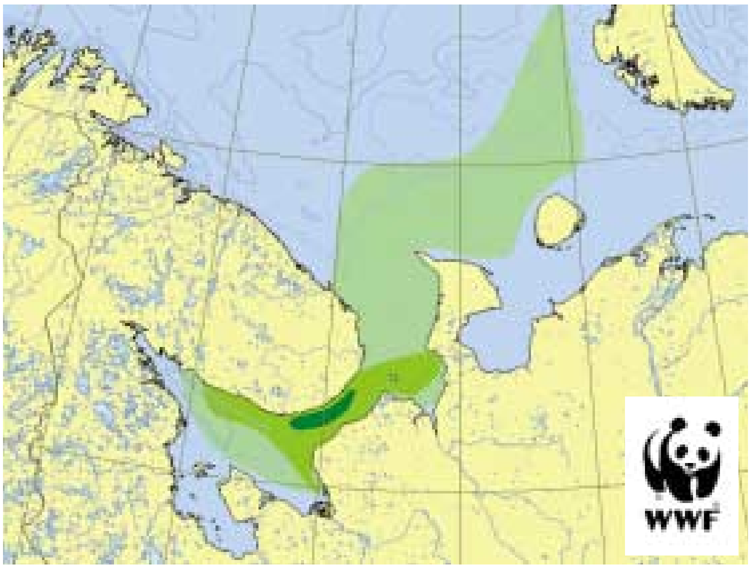


Figure 2.21:
Breeding range of the ringed seal.

The general breeding area is in light red, with concentrations of breeding animals in darker red.

(References, see pp.148-151).

Figure 2.22/23:
More detailed maps below show the status of ringed seal breeding areas at Svalbard (left), with particularly suitable breeding sites in the inner fjords depicted in darkest red, and the status in the Pechora and Kara Seas (right).

(References, see pp.148-151).

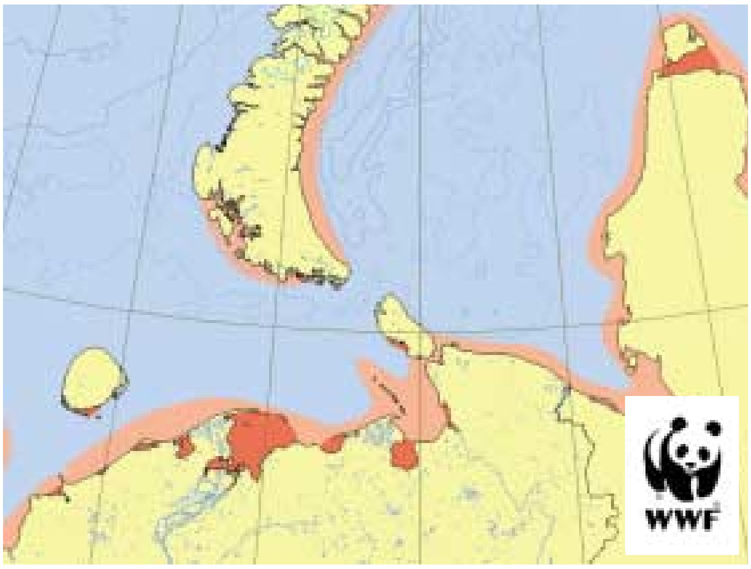


Figure 2.24: Walrus distribution in the Barents Sea ecoregion. Summer areas: Green, encircled areas. Wintering areas: Light brown. Dots show the location of haulouts (traditional resting sites): Dark red=present haulout; Light red=abandoned haulout. It should be noted that a large haulout with more than 1,000 animals was reported from Bjørnøya in 1604 (not marked on the map). A green dot in the Pechora Sea marks a possible southern breeding site. (References, see pp.148-151).

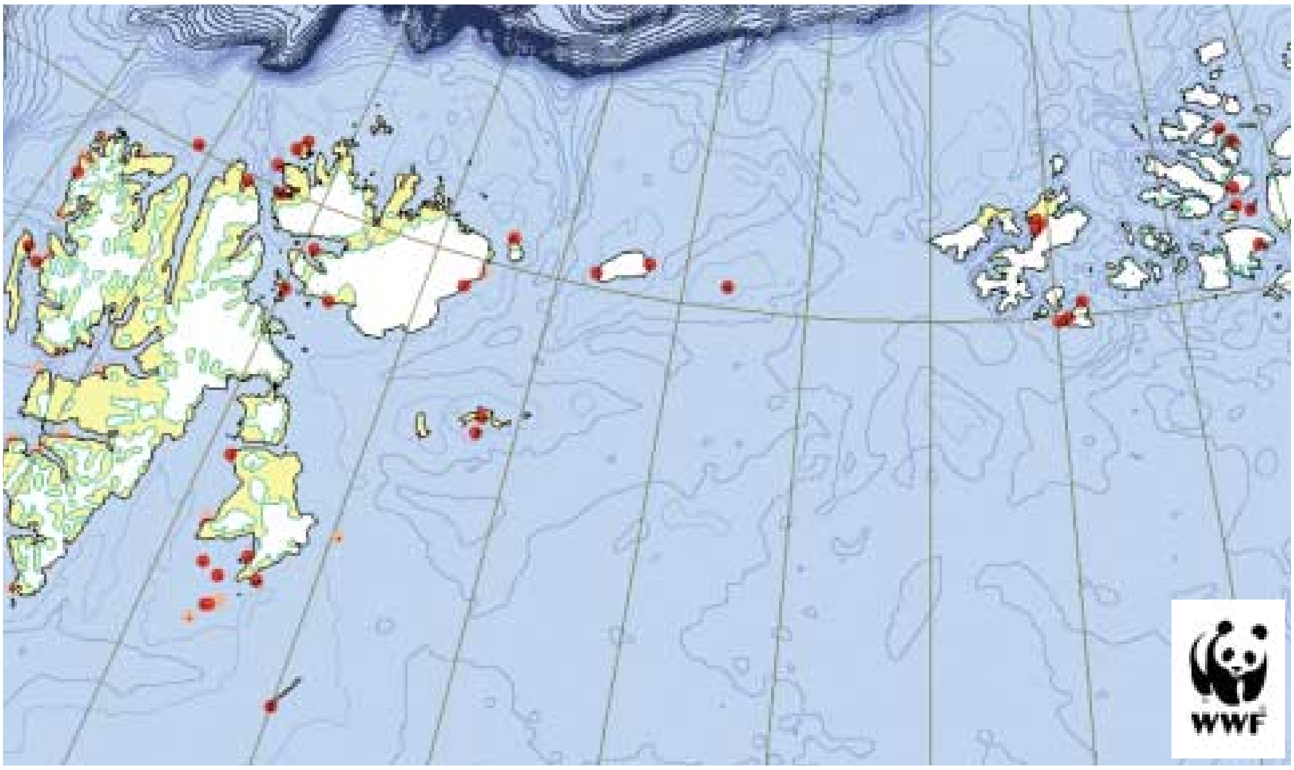


Figure 2.25: The map shows haulouts at Svalbard and Franz Josef Land in more detail. (References, see pp.148-151).

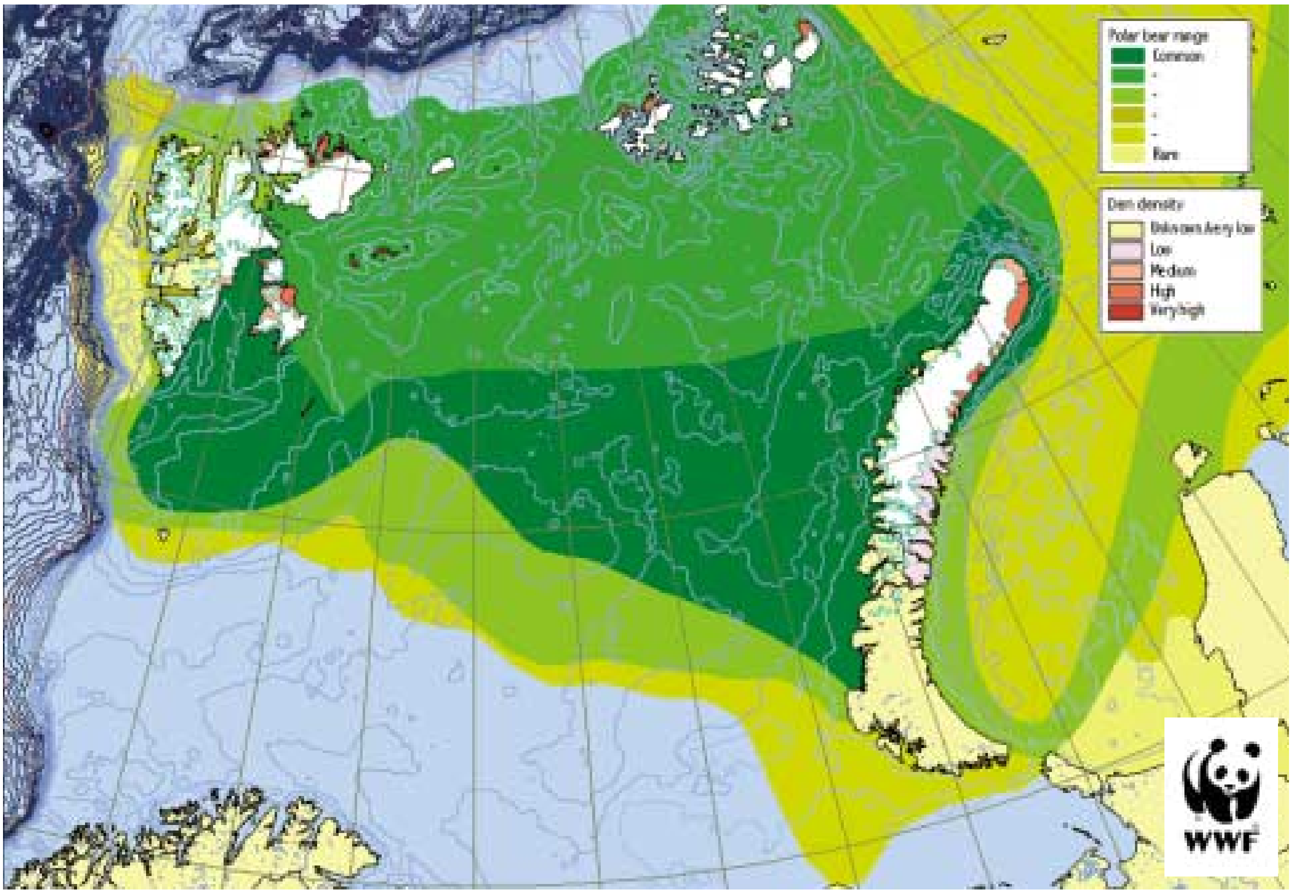


Figure 2.26: Polar bear distribution. The general frequency of polar bear observations on drift ice reflects the average position of the ice edge through the year. The red colours (terrestrial) depict relative densities of polar bear dens. (References, see pp.148-151).

The harp seal is found in most parts of the ecoregion, and is by far the most numerous species. Its most important breeding site is situated in the White Sea – in "The Funnel" east of the Kola Peninsula. Russian scientists estimated the number of newborn pups in the area to be somewhere between 240-350,000 in 1998, suggesting a total population in the ecoregion of approximately two million animals.

Along with the true marine mammals, the polar bear (*Ursus maritimus*) inhabits the region all year round. The present number of polar bears in the ecoregion is estimated at 3-5,000 (Wiig et al. 2000). Important denning areas include Svalbard (100-125 dens, excluding Hopen and Kong Karls Land), Franz Josef Land (50-150 dens) and Novaja Zemlya (100-250 dens) (Belikov & Matveev 1983, Brude et al. 1998, Brekke & Fjeld 1991). Very high den densities are found on Hopen (35 dens in 1996, which equals 0.76 dens/km^2) (Theisen & Brude 1998), and Kong Karls Land (77 dens in 1980, equalling 0.23 dens/km^2) (Larsen 1986). The otter (*Lutra lutra*) is another mammal closely linked with the sea. The coast of Finnmark represents the northern limit of its distribution.

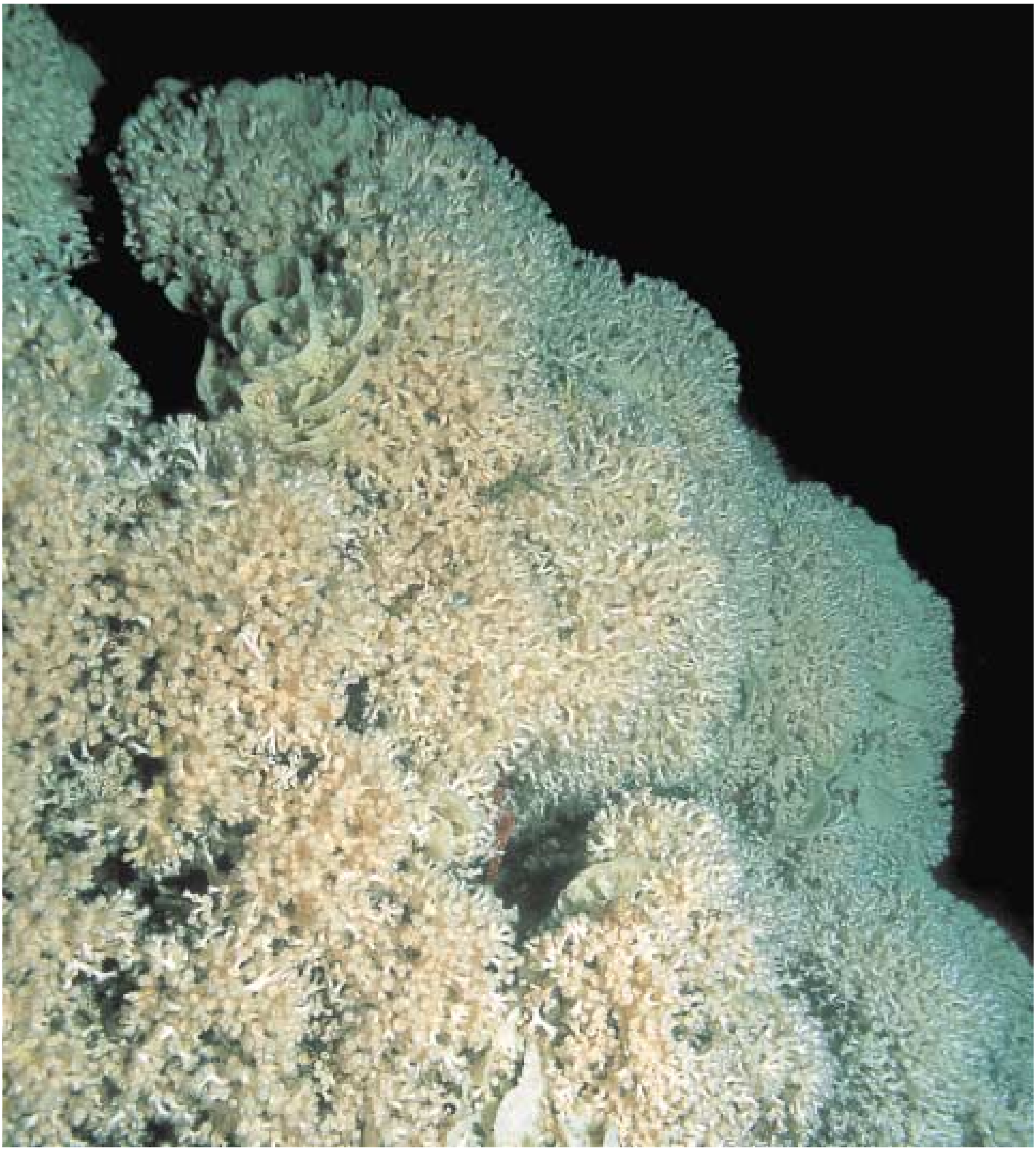
Except for the commercially interesting species (harp seal and minke whale) we know relatively little about the distribution and abundance of the marine mammals in the Barents Sea, and there is a lack of data to make reliable population estimates. According to von Quillfeldt and Olsen (2003) there is an urgent need to improve our understanding of how access to food, predation and climate change affect the populations of marine mammals in the Barents Sea; to describe the significance of marine mammals in the marine ecosystem; and to collect data regarding distribution of the non-commercial species.

Production and consumption

The quantitatively most important mammals in the upper part of the food chains are minke whale, killer whale, white whale, ringed seal, harp seal, bearded seal, walrus and polar bear. Neither mammals nor birds constitute much of the total biomass in the Barents Sea, however. The following figures (from Sakshaug et al. 1992) illustrate roughly the population densities of various organisms and groups of organisms, measured as kg carbon /km^2 (the area of the Barents Sea set at 1.4 million km^2):

Bacteria	400
Phytoplankton	2,000
Zooplankton	3,000
Capelin	400 (30-700)
Cod	300 (150-700)
Whales	20
Seals	10
Seabirds	1
Polar Bear	0,1
Human (Norway)	80
Human (Japan)	1600

Based on figures from the same source, 14 million seabirds, 1.3 million seals and 55,000 whales in the Barents Sea (with total biomasses of 8,000, 110,000 and 200,000 tons, respectively) consume food equivalent to a primary production of 12 million tons of carbon per year. Considering a moderate estimate of average new (surplus) primary production per year of 60 grams of carbon per m^2, Sakshaug et al. (1992) set the total yearly primary production in the Barents Sea to 85 million tons of carbon. This is seven times more than the production necessary to supply seabirds and sea mammals, so even if half of the primary production is sedimented and the rest goes to support secondary and tertiary consumers (zooplankton and fish) and fisheries, one may conclude that primary production is not limiting the seabird and sea mammal populations in the Barents Sea (Sakshaug et al. 1992).



Lophelia reef. Photo: Erling Svensen

3. PAST, PRESENT AND FUTURE CHALLENGES

The biological production of the Barents Sea has for thousands of years sustained and ensured the well-being of the peoples and communities of northern Norway and northwest Russia. Despite the ecoregions distance from densely populated areas, the Barents Sea has historically been the most easily accessible part of the Arctic. Harvesting of the great abundance and diversity of marine mammals was initiated by the Pomors of the Russian Arctic coasts. It increased considerably soon after the travels of Willem Barents and other European explorers at the end of the sixteenth century, resulting in the near extinction of a number of sea mammal populations. Many of these have not been able to recover since. Today, fisheries most seriously affect the biodiversity of the ecoregion. While the threat of radio-active contamination has been a cause of concern for the last forty years, other new, major threats are appearing: Shipping activities are increasing rapidly; the petroleum industry is already developing in the southernmost parts of the ecoregion; the aquaculture industry is expanding, and long-range pollution, climate change and introduced species may prove to be important challenges in the near future.

Fisheries

With some very minor exceptions, technological limitations ensured that fisheries did not have a significant impact on the Barents Sea ecosystem before the middle of the twentieth century. Shortly after the evolution of small-scale coastal fisheries into large-scale offshore fisheries, however, the abundant fish stocks of the Barents Sea decreased notably. Although fisheries management in recent years has resulted in improvements and sustainable utilization of some stocks, fishing pressure on other stocks is so high that they are close to or beyond the limits of sustainable use (OSPAR 2000).

One of the classics in the history of fisheries is the decline of the Norwegian spring-spawning herring (*Clupea harengus*), spawning near the Norwegian coast from where ocean currents transport the fry into the southern Barents Sea. The introduction of the power block, sonar, and not least the mapping of migration routes meant that total annual catch increased from approximately 300,000 tons after World War II to 1,650,000 tons in 1956 and 2,000,000 tons in 1966 (two-thirds of the estimated remaining spawning stock at the time). After this, the population collapsed entirely and took 25 years to recover in spite of protection. After the collapse, the feeding areas north of Iceland were aban-doned in favour of the Norwegian coast. Northern Norwegian fjords today serve as wintering areas. This stock is at present considered to be within safe biological limits (IMR 2002).

The capelin (*Mallotus villosus*) is another pelagic plankton feeder, showing marked natural fluctuations in stock size. Efficient fisheries developed in the 1960s and 1970s, with little attention to the natural ups and downs of the stock. The Barents Sea capelin collapsed in 1985, and the International Council for the Exploration of the Seas (ICES) recommended that the quotas be set to zero in 1986. However, the Norwegian-Russian fishery commission allowed a winter quota of 120,000 tons, causing a total population crash (SSB 1988). Fisheries were halted for five years to give the stock some time to recover. Fishing was resumed again in 1991, resulting in another collapse only two years later. In 1997 the Barents Sea stock was estimated to be 800,000 tons, 10% of the size in 1975 (OSPAR 2000). A small fishery was permitted in 1999, when the spawning stock was estimated to 1,200,000 tons. Since then, the capelin stock has partially recovered, and the stock was in 2001 estimated at 3.6 million tons. However, a decrease in the stock has been observed since 2002.

The northeast Arctic cod (*Gadus morhua*) stock is potentially the largest cod stock in the world, with a bio-mass in the 1950s of 3-4 million tons. The cod fishery historically has been the most important fisheriy in the region. Coastal fisheries took mainly adult, large fish, but the introduction of offshore trawlers meant a transition to fisheries based on small, immature fish. The extent of the trawling led to a sharp reduction in cod survival to spawning age. After overfishing brought the cod population to an all-time low in the beginning of the1980s, the stocks grew steadily due to a quite successful Norwegian-Russian management regime (Hønneland et al. 1999). According to the Russian Polar Institute for Fisheries and Oceanography, however, the number of vessels catching demersal fish has increased twice since 1994, while in the same period the cod stock has decreased by 45%. Large numbers of undersized cod have been caught. A press release from the Norwegian Ministry of Fisheries in 1993 stated that in the preceding year, the cod quota had been exceeded with between 80,000 and 130,000 tons (Økland 1999). The marine researchers have not been very successful in estimating stock size, a problem probably partly caused by illegal (not reported) fishing. Because large cod is best paid, undersized cod is dumped and not reported (the Institute of Marine Research in Bergen has, according to Økland (1999), estimated that 100,000 tons of cod "disappeared" every year between 1995 and 1998 (the total cod quota for 1996 was 740,000 tons). Some of the disappearance problem may be due to underestimating the impact of cod-eating sea mammals, but since the 100,000 tons relate to large cod, this extra impact must be small. In addition to possible illegal dumping, the reported small-cod fishery has forced Norwegian and Russian management bodies to close many areas for fishing.

Unfortunately, the Russian management bodies from time to time experience acute shortages of funding for fuel, and most of the time there are no vessels on patrol in the Russian Economic Zone (Hønneland et al. 1999).

This must all be viewed on the background of natural fluctuations in the interplay between cod, herring and capelin, in turn dependent on the varying inflow of Atlantic water. Although the situation for the Norwegian arctic cod has improved the last year, fishing pressure has been higher than recommended since 1998. While the International Council for the Exploration of the Seas (ICES) recommended a total quota of 110,000 for the Barents Sea cod fisheries in 2000, Norwegian and Russian authorities settled for 390,000 tons. For 2001, 2002 and 2003 ICES recommended quotas of 260,000, 181 000 and 305 000 tons respectively, but Norway and Russia agreed on a quota of 395,000 tons for each year. According to ICES, the stock is currently being harvested outside of safe biological limits. For the Norwegian coastal cod the situation is worse. In 2003 ICES described the stock as historically low and recommended full stop in harvesting.

ICES STOCK STATUS REPORT

Every year, the International Council for the Exploration of the Seas (ICES) through its Advisory Committee on Fishery Management (ACFM) presents a status report of fish stocks, with recommendations for quotas and stock management. Norway and Russia use the recommendations as guidance, but because of strong pressure from the fish industry, they are usually not followed in the end. The status of some Arctic fish stocks presented by ACFM is given here:

Norwegian Arctic Cod:	SSB reached 653,307 tons in 2003, which is higher than the precautionary limit, 460,000 tons. Fishing pressure has been higher than recommended since 1998 and the stock is harvested outside safe biological limits.
Norwegian Arctic Haddock:	SSB reached 120,009 tons in 2003, which is higher than the precautionary limit of 80,000 tons. Fishing pressure has been higher than recommended since 1997 and the stock is harvested outside safe biological limits.
Northeast Arctic Saithe:	SSB reached 437,232 tons in 2003, which is higher than the precautionary limit of 150,000 tons. Fishing pressure has been according to ICES' advice since 2002 and the stock is harvested within safe biological limits.
Greenland Halibut:	Stock size and SSB are considered to be low in historical terms, but have been improving recently. Reduced fishing is recommended.
Redfish:	Spawning stock is close to historically low and is outside safe biological limits. Management measures such as no trawling and reduced by-catch was introduced in 2003. ICES recommends significantly reduced fishing mortality.
Ling, Blue Ling and Tusk[2]:	Stock estimates for these species are not sufficient. ICES recommends reduced fishing, as they show negative trends.
Capelin[1]:	Stock is within safe bioogical limits but has a decreasing trend. TAC has been according to recommendations since 1994.
Norwegian Spring Sp. Herring:	SSB reached 5.2 million tons in 2003, which is higher than the precautionary limit of 5 million t. Fishing pressure has been according to ICES' advice since 1999 and the stock is harvested within safe biological limits.
Polar Cod[2]:	The stock has recovered and was estimated at 1.9 million tons in 2001.

SSB = Spawning Stock Biomass
TAC = Total Allowabel Catch
Reference: ICES – Advisory Comitee on Fisheries Management, ACFM spring 2003
[1]Reference: ICES – Advisory Comitee on Fisheries Management, ACFM fall 2002
[2]Reference: IMR – Havets ressurser 2003

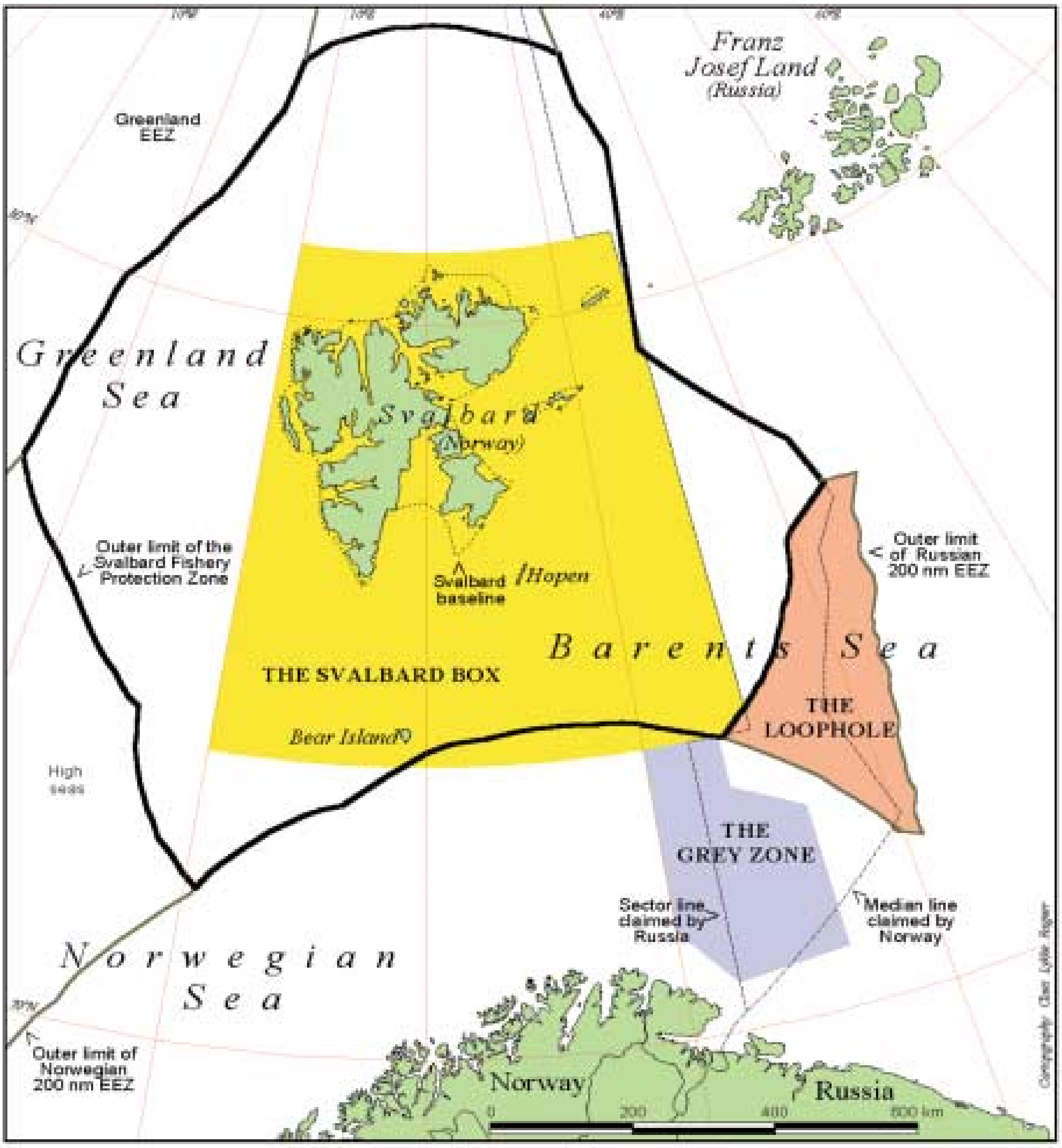


Figure 3.1: The legal setting for fisheries in the Barents Sea. Data on regulation areas in Russian waters have not been available.

The situation for a number of other species is also unstable or alarming, such as redfish (*Sebastes marinus*) and Greenland halibut (*Reinhardtius hippoglossoides*).

Barents Sea shrimp fisheries started in 1975, and have been largely unregulated. In 1984, 120,000 tons were landed of a total stock estimated at 470,000 tons. Three years later the stock was reduced to 150,000 tons. After five years of historically low landings in the mid-1990s, the stock increased again, but so did landings (data from the Norwegian Institute of Marine Research), and in the spring 2001, the Fisheries Research Institute in Tromsø estimated that the Barents Sea stock had decreased by 20% in one year. Large ice-class bottom trawlers with twin and triple trawls have largely replaced the smaller vessels of the coastal fleet.

The calculation of catches is based on landings only, and unreported discards complicate the management of fish stocks (Quillfeldt and Olsen 2003). Discards have not been studied in detail in the ecoregion. They result from two main sources: fishery regulations and financial constraints (OSPAR 2000).

Regulations:
- Discard of undersized fish.
- Quota for target species or bycatch overrun.
- Discard of catch caught after fishing has been stopped for the species.

Financial constraints:
- Discard of undersized fish.
- Discard of less profitable bycatch, particularly when using non-selective gear (shrimp fisheries; trawling in general).
- Torn nets (when catching large schools of herring; survival rate is close to zero in such cases).

Bottom trawling and dredging has caused considerable damage to the ocean bottom in parts of the southern Barents Sea, along the coast of southern Novaja Zemlya, and along the shelf edge from Norway to northern Svalbard. According to a map by Mathisov (1991), Russian marine scientists have considered these areas "devastated benthic biocenoses" (the amount of documentation is not known). Studies of deepwater corals off the Norwegian coast has revealed extensive damage caused by bottom trawlers. Fosså et al. (2000) have estimated that one third to half of the coral reefs have been damaged to some extent. Bottom trawls are heavy gear, weighed down by chains, metal "doors" and heavy weights. Double trawls are used regularly in shrimp fisheries, and experiments have also been performed with triple trawls. At each side of the rigging is mounted a 750 kg V-door, and between the trawl bags additional weights of 300 kg are added (Valdemarsen 1997). The impact of this appliance on the seafloor can be extensive, particularly from the heavy weights. The long-term impacts on the ecosystem of such habitat destruction are not well understood.

Human influence on seabird populations

The depletion of fish stocks in the Barents Sea is likely to have affected most parts of the ecosystem; seabirds are recognized as good indicators of changing environmental conditions. Fisheries affect the status of a number of seabird species directly and indirectly (Furness 1984). While the extensive dumping of bycatch and waste has positively affected the growth of northeast Atlantic fulmar (*Fulmarus glacialis*) populations, species foraging on pelagic planktivores have decreased substantially in the last twenty years. The most devastating impact came with the capelin collapse in 1985-86: The population of common guillemot (*Uria aalge*) on Bjørnøya dropped by more than 80% from 245,000 pairs in 1986 to approximately 36,000 pairs in 1987 (Mehlum & Bakken 1994). A similar decrease was observed along the Norwegian and Murman coasts. At Hjelmsøya in Finnmark, the common guillemot population dropped from 15,000 to 2,000 pairs (Strann & Vader 1986, 1987), and at Ostrov Kharlov it dropped from 7,475 individuals in 1985 to 1,216 in 1987 (Krasnov et al. 1995). It has been estimated that one million guillemots died in the Barents Sea during the winter (Sakshaug et al. 1994).

Fishing vessels off the coast of Norway. Photo: Maren Esmark

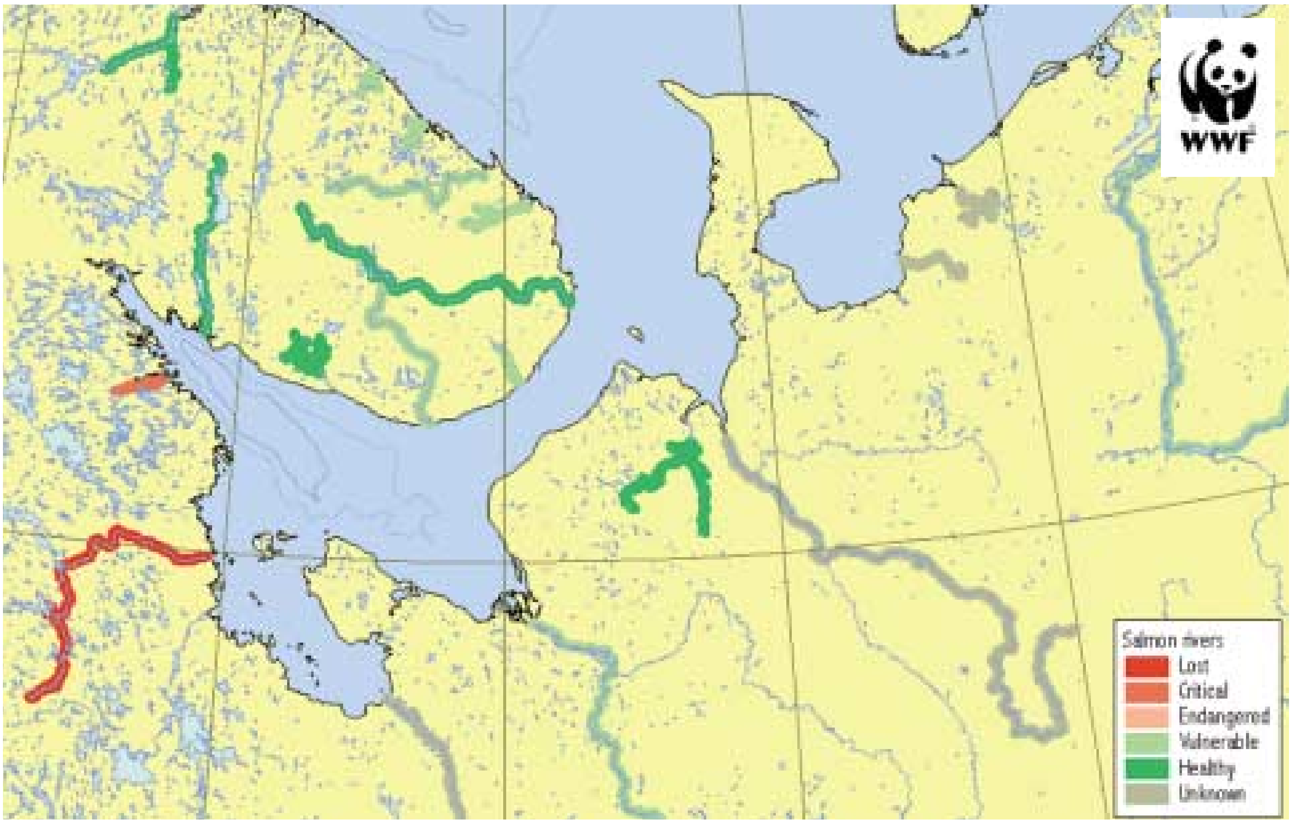


Figure 3.2: The Atlantic salmon has been the object of fisheries both at sea and in its spawning rivers for as long as there has been people in the region. Sea fisheries are today thoroughly regulated, but poaching is widespread and is, together with pollution of the spawning rivers, a main threat to many salmon stocks. The map depicts the situation in some Russian rivers, according to Lajus & Titov (2000). (References, see pp.148-151).

Another case of overfishing has had devastating effects on the islands of Røst in Lofoten. Røst has the largest puffin colony in the ecoregion, but the absence of herring fry made puffins unable to provide sufficient food for their young in 16 of 21 breeding seasons between 1969 and 1990, resulting in chick starvation and almost no reproduction (Mehlum & Bakken 1994). Puffins are long-lived, but as long as recruitment is negligible over very long periods, the population will decrease eventually - a decrease that has already started and will probably continue for many years even with an improved food situation (Anker-Nilssen 1998). The decrease during the last 10 years has been estimated to at least 100,000 pairs, the population today numbering ca. 500,000 pairs. Although earlier counts are encumbered with some uncertainty, Anker-Nilssen (1994) estimates that as late as 1980 the puffin population on Røst may have counted as many as 1,300,000 pairs.

However, other factors than prey availability alone will have to be considered in order to explain the decrease of seabird populations. The common guillemot colony on Hjelmsøy was estimated at 110,000 pairs in 1965 (Barrett 1994). With a population of only 15,000 in 1986, this means a 90% decrease even before the capelin collapse. A local decrease like this can be caused by a number of influences, but the most important could be bycatch in coastal fisheries. The use of drift nets for salmon increased by 500% outside western Finnmark between 1978 and 1985, and nets were often set within 4-10 nautical miles from seabird cliffs (Strann et al. 1991). Bycatch of guillemots in these nets was very variable and depended on fog and light conditions. Bycatches of more than 1,000 birds in one drift (600-1,200 m long and lasting some hours), and probably 3,000-4,000 birds a day have been reported. With 10-15 boats fishing outside the bird cliffs from 1 June to 5 August, it is not unrealistic to estimate that 20,000-50,000 breeding adult birds may have drowned in drift-nets in some seasons. The use of drift nets was banned in Norway in 1989 to protect decreasing salmon populations.

In another instance reported by Strann et al. (1991), a single vessel taking part in a local spring fishery for cod outside Troms, caught 2,579 guillemots in gill nets in one night. Of these, 33 were Brünnich's guillemots (mostly adults); the rest were mainly immature and young common guillemots. In this particular incident, ca. 40 vessels participated for 10-12 days, and since the fishermen reported that "all boats caught thousands of auks every night", Strann et al (1999) estimated that a high number of guillemots were killed. Instances like this one are probably rare, but common enough to have a particular Norwegian name (alkeslag = "auk battles").

Bycatch during longlining is another problem, involving in almost all cases fulmars hooked when setting the line. With 30-60,000 hooks in the water every day, a longliner can catch a substatial number of fulmars in open sea. Without mitigation measures, 1-2 fulmars per 1,000 hooks is not unusual. Very simple mitigation measures (releasing the line underwater or using a second, short line with fluttering bands while setting the longline) can reduce bycatch substantially (see Dunn & Steel 2001 and Løkkeborg 2000). It has been estimated that Norwegian longlining vessels set 476 million hooks in 1996, and if the lines set by the thousands of small coastal vessels in parts of the year are also included, estimates give bycatches of between 20,000 and 100,000 fulmars per year. The fulmar is however not a threatened species; it has increased substantially in the last decades due to the continual discharges of offal and bycatch from fishing vessels. Drowned birds are not used in any way.

A type of resource use that has caused local population decrease is collection of eggs and adults. This started in the whaling era, when ships added to their supplies by collecting eggs and adult birds from seabird colonies, and was continued by the growing fleet of fishing vessels. At Bjørnøya, the large colonies of guillemots were heavily (and illegally) exploited as a source of food for fox farms from the late 1920s (Mehlum & Bakken 1994). In parts of the Barents Sea ecoregion, the results of past local egg collection and hunting can be observed even today. Colonies of Brünnich's guillemot on Novaya Zemlya were "industrially exploited" from the 1920s, and the number of breeding birds started to decline dramatically in the late 1930s (Krasovskiy 1937, Uspenskiy 1956, Krasnov 1995). Based on Russian sources, Norderhaug et al. (1977) describe how some Brünnich's guillemot colonies on Novaja Zemlya have dwindled: Mys Cerneckogo - 200,000 birds in 1942, 55,000 in 1955; Bezymyannaya Guba - 1,644,500 birds in 1934, 290,000 in 1948; Puchovoj Zaliv - 600,000 birds in 1923 (late season, many had already left the colony), 121,000 in 1950; Mys Lil'e - 200,000 birds in 1925, 1,000 in 1950. In addition to collection by Norwegians for use in the soap industry in the beginning of the last century, Norderhaug et al. state that uncontrolled collection by local inhabitants is an important factor affecting the decline. After the Soviet nuclear test programme on Novaja Zemlya was initiated in the 1950s, the local people were moved to the mainland. Today, main settlements exist at Belushiya Guba and Rogachyovo southeast of Gusinaya Zemlya (Goose Land), but there are also a number of stations and small settlements spread along the coast (Boyarsky 1999).

Illegal collection of eggs and adult seabirds continues today in parts of the Barents Sea Ecoregion.

Down collection seriously affected the breeding population of eiders on Svalbard in the last centuries through a local variant of the "tragedy of the commons": No private land existed on the islands, so when Norwegian whalers and trappers arrived they did not introduce the age-old tradition of sustainable harvesting of eggs and down. In 1914, two and a half tons of eider down was brought from Svalbard to Norway, equalling approximately 80,000 nests emptied in one year (Bollingmo 1991). The total breeding population today is estimated at 17,000 nests, illustrating clearly that even the 1963 protection has failed to bring the eider population back to its former size. Demme (1946) reports about the same activity on Novaya Zemlya, where as much as 2,200 kg of down were collected yearly in the 1940s.

Marine mammal hunting

Of the 24 species of marine mammals recorded in the ecoregion, the northern right whale was brought to extinction already in the early whaling period. Of the remaining species,

- the bowhead whale and the blue whale have not been able to recover from their near extinction two hundred years ago, and are listed by CAFF as endangered in both Norway and Russia;
- the northern bottlenose and humpback whales are listed as endangered in Russia:
- the humpback whale is listed as rare in Norway;
- the sei whale and narwhal are listed as rare in Russia;
- the fin whale is listed as vulnerable in Russia;
- the walrus is classified as vulnerable in Russia;
- the polar bear is listed as vulnerable in Norway and rare in Russia.

The population of bowhead whales has not increased significantly. In the 1600s, there were probably 20,000-30,000 bowhead whales in the waters around Svalbard, but when the species was protected in 1929 it was almost extinct. Fin whale and blue whale in the Svalbard area are also almost extinct at present. The reason for the failure of many marine mammal species to increase in numbers despite current protection measures is not known, but may relate to competition from other species, very slow reproduction and changes in the available food base (Hansen et al. 1996). According to the OSPAR Commission (OSPAR 2000), it is likely that the patterns of energy flow and the dynamic properties of the ecosystems have been altered permanently by former whaling activities.

The populations of walrus and polar bear have also been close to extinction during the past 200 years as a result of hunting. The walrus was protected in the 1950s, and the polar bear in 1973, and their populations are no longer endangered. It is estimated that there are now about 2,000 polar bears on Svalbard and 3-5,000 in the ecoregion (Wiig et al. 2000).

For almost all of the marine mammal species in the ecoregion, little is known about their population dynamics and actual numbers. Six species are harvested more or less regularly: minke whale (Norway), harp seal (Norway and Russia), harbour seal (Norway), grey seal (Norway), bearded seal (Norway and Russia) and ringed seal (Norway and Russia). The last two are harvested mainly for local subsistence needs. The white whale is occasionally also caught in Russian waters for subsistence needs of local people. In addition to directed takes, human activities have indirect effects on sea mammals. Fish nets regularly kill harbour porpoises in Norway (and possibly other small toothed whales). The total Norwegian population of harbour and gray seals has been estimated at approximately 10 000 animals, or one tenth of the number along the British Isles. Nonetheless, harvest rates of marine mammals in the ecoregion are moderate and do not represent a threat to any population. A greater threat perhaps is the position of most species near the top of food chains, which make them vulnerable to persistant organic pollutants (POPs) and other contaminants.

In 1987, after the capelin population had collapsed, more than 100,000 harp seals migrated to the coast of Norway, where as many as 60,000 of them starved to death or drowned in fish nets. The reason for this migration seems to have been lack of food: After exterminating the herring, ocean trawlers turned to another key species of the ecosystem, the capelin. The ensuing capelin collapse deprived the cod of its main food source, and side-effects caused major reverberations throughout more or less the entire ecosystem. Harp seals eat mainly crustaceans (shrimps) and capelin, and were hit severely by lack of both.

Introduced species

Introduced species are increasingly becoming a problem in the region. It is not clear how many alien species have been introduced to the ecoregion. According to OSPAR (2000), four marine plants and seven marine animals have been introduced to the OSPAR convention area, region 1:

Sperm whales. Photo by: WWF-Canon / Hal Whitehead

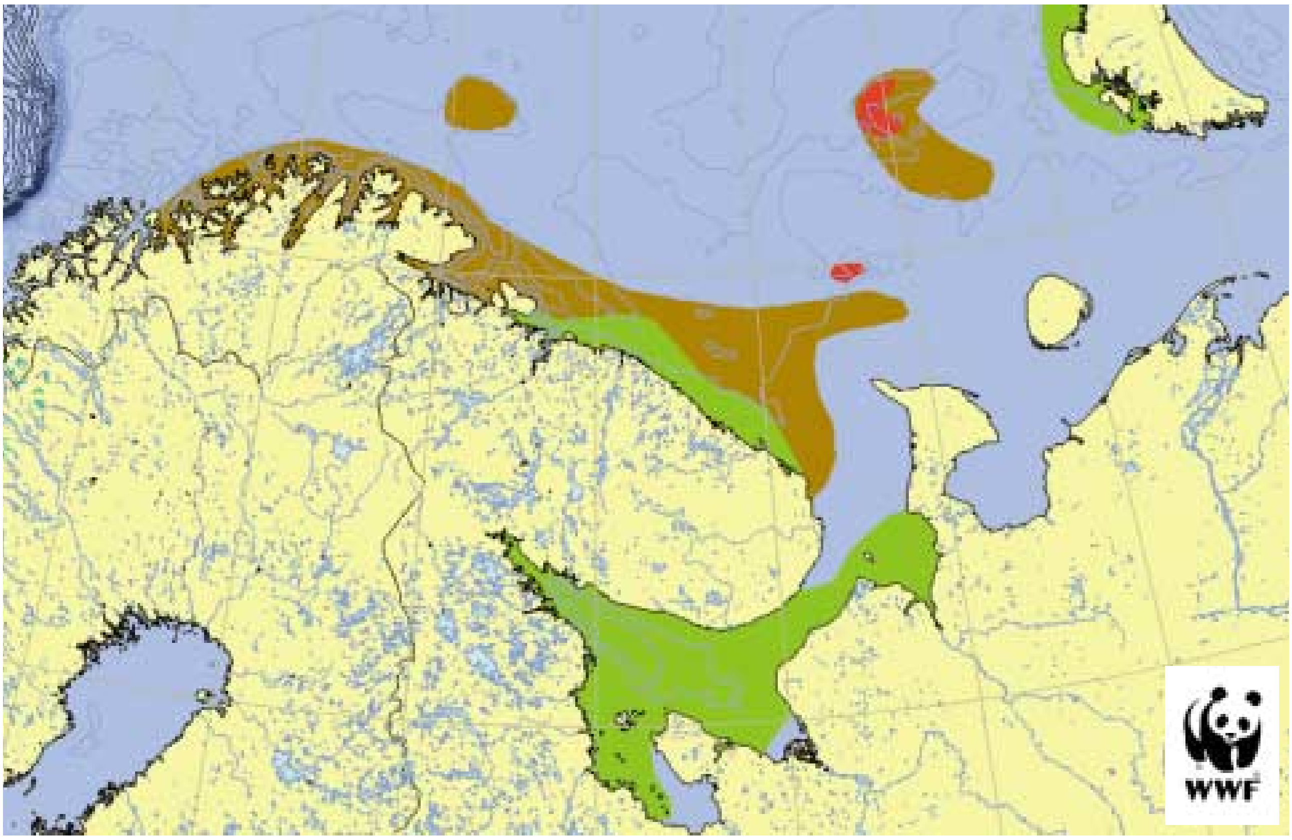


Figure 3.3: Distribution of some introduced species (2001): Two crustaceans, the Kamtchatka king crab Paralithoides kamtschatica (brown) and the snow crab Chionoecetes opilio (red), and the pink salmon Oncorhynchus gorbusha (green). (References, see pp.148-151).

Plants:

Rhodophyta	*Bonnemaisonia hamiferia*
Phaeophyta	*Colmomeria peregrina*
	Fucus evanescens
Chlorophyta	*Codium fragile*

Animals:

Crustacea	*Balanus improvisus*
	Lepas anatifera
	Paralithoides camtschatica
Mollusca	*Mya arenaria*
	Petricolaria pholadiformis
	Teredo navalis
Tunicata	*Molgula manhattensis*

The OSPAR list is not complete, as the Pacific salmon species *Oncorhynchus gorbusha* was introduced to the White Sea as part of Soviet plans for improving nature's yield, and today is found spawning in most of the rivers of the White Sea and parts of the Russian Barents coast. Another Pacific introduction is *Salmo gairdneri*, but this species does not seem to have spread from the culture ponds.

Paralithoides kamtschatica, or the Kamtchatka king crab, was purposely released by Russian scientists along the Kola coast in the 1960s. The first introduction was done offshore of the village of Teriberka in 1961, and the crab is now found in "dense concentrations" along the Murman coast (Mathisov & Denisov 1999). The king crab can reach a weight of more than 10 kg, and is an economically important species in the North Pacific. From the mid-1970s, Norwegian fishermen from time to time caught king crabs in their cod nets, and since then the population has grown remarkably and spread west along the Norwegian coast. Today, 100 king crabs or more stuck in a cod net is not unusual, and in the summer of 2003 the first observations of king crabs were reported outside the coast of Svalbard. Although the king crab has also spread east as far as the Goose Bank, the percentage of adult crabs increase westwards from Kola to Norway, and the speed of colonisation along the Norwegian coast has caused concern about the crab's impact on native benthic fauna. The king crab is known to consume capelin eggs, but it is unknown to what extent this may affect the capelin stocks. In addition, there is a risk that the king crab brings diseases or parasites that may affect other species in the marine ecosystem. A group of scientists is studying the potential ecological implications of the king crab invasion, but several years will elapse before any results are expected (Sundet 2002). No action has so far been taken to limit the distribution of the crab, and WWF has notified the Biodiversity Convention (CBD) that Norway's management of the king crab is inconsistent with the CBD. While the king crab is highly valued on the Russian side of the border, fishermen on the Norwegian side regard it as a nuisance - in particular as only a limited "research fishery" was allowed until 2002. Interviews with fishermen in Varanger revealed that the king crab significantly increased costs for the traditional fishereies. Nets are destroyed; catches reduced; and several traditional fishing sites have been abandoned due to the problems caused by the king crab (Sundet 2002). Due to strict regulations, by-catches of king crab cannot be used or sold. For 2001, the combined research quota for Norway and Russia has increased manyfold, to 200,000 crabs. In 2001, the Norwegian-Russian fisheries commission decided to open for ordinary commercial fishing of king crab from the autumn of 2002. The quotas for 2003 were set to 200,000 crabs in Norway and 600,000 in Russia. According to Sundet (2003) 15 million adult crabs in the Barents Sea in 2002 is likely to be a conservative population estimate. Population estimates are uncertain due to lack of data, but the population is expected to continue to increase in the future.

The occurrence of another common Pacific crab species, the snow crab (*Chionoecetes opilio)*, has recently been reported from the southeastern Barents Sea (Kuzmin et al. 1998) The species must have been introduced, possibly via ships' ballast water. So far, the distribution of *C. opilio* is limited (see map). Although it is smaller, *C. opilio* shows many similarities with the king crab regarding diet and reproduction. So far, it has spread more slowly than the king crab and its distribution in the Barents Sea is limited (see map). However, in the spring of 2003 the first observations were made outside the coast of Finnmark, indicating that it is spreading westward faster than previously expected.

Petroleum activities

The Barents Sea north of the Norwegian coast was opened for oil and gas exploration in 1980, and an environmental impact assessment was completed in 1988. During the period 1980-1992, 54 exploratory wells were drilled (Klungsøyr et al. 1995), mostly south of 72ºN outside of Troms and western Finnmark. Exploration drilling continued in 2000, after an eight-year pause due to uncertainty about economic yield. 17 exploratory wells have also been drilled on Svalbard by the Norwegians (Lønne et al. 1997), plus an unknown, but very limited number by the Russians.

The number of wells drilled in the Russian part of the Barents Sea is not known, but they are spread far offshore from nearly 76ºN west of Novaja Zemlya, south to the northern Kanin Bank. A number of exploration wells have also been drilled in shallow waters east of Kolgujev Island and in the Pechora Sea. Up to now a total of 11 significant discoveries have been made in the Russian Barents- and Pechora Seas: Murmanskoye, North Kildinskoye and Ludluvskoye, all gas; Shtokmanovskoye, Ledovoye and Pomorskoye, all gas condensate fields; North Gulyaevskoye, oil and gas; Prirazlomnoye, Varandey More, Medynskoye More and South Dolginskoye, all oil. In addition, another 125 fields or hydrocarbon bearing structures have been identified, although only between 9 and 12 percent of the area have been explored (Bjorsvik in press).

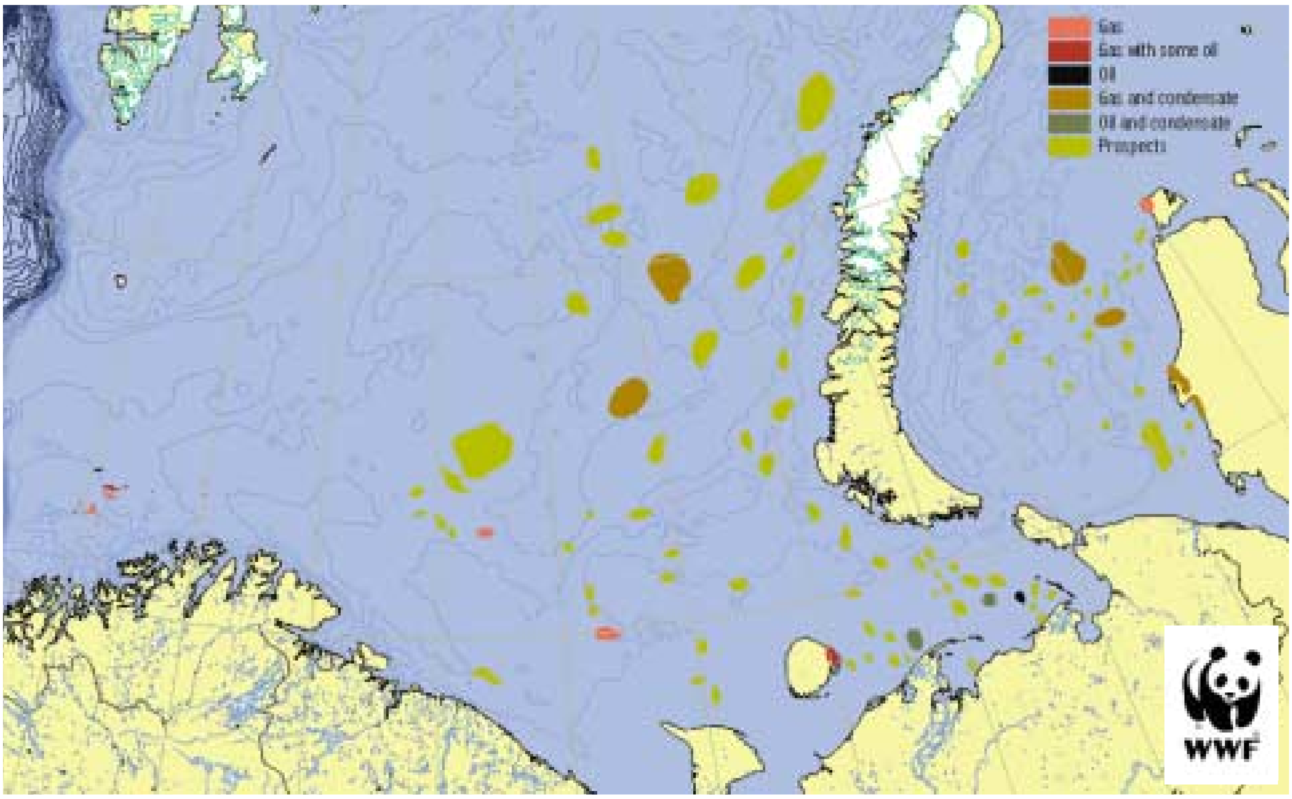


Figure 3.4: Petroleum fields in the Barents and Kara seas. (References, see pp.148-151).

The Barents Sea shelf (including the Pechora Sea) clearly holds vast volumes of oil and gas, but estimates of reserves potential in the area tend to vary. Estimates of undiscovered reserves in the undisputed Russian area of the Barents Sea, Statoil and Wood Mackenzie put at 1 billion barrels of oil and just above 3 Tcm of gas. In contrast to this, Russia's Natural Resources Ministry (NRM) in April 2003 said the area contained 16 billion barrels of oil, while the Barents Euro-Arctic Council says it holds 10 Tcm of gas, of which the Shtockmanovskoye is estimated to contain 3,000 billion m^3. In its "Energy Strategy for Russia through 2020" (2001), NRM said the Russian Barents Sea, Pechora Sea and the Kara Sea hold combined reserves of 10.6 billion tons of oil (79.7 billion barrels) and 54.5 Tcm of gas. Today 18 wells are producing oil or gas on land in northwest Russia. The first offshore field in the Pechora Sea, Prirazlomnoye, is expected to produce oil from 2005. This is the most significant oil deposit , with estimated reserves of 75 - 83 million tons (Rosneft 2003). Transportation is currently a major bottleneck for increased oil production and export from Northwest Russia. This will change if the expansion of the oil terminal in Verandej and the building of a new pipeline with an associated new oil terminal in Murmansk are carried out as planned. While there is much uncertainty regarding future development in the Russian part of the Barents Sea, petroleum activity is likely to increase considerably in the near future as both Russian and foreign oil and gas companies are investing heavily in the area.

The petroleum resources in the Norwegian part of the Barents Sea are considerable smaller than the Russian. The potential gas resources have been estimated to 850 billion m^3, while total oil resources in the Norwegian Barents Sea are estimated to about 300 million tons (OED 2003). Of this, 90% are yet to be discovered. The gas field Snow White off the cost of Finnmark is expected to be producing from 2006. The Goliath field, situated 60 km outside the city of Hammerfest, is likely to be the first oil-producing field, if the Norwegian government decides to open the Barents Sea for year-round oil production. The Norwegian Barents Sea is closed for oil and gas activities until 2004 awaiting the outcome of the environmental impact assessment and the general management plan

Seismic activity takes place in the initial phase of oil development, and has been performed widely in the Barents Sea. According to Matisov (1991), large areas west of Novaja Zemlya and in the Pechora Sea have been investigated with more than 20 pneumatic explosions per km^2 in the period 1975-1985. Pneumatic explosions have proven lethal to fish larvae, but only within some meters from the emission source (Klungsøyr et al. 1995). Sublethal effects are observed at greater distances, but the range is not well known. It has also been shown that adult fish leave areas where seismic activity is going on. Engås et al. (1993) found that cod left an area within 20 nautical miles from seismic explosions, and did not return within the first five days (trawl and longline catch of cod and haddock dropped by 50% after seismic activity). There is, however, no evidence that seismic activity affects whole populations of fish (Østby et. al 2003). Whales become stressed by seismic activity, and reactions such as escaping and changes in respiratory patterns and diving cycles are well documented for several species. Behavioural changes have been observed for bowhead whales as far as 73 km from the source (Østby et. al 2003).

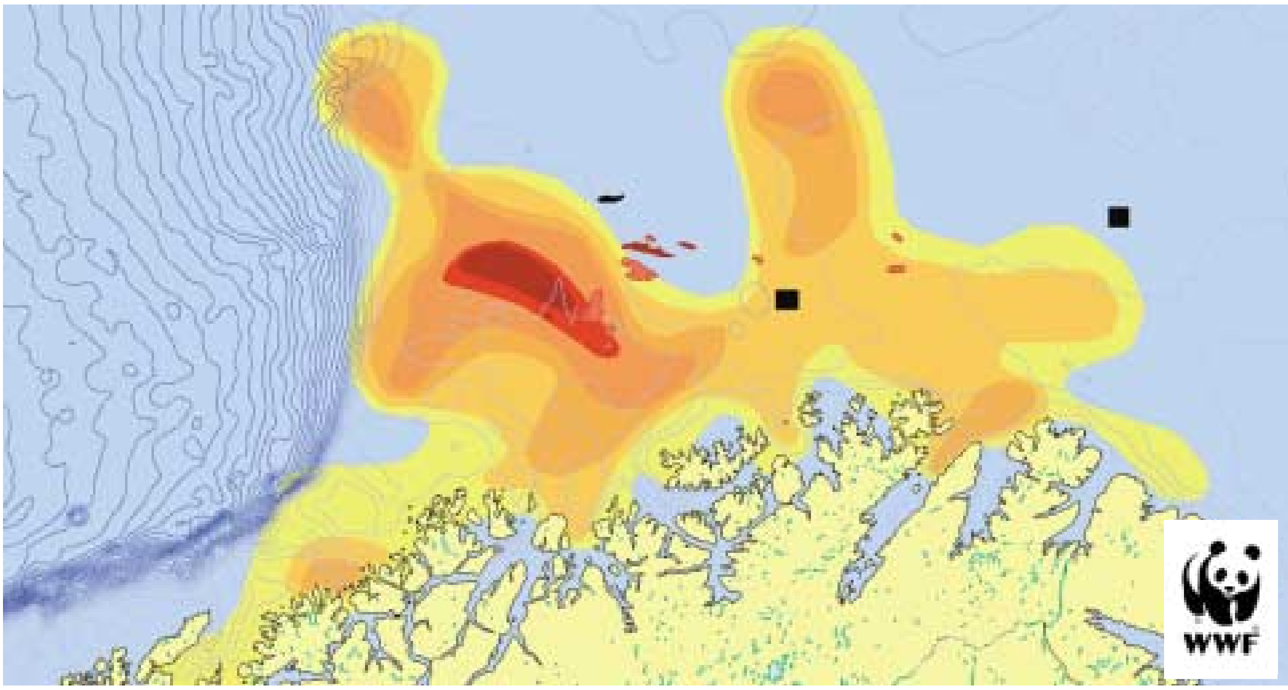


Figure 3.5: Petroleum fields off the Norwegian Barents coast coincide with areas of very high concentrations of cod larvae in summer (higher larvae concentrations in darker shades of orange. Gas fields = red, gas condensate = brown, oil = black. Two new oil fields are given as black squares). If these fields are developed, discharges of produced water or spills in summer may lead to significant larvae mortality and halt recruitment to the cod stock considerably. (References, see pp.148-151).

Exploration and production drilling are sources of discharges to the sea and emissions to air. Emissions include carbon dioxide, nitrogen oxides, volatile organic compounds and methane gas, while discharges consist of oil, metals, minerals and different chemicals. Because of the hydrocarbon contamination from oil-based drilling fluids (used to lubricate and cool the drill), discharge of oil-based mud was banned in Norway in 1991, so most of the drilling on the Norwegian shelf today uses water-based drilling fluids. These do, however, contain more chemicals than their predecessors, causing an increase in discharge of chemicals on the Norwegian shelf in recent years (Lønne et al. 1997). According to the Norwegian State Pollution Control Authority, 214 km^2 of sea bottom is contaminated because of drilling discharge in the Valhall field in the North Sea. Some of the chemicals used there are banned today, but the figure gives a rough idea of the extent of the problem.

Another source of pollution is "produced" water, which accompanies oil and gas when they are brought to the surface. The amount of produced water increases with the age of the well, and may, at the end of a well's life, constitute 98% of the volume pumped from the well (Svardal 1998). Although some cleaning is done to reduce oil content to under 40 ppm., the water still contains oil when it is discharged to the sea as well as a number of other chemicals. Produced water contains alkylphenols, which, according to the Norwegian Institute of Marine Research (Svardal 2000), causes a decrease in estrogen levels and reduced egg production in cod. Among other sources of pollution are leaks in risers, processing facilities and export tubes, careless handling of chemicals on the platforms (paints, solvents, cleaning chemicals), exhaust from machines/turbines, release of volatile organic compounds when loading, "untidy" contractors flushing the pipe systems (some routinely - though illegaly - dump cleaning fluids directly in the sea), releases of hydraulic fluids, dumping of metal sand from corrosion repairs, and so on.

While regular discharges of oil and associated chemicals probably have the most serious environmental effects over time, acute oil spills may have more devastating effects on a local scale. In the 1997 AMAP report, a big oil spill is ranked as one of the biggest threats to the arctic environment. Two studies carried out for the Norwegian Government conclude that the highest probability of large oil spills in the Barents Sea are related to shipping activities to and from petroleum installations and leakages from underwater pipelines. The probability of blow-outs is considerably lower (Scandpower 2003 and Veritas 2003). According to the Norwegian State Pollution Control Authority, oil rescue operations will have very limited effect after an oil spill, hardly any effect in rough weather, and none whatsoever if an oil spill occurs in water with ice. Furthermore, chemicals added to dissolve the oil loose much of their effect at low temperatures.

Therefore the amount of chemicals necessary may be so large that the cleaning operation in itself will be a heavy load on the environment.

Microbial breakdown of oil spills depend on the availability of nitrogen and phosphorus in the water to accompany the breakdown of carbon. This means that microbial breakdown will proceed very slowly in summer - when available nutrients are few - and be most efficient in winter (Sakshaug et al. 1992). Winter however adds the problem of ice. Oil caught in pockets under the ice, or frozen in, may last throughout winter with hardly any microbial breakdown - and may melt out of the ice in spring, far away from the source of the spill.

A problem that calls for particular attention is the possible attraction of ship transport and search and production installations to polynyas. These ice-free areas are vital for a large number of overwintering animals of several groups, while at the same time offering improved conditions for activities connected to oil and gas extraction. An oil spill in the sea ice or near the ice edge may prove devastating to the local ice fauna and the vital primary productivity taking place along the ice edge in spring.

Eggs and larvae of marine organisms are particularly sensitive to oil spills because of the highly toxic compounds released during the oxidation of oil. This oxidation is light-dependent, and experiments have shown that cod egg survival dropped from 85% to 0% when light was added to seawater with a surface oil layer (Sakshaug et al. 1992). Adult fish are usually not much affected. Models estimating ocean currents and lethal effects on fish egg and larvae shows that a large oil spill in the Barents Sea in the worst case may kill as much as 20% of a year class of cod and 8% of yearclasses of herring and capelin (SINTEF 2003). Effects of oil spills or other discharges from petroleum activity in the Arctic on plankton and benthos, such as coral reefs, have not been the subject to major research efforts. Negative effects are likely to be extensive as these organisms live from filtering the water and easily take up toxic substances occurring in the water masses.

Effects of oil on seabirds are well known. Apart from the toxic effects, seabirds will perish from cooling when the oil destroys the insulating effect of their plumage. Oil spills can potentially kill off a large proportion of a seabird population at any time of the year. In late summer and autumn, moulting flocks are sensitive; in winter darkness, feeding flocks in open sea are vulnerable; and in spring and summer, bird cliffs and coastlines are the worst possible locations for an oil spill or oil pollution.

Flushing of the tanks by a passing oil tanker killed thousands of birds in Skagerrak (southern Norway) in the winter of 1981, 45,000 of which were picked up along the coast. A very minor spill (maybe less than 50 x 50 meters) of the same type caused the death of 10-20,000 seabirds (mainly Brünnich's guillemots) wintering in Varangerfjord in 1979 (Isaksen et al. 1998).

In 1989 the grounding of Exxon Valdez in Prince William Sound killed somewhere between 100,000 and 500,000 seabirds (Isaksen et al. 1998), and between 100,000 and 200,000 birds were probably killed as a result of the sinking of the Prestige outside the coast of Spain in November 2002 (SEO 2003). After the Exxon Valdez oil spill, negative effects on sea mammals have also been well documented. Exposure to fresh oilspills may lead to extensive damage of bone marrow, liver, kidneys and the central nervous system. Seals, otters and polar bears are regarded as more vulnerable to oil spills than whales (Brude et. al 2003).

Shipping

Many factors will contribute to a significant increase in shipping activities in the Barents Sea in the near future. The transport of petroleum is growing as petroleum activities in the Barents region develop, and because transport of products from existing inshore fields is shifting from pipelines to ships. Russia is also considering importing nuclear waste from Europe, as well as to facilitate transport from Europe to Japan via the Northern Sea Route. In both cases, the radioactive material will be shipped along the Norwegian and Murman coasts. The coastline in this region is among the most hazardous in the world, with rough weather and innumerable islands, skerries and rocky shallows.

As most offshore oilreserves are found in areas of shallow water, oil produced from these fields will be transported in smaller tankers, 40-60,000 DWT, to deep-water harbours with oil terminals. From the terminals, oil will be shipped to the markets in tankers of 100,000 DWT and above. In addition to the oil produced in the region, oil from further east will increasingly be transported to oil terminals along the Barents Sea. 2002 and 2003 saw a marked increase in oil being transported by railway to terminals in the White Sea. Both the railway system, several smaller oil terminals and the systems of canal boats are being upgraded in order to transport larger volumes of oil. The oil is normally reloaded from smaller tankers of about 15-20,000 tons to large tankers in the Kola fjord. In the Kola fjord there are two reloading terminals receiving oil from ports in the White Sea and the Pechora Sea. Both terminals handle 100,000 ton vessels, and a third terminal is due to start operations in 2004. Oil also comes to Murmansk from western Siberia. Oil is reloaded from ice-breaking vessels coming from the Kara Sea port of Dikson (Frantzen and Bambulyak 2003). Four of Russia's major oil companies are also planning the construction of a pipeline from Siberia to the Kola Peninsula with a capacity of 2.5 million barrels a day. According to current plans the pipeline should be transporting oil by 2007. Main markets for this oil are expected to be Europe and the US. The amount of oil exported from northwest Russia and shipped through the Barents Sea may increase from approximately 4.5 million tons in 2005 to as much as 15 million tons in 2010 (Frantzen and Bambulyak 2003).

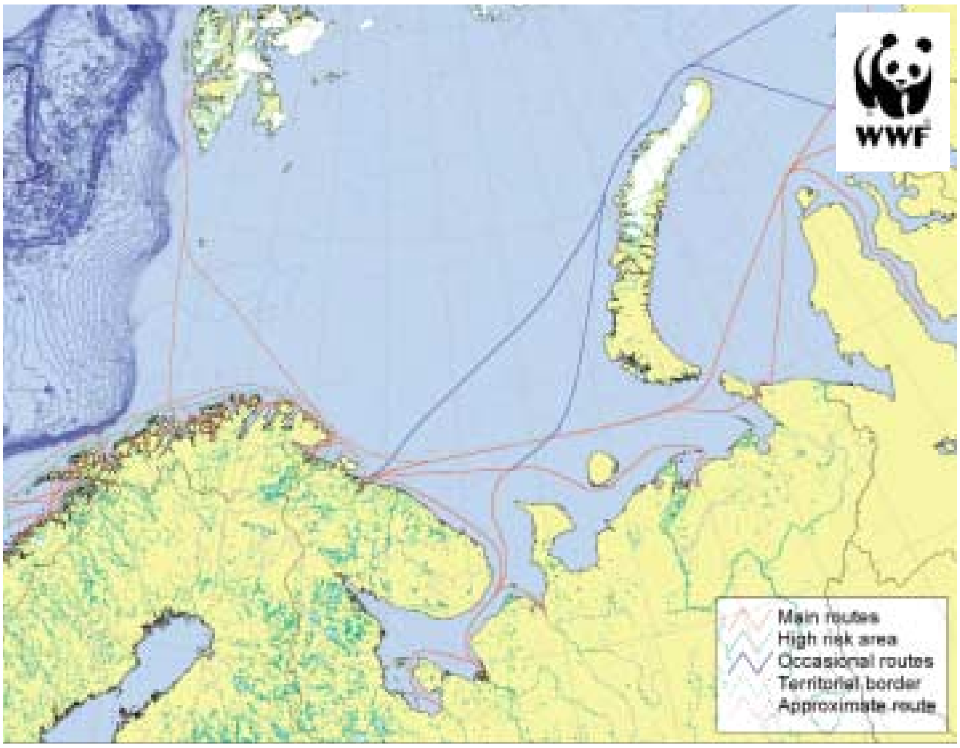


Figure 3.6:
Shipping may lead to oil spills through accidental or routine releases, or in case of accidents. Scenarios, including oil transport from the large Barents Sea deposits and transport of nuclear waste along the Northern Sea Route, make shipping a very significant threat to biodiversity in the European Arctic. Shipping routes traditionally follow the easiest path in winter including polynyas and shoreleads of very high importance to many species. The map shows the most important ship routes, but has the most detail for Norway due to availability of information. High risk areas are compiled from Norwegian sources, and only relate to Norwegian coastal areas.

(References, see pp.148-151).

There is also a growing interest in developing the "Northern Sea Route" as a transport route between the Atlantic and the Pacific (see for example Ragner, C.L 2000). Furthermore, there are several initiatives to increase shipping in northern Norway and northwest Russia under the "Northern Maritime Corridor" project, an initiative funded under the European INTERREG-programme.

Shipping may lead to oil discharges to the marine environment through operational discharges, illegal dumping or accidents. Increasing transport of petroleum products and the possibility of shipboard transport of nuclear material through the area make shipping one of the major threats to biodiversity in the European Arctic. Shipping routes traditionally follow the easiest path in winter, including polynyas and shoreleads of very high importance to many species. The map shows the most important ship routes, but has the most detail for Norway due to availability of information. High risk areas are compiled from Norwegian sources and only relate to Norwegian coastal areas.

While shipping has the potential to be a comparatively environmentally friendly transportation mode, it also involves some serious environmental risks. An accident with a ship containing oil, radioactive waste or other hazardous cargo could have devastating effects on both biodiversity and industries in the Barents region. The Prestige spill is the latest reminder of the potential environmental, economic and social impacts of an oil spill.

While major accidental oil spills, like the Prestige and Erika, generate a lot of attention, it is the operational discharges that are the main source of oil pollution from shipping to the oceans. It is estimated that normal shipping operations are responsible for over 70% of the oil entering the sea from marine transportation. As the oil is often spread over a large number of locations, the effects of operational discharges may appear less dramatic than the catastrophic local effects of accidental oil spills. They do, however, give rise to a number of chronic pollution problems along densely trafficked routes and in areas such as docks and harbours. It is well known that even very small amounts of oil on the sea surface can have dramatic consequences on seabirds.

In addition to accidental and operational discharges, illegal dumping of oil to the sea is unfortunately a wide-spread practise in shipping. According to statistics from SFT (the Norwegian Pollution Control Authority) illegal discharges amount to 10% of the registered oil discharges from shipping in the northern Norwegian waters. This figure is likely to be an underestimate (Hansen, V.J. 2003).

The introduction of alien species via ships' ballast water is a major, and still unsolved, environmental problem. With increased shipping, in particular exports of high-density cargoes such as oil and LNG, the volume of ballast water discharged into the Barents Sea will increase considerably. The volume of ballast water discharged will equate approximately 30% of the volume of exported oil. With the current markets for petroleum products, 70-80% of the ballast water is likely to originate from European ports and 20-30% from US ports. European ports lie within the same bio-geographical zone as the Barents Sea, which may reduce the risk of species introduction. However, many European ports are already infested with alien species, so there is a risk of secondary introduction to Barents Sea via ballast water. Risk assessments performed by Veritas (2003) indicate that 15% of the expected ballast water discharges can be classified as "high-risk" and 45% as "medium risk".

While the probability of an alien species surviving and reproducing in the Barents Sea may be low, the potential consequences on biodiversity and industries may be enormous (Veritas 2003). An alien species, i.e. a virus or parasite, could have wide-scale ecological and economic effects – something that we have already seen in many places around the world. Furthermore, the successful establishment of two alien crab species, the red king crab (*Paralithodes camtschaticus*) and the snow crab (*Chionoecetes opilio*), could indicate that the Barents Sea is receptive to new species.

Pollution

Hydrocarbons

Today, only limited amounts of petroleum are extracted in the ecoregion, and the main input of petroleum hydrocarbons is from river transport. Although data are sparse on concentrations in arctic rivers, Russian measurements indicate a 4-20 times higher concentration of petroleum hydrocarbons in the mouth of the Ob than in the Rhine or the Elbe (Hansen et al. 1996). It has been estimated that of the 200,000 tons of petroleum hydrocarbons entering the region every year, 60-70% is discharged into the Kara Sea from its enormous catchment area. Local pollution is however also clearly noticeable in the Pechora Sea, and it is increasing steadily (Hansen et al. 1996). Apart from river runoff, hydrocarbons also enter the ecoregion via the Atlantic current (from production areas in the southwest), and from ship spills as well as drilling activities. Petroleum hydrocarbons (PHC) are a complex mixture of organic compounds with very different effects on marine life - from alcanes, some of which are produced by marine organisms themselves, to very toxic and carcinogenic aromatic and heterocyclic compounds. The highest concentrations of PHCs were recorded in the southeastern Barents Sea in 1978, with levels up to 52 mg/l - or ten times the allowed limit (Hansen et al. 1996). Today, the highest levels are found southeast of Kolguev Island and to the east of Dolgiy Island outside Pechora Bay (N. Denisenko pers. comm.), as well as in Kola Bay, where concentrations between 8 and 39 mg/l have been found near Murmansk, Severomorsk and Poliarniy (Ilin et al. 1997). Aromatic hydrocarbons in bottom sediments are generally found in the highest concentrations in the western Barents Sea, but the highest concentrations have been found near oil fields such as Prirazlomnoye and Kolguevskoye. The risk of pollution by PHCs will increase dramatically as a larger portion of Russia's oil exports will be shipped through the Barents Sea and the planned petroleum developments are carried out.

Heavy metals

Heavy metals like cadmium, mercury and lead are toxic in very low concentrations, as are metals such as nickel, copper, zink and vanadium. They reach the ecoregion by air from the large industrial centres on the Kola Peninsula, Eastern Siberia and elsewhere. They are transported from inland sources by rivers zand atmospheric pollution deposited in snow, and they are carried by ocean currents.

Even the most remote areas of the ecoregion are affected, often more than the populated areas. According to Savinova et al. (1995), heavy metal concentrations in muscles of seabirds can be 200 times higher in Svalbard and Franz Josef land than in Northern Norway. There are large variations also between areas at the same latitudes; the mercury content in muscle and liver of seabirds from the western coast of Svalbard has been measured at 3.4 mg/kg, while on Franz Josef land it is only 0.5 mg/kg (Savinova et al. 1995). Enhanced deposition of bio-available mercury occurs at high latitudes, and the Arctic may play a previously unrecognised role as an important sink in the global mercury cycle (AMAP 2002). There is strong evidence that current mercury exposures pose a health risk to people and animals in the arctic, including neurobehavioral effects. AMAP (2002) also concludes that current cadmium levels in some seabirds could cause kidney damage and that cadmium accumulates in birds and mammals. However, not enough is known about trends in cadmium concentrations and effects of cadmium exposure in the ecoregion. Dramatic reductions in the deposition of atmospheric lead have occurred in the northeast Atlantic due to the phasing out of leaded gasoline (AMAP 2002).

Persistant Organic Pollutants

The combined effect of ocean currents, atmospheric transport and river drainage results in the Barents Sea being a "sink" not only for heavy metals, but also for globally produced persistant organic pollutants. Concentrations vary widely within the ecoregion, however, in water, sediments, and biota. This results in part from the effect of local pollution relative to long-range pollution, exemplified by the tenfold levels of polyaromatic hydrocarbons in sediments around Svalbard settlements relative to levels common in the Barents Sea region. Different contaminants are also found in different levels at the same locality. While the highest concentrations of DDT in Barents Sea water are found off the Murmansk coast on the Kola Peninsula, the levels of HCHs in the same area are only half of those found in water from the Canadian Arctic (Hansen et al. 1996). Even more remarkable is the fact that, when moving a bit up the food chain, glaucous gull liver samples from Franz Josephs Land contained seven times as much PCB as samples from Svalbard (AR 2002). Very different levels of contamination over extremely short distances have been found on Bjørnøya, where DDE concentrations in arctic char (*Salvelinus alpinus*) from lake Øyangen averaged 3.4 ng/g wet weight, while concentrations in char from Lake Ellasjøen averaged 57.7 ng/g (Skotvold et al. 1997). The two lakes are 8 km apart. Ellasjøen has been studied regarding the linkages between the marine and limnic ecosystems through the deposition of seabird guano. The seabirds are affected while feeding at contaminated wintering sites. The results so far indicate that guano may be an important transport medium for POPs to lake Ellasjøen (Evenset et al 2002).

The present POP accumulation in the blubber of marine mammals is probably not high enough to cause detrimental effects to the animals under normal circumstances, but when fat from the blubber is metabolised in periods of reduced food intake, the compounds may be redistributed within the body and pose a health risk to the animals. POP levels generally increase from bottom to top in the food chains. While studies have shown relatively low levels of POPs in both sediments and plankton from the Barents Sea, very high levels are found in some of the local top predators. This is due to the fact that most POPs are fat soluble, and therefore accumulate in the animal's lipid stores or blubber insulation - which is consumed by the next level in the chain. The effect is most pronounced in marine mammals, but diet-related differences in POP levels between species have been found even among ice amphipods (Borgå 2001), and are clearly demonstrated by seabirds: Benthic feeding birds like eiders have low concentrations of PCB (0.15 mg/kg liver tissue), fish-eating puffins are intermediate (0.70 mg/kg), while egg and chick-eating glaucous gulls have the highest concentrations (8.90 mg/kg) (Hansen et al. 1990). Fat-soluble POPs are also transferred from mother to lactating young with the milk.

The exact physiological effects of POPs on arctic organisms are gradually being teased out. The effects on reproduction are numerous (AMAP 2002): In birds they include eggshell thinning, decreased egg production, increased mortality of chicks and changing in parental behaviour. In mammals, they alter hormone levels, reduce sperm production and decrease the survival of offspring. In fish they decrease the survival of eggs and larvae. Furthermore, POPs are known to weaken several parts of the immune system, to cause brain damage and to decrease bone density.

Studies have shown that polar bears on Svalbard with high levels of PCBs produce less immunoglobulins when exposed to infections, indicating a weakened immune response (Vongraven 2000). A relatively high level of infectious diseases among polar bears (for instance brucellosis) means that PCB-induced immune deficiencies can affect survival significantly. Svalbard bears have 3-6 times higher levels of PCBs than Alaskan and Canadian bears, and new data show that certain PCB metabolites (hydroxy-PCBs) occur in levels 9-12 times higher than the highest level found in any other animal (Vongraven 2000). The problem of female hermaphroditism in polar bears, suggesting that normal hormone patterns are being disrupted, has also tentatively been ascribed to PCB poisoning. In the glaucous gull population on Bjørnøya, PCBs have affected nesting behaviour and adult survival (AMAP 2002). Because POP levels in both polar bears and glaucous gulls are far higher in the Barents Sea ecoregion (Svalbard) than in any other part of the Arctic, it is reasonable to assume that the ecoregion receives relatively high levels of long-range pollutants. If not noticeably reduced, POP emissions may have (and probably already do have) serious consequenses even in species living in an otherwise unaffected environment.

Data are limited regarding the contaminant status in biota of the Russian Barents Sea, but there is cause for concern. A mass mortality of white whales in the White Sea in the early 1990s was attributed to "pollution" (Mishin 1998; cited in Hønneland et al. 1999). See Lønne et al. (1997) for a thorough description of contaminant status in the Barents Sea, and AMAP (1997) and AMAP (2002) for the situation in the Arctic in general.

International agreements have had an effect on arctic contamination, as exemplified by the 30-40 fold decline in DDT levels in the liver and muscle of herring gulls from the Barents Sea during the 1980s. Unfortunately, agreements have been limited with respect to the wider range of contaminants, and the decrease in DDT levels has been accompanied by an increase in PCB levels. New substances are also appearing on the scene, such as insecticides originating from other parts of the world, but ending up in the Barents Sea "sink". For example, toxaphene residues have been found in large concentrations in harp seals east of Svalbard (100 ng/g lipid). This concentration is 20 times higher than that found west of Svalbard (and four times higher than in Canadian studies; Wolkers & Burkow 1999).

Since 2001, several countries have signed the Stockholm Convention, a global treaty that prohibits the use of 12 POPs. It is hoped that this will ideally result in lower levels of these toxics in the Barents Sea in the long term. However, several POPs, including brominated flame retardants (PBDEs) and the extremely persistant compound PFOS, are not regulated by global or regional conventions. These toxics are present at elevated levels in some arctic animals, and little is known about their potential effects on the biodiversity (AMAP 2002).

THE WORLD'S MOST POWERFUL NUCLEAR BLAST

The world's most powerful hydrogen bomb was detonated on the 30th of October 1961, in the so-called "Northern Testing Ground" on Novaya Zemlya. The bomb had an explosive force of 58 megatons, or almost 6,000 times more powerful than the Hiroshima bomb. The bomb was dropped by an aircraft and detonated 365 meters above ground. The shock wave produced by the bomb was so powerful that it went three times around the earth. The mushroom cloud extended almost 60 kilometres into the atmosphere. Resulting downfall was measured over the entire northern hemisphere. The flash of light could be observed on the island of Hopen southeast of Svalbard, in Sør-Varanger in the Norwegian county of Finnmark, and at the Inari Lake in Finnish Lappland (Nilsen & Bøhmer 1994).

Radioactive contamination

Radioactive materials can pose a major threat to people, wildlife and ecosystems. The effects of radiation vary significantly among and between species, but common effects include mortality, reduced reproduction and genetic damage. Due to relatively limited research efforts, however, we have little detailed knowledge about impacts on ecosystem health (AMAP 2002).

The major sources of radioactive contamination in the ecoregion are global fallout from atmospheric nuclear weapon testing, discharges from European reprocessing plants and fallout from the 1986 accident at the Chernobyl nuclear power plant (Hansen et al. 1996, AMAP 2002). However, radioactive contamination poses a very significant potential threat to the ecoregion: the Kola Peninsula has the world's highest density of nuclear reactors, in the form of decommissioned nuclear submarines, older nuclear power plants and nuclear weapons, as well as significant quantities of fresh and spent nuclear fuel and large and improperly stored stockpiles of radioactive waste. (AMAP 2002, Hønneland 2003, Nilsen & Bøhmer 1994).

Nuclear weapons testing

Novaja Zemlya was the arena of Soviet nuclear testing from 1954 to 1990, and was exposed to 87 atmospheric, 42 underground and three underwater nuclear explosions during that period (Nilsen & Bøhmer 1994). Fallout from atmospheric tests tends to be spread globally, as on average only 12 % settles in the immediate surroundings (Wilson et al. 1997). The underground tests seem to have had negligible impact on soil, air and water, while the underwater tests (the first in Chernaya Bay in 1955) are assumed to have had only short-term impact on the surrounding waters, but longer-term impacts on sediments. Radioactive activity is now documented on four sites at Novaja Zemlya: Chernaya Bay, Sukhoy Nos Penninsula, Bashmachnaya Inlet and the Matochinkin Shar Strait (AMAP 2002). In Chernaya Bay, concentrations of plutonium in the lower sediments have been measured at approximately 5,500 Bq/kg. This is the highest level of plutonium measured in the Barents Sea. (Hansen et al. 1996).

Nuclear weapons have also been used for civlian purposes. On the Kola Peninsula, three nuclear bombs were detonated in the Kulpor mine in the Khibini Mountains, 15 kilometres east of the town of Kirovsk (Nilsen & Bøhmer 1994, AMAP 1997). The first bomb was detonated in 1972, and two others in 1984. Elevated levels of certain isotopes have been registered in a river flowing just below the mine, emptying into the Imandra Lake. The attempts to use nuclear bombs to increase the extraction of ore were not considered successful, and the mine is now closed. In the county of Arkhangelsk, three bombs were detonated in connection with seismic gauging of the crust of the earth between 1971 and 1988. In 1981, a nuclear bomb was detonated in the Nenets Autonomous Region. The aim of the explosion was to put an end to a blowout from a gas well at the Kumzhinskoye field, but it was not successful (Nilsen & Bøhmer 1994).

MEASURES OF RADIOACTIVITY

When given a certain amount of radioactive material, it is customary to refer to quantity based on its activity rather than its mass. The activity is the number of disintegrations or transformations the quantity of material undergoes in a given period of time.

Curie (Ci): 3.7x1010 disintegrations per second (dps)

Becquerel (Bq): 1 dps. MBq = 106 Bq (mega-)
GBq = 109 Bq (giga-)
TBq = 1012 Bq (tera-)
PBq = 1015 Bq (peta-)

Radiation units

Radiation is often measured in one of these three units, depending on what is measured and why:

Roentgen: A unit for measuring the amount of gamma or x rays in air, expressed in Coulombs/kg.
Gray: A unit for measuring absorbed energy from radiation.
Sievert: A unit for deriving biological damage from radiation. It relates the absorbed dose in tissue to the effective biological damage of the radiation.

Source: Idaho State University (http://www.physics.isu.edu/radinf/terms.htm)

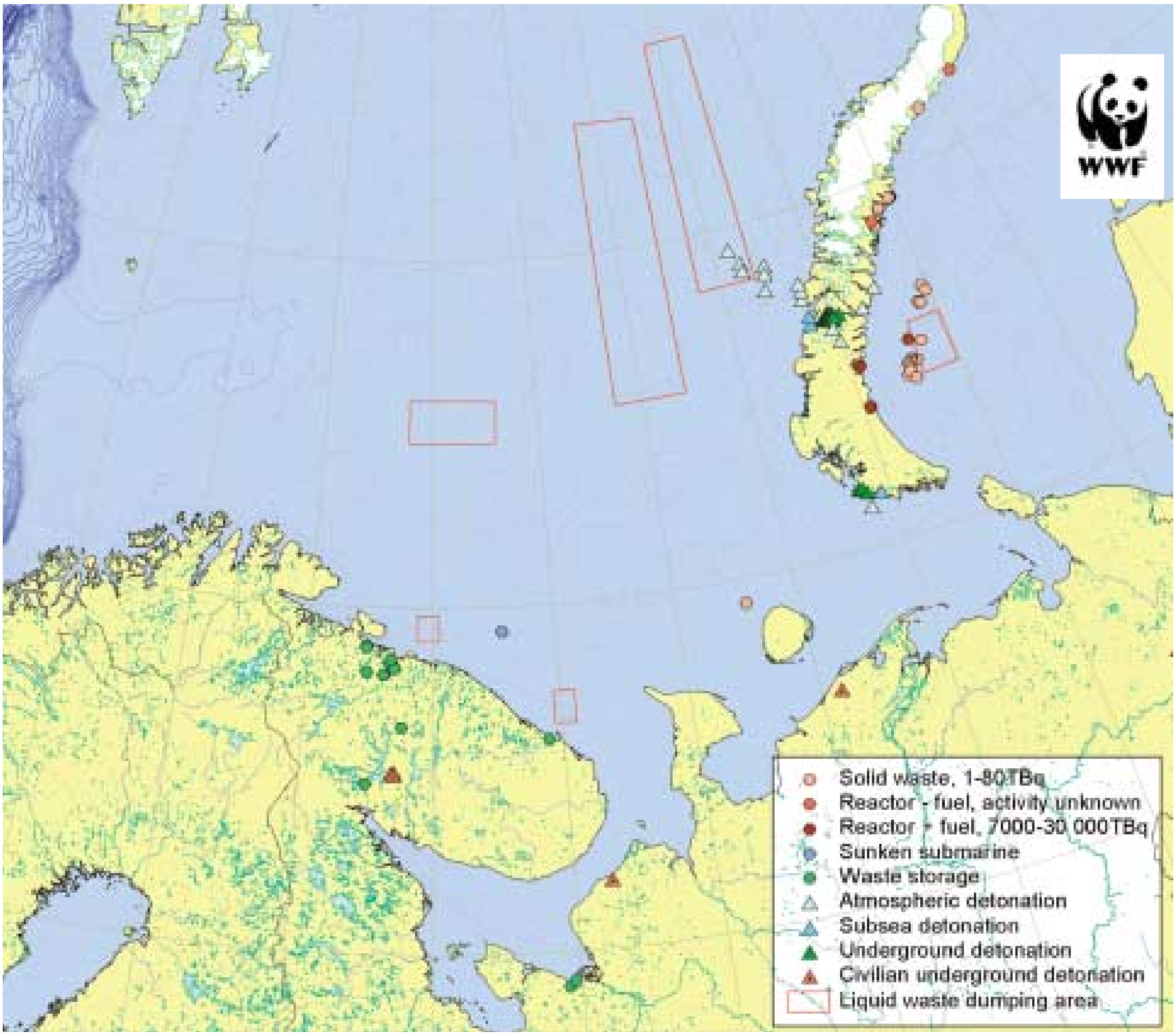


Figure 3.7: Sources of radioactive contamination in the Barents Sea ecoregion: Nuclear detonations, waste dumping and storage facilities

Long-distance sources

The Kara Sea receives riverine input from the enormous catchment areas of the Ob and the Yenisey rivers, including nuclear installations in Mayak (Production Association Mayak), Tomsk (Siberian Chemical Combine; Tomsk 7), and Krasnoyarsk (Zheleznogorsk Chemical Combine; Krasnoyarsk-26). According to data cited by Hansen et al. (1996), a total activity of 4,440 PBq is stored at Majak. In the 1950s, approximately 100 PBq were released in the river system, much of which is still present and may reach the larger rivers. The Russian Hydrometeorological Service indicate that in the period 1961-1989, the amounts of radionucleides transported to the Kara Sea included 650 TBq from the Ob and 450 TBq from the Yenisey (cited in Lønne et al. 1997).

The most important sources of new radioactive material to the Barents Sea have however been the nuclear reprocessing plants at Sellafield (formerly Windscale) and Dounray in the UK, and Cape de la Hague in France. In the late 1960s until the mid-1980s, releases of radiocaesium from Sellafield were 100 times higher than the releases from Dounreay and Cap de La Hague. It is assumed that about 20% of the caesium and 30% of the strontium discharged from the plant is transported to the Barents Sea, with a transit time of four to six years. Discharges from Dounray and Cape de la Hague take even less time to reach arctic waters (Lønne et al. 1997). In the early 1980s, caesium (137Cs) concentrations in the southern Barents Sea were 30 Bq/m3, which was five to six times more than levels recorded a decade earlier. Discharges from Sellafield and Le Hague then decreased significantly, and caesium levels measured in the Kara Sea in 1992 were the lowest since1961 (Hansen et al. 1996). However, in 1994 the discharges of technetium-99 from Sellafield increased markedly, despite heavy protests from the Norwegian government and others. These discharges have resulted in measurable increases in the levels of technetium-99 in biota along the Norwegian coast (Norwegian Radiation Protection Authority 2003a). According to the Norwegian Radiation Protection Authority, reduction of the Sellafield discharges would be a relatively simple affair. In the autumn 2003 the operator of the Sellafield plant (BNFL) announced that it would launch a full-scale trial treatment of liquid radioactive waste that is expected to reduce the plant's radioactive technetium 99 discharges significantly.

While little data exist on radioactive contamination from non-nuclear sources, it is well documented that pumping oil and gas from the continental shelf in the North Sea produces large quantities of water contaminated with naturally occurring radioactive substances. (Marina II 2002, Sintef 2003) This results in releases to the marine environment of naturally occurring radionucleids such as 226 Ra, 228 Ra and 210 Pb, which are concentrated and made available for consumption by biota. According to a recent study funded by the European commission, North Sea oil and gas operations probably contribute more to man-made radioactivity to North European marine waters than the nuclear industry (MARINA II 2002). There is very little knowledge about impacts from such discharges on biodiversity (Norwegian Radiation Protection Authority 2003b).

Local sources

More than 190 000 m3 of liquid low-level nuclear waste from the Russian Northern Fleet and Murmansk Shipping Company were dumped in five defined areas in the Barents Sea between 1960 and 1992 (Sjøblom & Linsley 1995, Nilsen & Bøhmer 1994). Small amounts have also been dumped beyond these areas, and a major discharge of liquid waste from the ice-breaker Lenin took place in the Kara Sea in 1976 (Nilsen & Bøhmer 1994).

Low- and medium-level solid waste (mostly objects contaminated during ship repair) has mainly been dumped in the Kara Sea. According to the Yablokov report (1993; referred to in Lønne et al. 1997), 6,508 containers have been dumped there (4,641 of these by the Northern Fleet). The Murmansk Shipping Company has records of 11,090 containers dumped "in Arctic waters", 9,223 of these onboard sunken ships. The ship Nikel loaded with solid waste (.,5 TBq) was sunk west of Kolgujev Island in the Barents Sea (Nilsen & Bøhmer 1994). Russia stopped maritime dumping of nuclear waste in 1993, and has since then stored exhausted nuclear fuel cores and other waste onshore (Hønneland 2003).

Nowhere else on earth is there such a concentration of naval nuclear reactors as on the Kola Peninsula. The Russian Northern Fleet contains a large number of nuclear powered vessels. As of November 2001, a total of 109 nuclear submarines had been taken out of operation. Of these, 41 have been dismantled and at least 50 contain spent nuclear fuel (AMAP 2002). Some of these submarines are in a poor condition, and certainly Norway and other governments regard them as both a contamination and a security risk (Norwegian Ministry of Foreign Affairs 2001). Since 1988 the Northern Fleet has gradually decreased the number of nuclear vessels it operates. Murmansk Shipping Company holds a fleet of seven nuclear driven polar icebreakers and one container ship in the area, most of which are reaching the end of their service life (Hønneland 2003). Like the nuclear powered submarines, the icebreakers have to have spent nuclear fuel removed and reactors refuelled at regular intervals.

The process of dismantling the nuclear submarines generates significant amounts of spent nuclear fuel and other solid and liquid radioactive waste. This increasing amount of radioactive material is to a large extent improperly stored and handled. The Murmansk Shipping Company has stored spent nuclear fuel on board three of its so-called service ships, Lepse, Imandra and Lotta (Hønneland 2003). By 1993 all these ships were filled to capacity. Lepse holds 634 partly damaged spent nuclear fuel elements, and the entire ship is now considered nuclear waste. According to Hønneland (2003) local storing facilities for nuclear waste are long since filled to capacity and large amounts of radioactive waste are stored under unsatisfactory conditions. For instance, 32 containers with waste from 200-220 exhausted nuclear fuel cores from Soviet submarines have been stored outdoors in an open field at Zapadnaja Litsa since 1962. Nilsen (1997) reports that most of these containers are stored in three concrete tanks in poor condition. The tanks are now full, and new containers have been stored on the ground outside. The spent nuclear fuel that is supposed to be reprocessed is leaving the region very slowly because Russia only has two special train sets for spent nuclear fuel transportation and because the reprocessing facility in Mayak in Siberia has limited capacity (Hønneland 2003).

The 17 nuclear reactors that have been dumped along the eastern shore of Novaja Zemlya (in the Kara Sea) at depths between 13 and 135 meters also arouse significant concern. Seven of these reactors are particularly dangerous because spent fuel could not be removed before they were dumped (Hønneland et al. 1999, Nilsen & Bøhmer 1994). One submarine, the K-27, with its two liquid-metal cooled reactors intact with fuel, was dumped in the Stepovogo bay after an accident (Nilsen & Bøhmer 1994, Strand et. al 1997). Four sections of other accident-damaged submarines (the K-11, K-3 Leninski Komsomol, K-19 and one unknown) with eight reactors, three of which still contain nuclear fuel, were dumped in Abrosimova Bay between 1964-66. Four reactors - three damaged reactors from the icebreaker Lenin and a reactor shielding assembly with fuel - were dumped in the Syvolky bay in 1967, and a reactor with fuel from the submarine K-140 was dumped in the Novaya Zemlya Trough in 1972 (Strand et. al 1997). The last two reactors (without fuel) were dumped in Techniya Bay in 1988 (Nilsen & Bøhmer 1994). Lønne et al. (1997) suggest that each of the reactors with fuel may still contain ca 1 PBq, while Nilsen & Bøhmer (1994) refer to Russian estimations of 85 PBq as a total for all of them at the time of dumping. While there is no doubt that large amounts of radioactive waste have been dumped in the Barents Sea, more recent studies indicate that the amounts probably have been somewhat overestimated in the mentioned reports (AMAP 2002).

So far, the dumping of radioactive material has only resulted in local radioactive contamination around the dumping sites (AMAP 2002). The major risks of leakages to the marine environment are longer term, after the containment material corrodes. Pfirman et al. (1995) have also pointed out that some of the Novaja Zemlya dumping sites are in fjords with calving glacier fronts, a fact that could lead to disruption of the dumping sites.

The wreck of the nuclear submarine "Komsomolets" which sank to a depth of 1,658 meters west of Bjørnøya in April 1989 also represents a potential source of contamination, but according to Hansen et al. (1996), estimates indicate that released radionucleides will mix slowly with the huge water masses of the deeper part of the Norwegian Sea and not pose a significant threat.

The submarine "Kursk" which sank to 108 meters depth east of Murmansk did not, unlike "Komsomolets", contain nuclear warheads, and the two reactors on board were closed down during the accident in August 2000. In 2001, Kursk was successfully raised and transported to a dock near Murmansk (AMAP 2002). On August 30th 2003, the nuclear submarine K-159 sank during transport from the Gremikha base to Poljarnyj shipyard where it was due to be decommissioned. It lies at a depth of approximately 240 m just outside the Kola fjord and contains two VMA-type reactors and approximately 800 kilograms of spent nuclear fuel. So far, no radioactivity has been measured near the wreck and Russian authorities are investigating different technical solutions for lifting the K-159 from the sea bottom in order to safely decommission the submarine.

132 lighthouses powered by radionucleid thermoelectric generators are located on the Kola Peninsula and Novaja Zemlya. The 2.6 kg of Sr90 has to be changed after about 10 years of use, and the total radioactivity in these lighthouses has been estimated to be between 200 and 1,300 PBq (Nilsen et al. 1994, cited by Lønne et al. 1997).

The Kola nuclear power plant situated in Polyarnye Zori has four 400 megawatt pressurized water reactors. The two oldest reactors were finished in 1973 and 1974 and the remaining two in 1981 and 1984. The International Atomic Energy Agency has calculated the probability of a serious meltdown of the two oldest reactors to be 25% over a period of 23 years (Hønneland 2003).

Both reprocessed and spent nuclear fuel for reprocessing are sometimes transported by ships to and from reprocessing plants. There are suggestions that such shipments between EU, and Japan in the future may use the Northern Sea Route. According to AMAP (2002) there are also ongoing discussions of shipping spent fuel from Europe to Russia via Murmansk for processing in Russia.

In general, the levels of radioactive contamination both in sediments and in biota in the Barents and Kara Seas are much lower than in seas farther south in Europe (Baltic Sea: 1/16; Irish Sea: 1/12; Kattegat 1/6. Institute of Marine Research, Norway). Measurements of radioactivity in cod and haddock during and after the Soviet atmospheric nuclear weapon tests indicate that radioactive contamination in marine fish decreased rapidly after 1963, when the highest values were reported (80 Bq/kg wet weight). In 1968, values were below 10 Bq/kg, and more recent measurements show values well below this (Hansen et al. 1996 and AMAP 2002). Currently only radionucleides from discharges at European reprocessing facilities show an increasing trend in the marine environment of the Barents Sea.

The threat of radioactive contamination from parts of northwest Russia has led to the establishment of several international cooperation agreements. These include the projects under the Norwegian Plan of Action for Nuclear Safety, the Arctic Military Environmental Cooperation (AMEC) between USA, Russia and

Norway, the Nunn-Lugar Cooperative Threat Reduction Program (CTR) and projects under several other existing financial, military and political agreements (Hønneland 2003). Most recently, a Multilateral Nuclear Environmental Program (MNEPR) agreement was signed by nine European countries, two pan-European organisations, and the United States. Its main goal is to provide an organisational and legal structure through which foreign nations can offer Moscow long-term assistance in submarine dismantlement and spent nuclear fuel cleanup in Northwest Russia.

While much attention has been given to the effects of radiation on human health, it is only recently that specific consideration has been given to impacts on ecosystems. Very little is known about the long-term effects on the marine environment of low-dose, chronic exposures of radioactivity (AMAP 2002, Norwegian Radiation Protection Authority 2003b). There is no doubt, however, that effects of radiation may include important impacts on all living organisms and important ecosystem functions and processes. Recent efforts have highlighted the inconsistencies among the management and regulatory approaches for radioactivity and other environmental pollutants (AMAP 2002).

Figure 3.8: Disposal of radioactive waste in the Kara Sea

The Bellona Foundation in 1998 published this overview of potential sources of radioactive contamination in the Russian Northern Fleet (Nilsen 1998):

Place		Amount
Zapadnaya Litsa	Naval Bases	26 operational nuclear submarines One inactive nuclear submarine with nuclear fuel One inactive nuclear submarine 23,260 spent fuel assemblies 2,000 m^3 liquid radioactive waste 6,000 m^3 solid radioactive waste
Vidyayevo (Ura Bay)	Naval bases	4 operational nuclear submarines One reactor of Nurka class 14 inactive nuclear submarines containing nuclear fuel At least 3 m^3 liquid radioactive waste. Solid radioactive waste
Gadzhievo (Skalisti)	Naval bases	Unknown number of nuclear submarines 200 m^3 liquid radioactive waste 2,037 m^3 solid radioactive waste Occasional service ship containing nuclear fuel Occasional service ship with liquid radioactive waste
Saida Bay Severomorsk Gremikha	Storage Facility Naval base Naval base	12 submarine hulls with reactors Three nuclear powered battle cruisers Some operational nuclear submarines 15 inactive nuclear submarines 0 m^3 solid radioactive waste 00 m^3 liquid radioactive waste 5 spent fuel assemblies or cores from submarines with liquid metal cooled reactors
Nerpa	Shipyard	2 submarines in process of being decommissioned Periodical service ships containing spent nuclear fuel Periodical service ships with liquid radioactive waste 200 m^3 solid radioactive waste 170 m^3 liquid radioactive waste
Shkval (Polyarny)	Shipyard	One submarine in for maintenance One service ship with spent nuclear fuel One service ship with liquid radioactive waste 7 inactive nuclear submarines with fuel Storage facility for solid radioactive waste 150 m^3 liquid radioactive waste
Sevmorput	Shipyard	One inactive nuclear submarine with spent nuclear fuel One inactive nuclear submarine Occasional service ship with liquid radioactive waste Storage for solid radioactive waste
Severodvinsk	Shipyards	12,539 m^3 solid radioactive waste 3,000 m^3 liquid radioactive waste 4 nuclear submarines in for maintenance 12 inactive nuclear submarines with nuclear fuel 4 reactor compartments from decommissioned nuclear submarines
Russian Arctic Cost	Lighthouses	132 lighthouses with RTG, Strontium-90 batteries
Kara Sea	Dumped nuclear waste	10 reactors without fuel 6 reactors with spent fuel 17 vessels with solid radioactive waste 6,508 containers with radioactive waste

Fish Farming

As the wild capture fisheries in the Barents Sea are facing serious challenges, aqauculture, the farming of marine organisms, is for many emerging as an attractive alternative. More stable and predictable production volumes as well as large markets in the EU and the US are among the advantages seen from a business perspective. The Russian market for seafood is growing, and both the Norwegian and Russian government advocate further development of aquaculture in the ecoregion. There is already a large salmon and trout industry in northern Norway. In northwest Russia there is some production of salmon, rainbow trout and mussels but the industry has just started to develop.

The aquaculture industry is expected to grow on both the Norwegian and Russian sides of the Barents Sea. Governments and industry in both countries show great interest in increasing the production of farmed fish and molluscs. Species such as cod, halibut, sea-urchin, king crab and saithe are increasingly becoming popular for aquaculture in addition to trout and salmon. Due to icing and cold waters, most of the Russian part of the Barents Sea is less suitable for fish-farming than the warmer Norwegian coast. In Russia, large scale salmon farming is possible on the western part of the kola peninsula, while the production of farmed charr, rainbow trout and mussels have a larger potential also in the White Sea (Akvaplan-Niva 1994).

If properly regulated, aquaculture can provide good opportunities for local development without large impacts on the ecosystem. Poorly managed and regulated aquaculture, however, can have severe negative impacts through the release of excessive nutrients and chemicals, as well as escapes of farmed fish and the risk of disease transfer. The expansion of the aquaculture industry gives rise to two overriding concerns: The intrusion of fish farms into vulnerable marine and coastal areas, and the overall sustainability of an industry that depends on large catches of wild fish to feed farmed fish.

Impacts of aquaculture on the arctic environment

In the Barents Sea there are different types of aquaculture. Mussel farming is conducted in sea, with natural seeding, and apart from limited local conflicts with seabirds, this production has no significant environmental impact on the marine ecosystem. Fish farming in closed tanks on shore is used for hatcheries to salmon and trout, and also for growing charr, trout and cod. This activity is possible in arctic areas, even at low temperatures, if clean water and energy for heating is available. However, the extraction of freshwater from rivers can have severe impact on the river habitat in dry periods and the wastewater can contain harmful concentrations of nutrients, chemicals and be a potensial source for infection of, among others, the salmon parasite *Gyrodactylus salaris*.

Aquaculture facility “Villa Leppefisk” in northern Norway. Photo: Maren Esmark

However, the most common fish farming production in the Barents Sea is that of open sea cage farming of Atlantic salmon *(Salmo salar)* and rainbow trout (*Oncorhynchus mykiss*). This type of farming can potentially impact the marine environment through discharges of nutrients and chemicals. Improved farming techniques the last ten years has severely cut the amount of nutrients released from a farm and good monitoring systems address potential impacts on bottom habitats. However, sufficient regulations for controlling cumulative effects of several farms in an area, is still missing. The use of antibiotics has been significantly reduced, and does not today represent any major threat to the environment. Concern has been raised on the discharge of copper from fish farms. Copper is used as an anti-fouling agent on the nets, and as the industry grows in Norway, so might the total discharge of copper, if restrictions are not in place.

The Norwegian Government has declared escapes and sealice as the most significant and urgent environmental problems related to fish farming (Stortingsmeld. 12, 2001-02). The total number of escapes in Norway in 2002 was 630,000 fish, both salmon and trout. Ecological impacts of escaped fish are mediated through ecological competition, genetic "pollution" and the spread of parasites and infectious diseases

Cultured salmon in nature, and results in a mixture of fish from different populations to an extent never seen before. Cultured salmon diverge from their wild origin due to environmental and evolutionary processes, because of brood stock selection, natural selection to artificial conditions and phenotypic plasticity (Flemming et al. 1996).

Since 1986, the Norwegian Directorate of Nature Management has monitored the amount of escaped fish in rivers and fjords. Historically, the amount has been low in in the counties of Troms and Finnmark. However, the numbers for 2002 shows that at Kinn, in Troms/Nordland, there was an alarmingly 48 per cent of farmed salmon in the sea fishery. In the Altavassdraget (Alta River) there was 20 percent escaped fish in 2002 (DN 2003).

Sealice is a marine parasite, naturally occurring on salmonids. More than 10 lice can be lethal to migrating smolts. The millions of farmed fish that stay in the fjords all year round now serve as a host for the sea lice and can potentially create large concentrations of the parasite (Heuch & Moe, 2001) A study from 2002 shows that infections of sea lice are significant, and are likely to affect local stocks of seatrout and Arctic charr (Bjørn et al. 2002).

Indirect impacts on wild fish stocks

Because most species used in marine fish farming are carnivores, fish farming causes a high demand for fatty and protein-rich fish- feed. Most fish species used for fish feed are important for the marine ecosystem, as they are prey for fish, birds and mammals. In Norwegian fish farms, 1 kg of farmed salmon in average requires 4 kg of wild caught fish (Tuominen and Esmark 2003). Species occurring in the Barents Sea, such as capelin, norway pout and blue whiting are frequently used in fish feed. An expansion of the aquaculture industry in the ecoregion may therefore increase pressure on wild fish stocks in the Barents Sea and elsewhere.

Given the increasing interest in aquaculture in the Barents region and its potential negative impacts on the ecosystem, the mitigation measures undertaken in the future will decide if the industry develops sustainably or turns into a new major threat to the biodiversity in the Barents Sea.

Climate change

The climate on Earth has changed noticeably during the last 100 years, with an increase in the global average surface temperature during the 20th century of about 0.6^{o}C. The year 2002 was the second warmest year worldwide since records began in 1860. Nine of the ten warmest years have occurred since 1990, including 1999, 2000 and 2001, and only 1998 was warmer than 2002 (IPCC 2001). There is broad scientific consensus that the changes in climate observed over the past century are the result of emissions of greenhouse gases like carbon dioxide due to human activity (Mann et al., 2003; IPCC, 2001).

The concentration of CO_2 in the atmosphere has already increased from the pre-industrial concentration of 280 ppm to the present day value of 355 ppm (Ormerod et al. 1999). A continuing economic growth of 2-3% a year - with accompanying emissions of greenhouse gases - will, according to estimates, cause an increase in earth's mean temperature of somewhere between 1.7 and 4^{o}C from 1990 to 2100.

The IPCC 2001 report states that climate change in the polar regions is expected to be among the greatest of any region on Earth. Twentieth century data show a warming trend of as much as 5^{o}C over land areas, and precipitation has increased (IPCC 2001). Climate change, in combination with other stresses, will also affect human communities in the Arctic. The impacts may be particularly disruptive for communities of indigenous peoples following traditional lifestyles. On the other hand, communities that practice these lifestyles may be sufficiently resilient to cope with these changes. However, there will be economic benefits - including new opportunities for trade and shipping across the Arctic Ocean, lower heating costs and easier access for ship-based tourism.

Under this scenario, cod, capelin and herring will increase their populations to historic maximum levels, the total fish biomass being maybe three times that of today. Patterns of distribution will change, the spawning area of capelin for instance shifting from the Norwegian coast to the coast of Novaja Zemlya.

On the other hand, primary productivity may decrease due to the reduction of sea ice and the associated ice algae species that have an important role as well (Alexander 1992; Klungsøyr et al, 1995). The spring bloom probably also be limited to a smaller zone compared to its present distribution.

Some species may be forced to migrate northwards following the retreating ice-edge. Polar-cod, which live along the ice edge, would have to adapt to new conditions. Seal, such as the ringed seal, which breed and raise their young on or near the ice edge, would experience a loss of habitat. Polar bears which hunt seals from the ice edge would have to move further north in search of prey. Female polar bears may have to go longer distances in pursuit of food leaving cubs unattended and vulnerable (WWF 2002). Walruses would encounter the problem of finding adequate sea ice to support their weight. The retreat of sea ice will threaten the existence of several polynyas and associated species. However, some species may benefit from the retreat of competitors, and could then expand their range.

Nature's complexity makes it difficult to predict the outcome of global climate change. In the case of a net increase in sea temperature, a number of unforeseen effects may emerge. For instance, the zooplankton species *Calanus finmarchicus* will most likely increase its distribution northwards as the water warms, displacing cold-water species like *C. glacialis* and *C. hyperboreus*. This seemingly unimportant shift may prove detrimental to local populations of seabirds and marine mammals, as intake of 1 kg *C. finmarchicus* contains 26 times less fat than 1 kg of *C. hyperboreus* (Scott et al. 2000). Also, as a preliminary report from the Norwegian Polar Institute (2003) points out, climate impacts will serve as the backdrop for other impacts, setting the conditions that will determine how other environmental parameters will react to other stressors.

Threat assessments

Threats to the fragile environment of the Barent Sea have been assessed by several sources. Two of them are reproduced in the tables below, listing current and potential threats. The first one resulted from a group of Russian and Norwegian scientists working together at the WWF Biodiversity Workshop in St. Petersburg (the group considered threats in the Svalbard sub-region, but the results are applicable to a large part of the Barents Sea eco-region). The other one is from the OSPAR Commision.

Oil-damaged common guillemot after the Prestige accident 2002. Photo: WWF-Canon / Jorge Sierra

THE WWF BIODIVERSITY WORKSHOP - SVALBARD SUBREGION GROUP

C=current threat, P=potential threat

Factor	Spatial scale	Biological level of impact			Time scale	
		Low	Medium	High	Short	Long
Climate change *CP*	Broad			x		x
Fisheries *C*	Broad[1]			x	x	x
Whaling, historic	Broad[2]			x		x
Pollution/POPs *CP*	Broad[3]	x	x	x	x	x
Walrus harvest	Broad			x		x
Radionucleides *P*	Broad	x	x	x		x
Heavy metals *P*	Broad	x	x	x		x
Oil/gas *P*	Broad/local	x	x	x	x	x
Shipping[4] *C*	Local		x	x	x	x
Alien species[5] *P*	Broad/local	x	x	x		x
Whaling, modern *C*	Broad	x[6]			x	x
Sewage *C*	Local		x		x	
Hunting, local *C*	Local	x			x	
Tourism *C*	Local	x			x[7]	
Coal mining *C*	Local	x			x	
Scientists *CP*	Local	x			x	

Footnotes:

1: Destruction of bottom habitats, bycatch, overfishing, oil spillage, loss of equipment (nets), garbage dumping

2: Historical extirpation

3: Trophic level dependent - long range transport

4: Accidental oil spills, habitat disruption (e.g. ice breeding seals), whale strikes, introduction of alien species

5: Parasites and diseases included

6: At current harvest level

7: Risk of discharges (eg. oil)

The OSPAR Quality Status Report 2000 - Human pressures

The OSPAR Commision's Quality Status Report for OSPAR region 1 (arctic waters) covers the area from eastern Greenland to 50° E, and from 62° N to the North Pole. The executive summary ranks human pressures on the marine ecosystem in three categories:

Major effects:	- Fisheries:	- Stocks fished close to, or beyond, sustainable limits. - Inadequate reporting of discards. - Benthic habitats/species affected by bottom trawling.
	- Whaling:	- Has permanently altered the energy flow and dynamic properties of ecosystems.
Medium effects:	- POPs:	- Increasing number of compounds found in biota.
	- TBT:	- Effects on fauna from antifouling paints (imposex in dogwhelks).
	- Aquaculture:	- Spread of salmon lice. - Genetic composition of wild salmon altered by inbreeding with escaped farm fish.
	- Oil:	- Released in harbours and by ships. Potential for large impact, and remedial action is difficult in cold climate.
Lesser effects:	- PAHs:	- Mainly local sources, generally low concentrations.
	- Metals:	- Effects apparent near point sources, some health implications.
	- Radionucleides:	- Of negligible significance at present. Future releases from dumpsites and accidents a potential threat.
	- Eutrophication:	- Not an issue of concern in the region.
	- Physical impact:	- Minor problems only.
	- Biological introductions:	- An insignificant problem, except for the Kamchatka crab.

Harp seal. Photo by: WWF/Kjell-Arne Larsson

Minke whale. Photo: WWF-Canon / Morten Lindhard

PROTECTED AREAS

The World Conservation Union (IUCN) has developed an international system of classifying protected areas. In the current version, there are six different management categories:

Category	Main Management Objective	Type of Protected Area
I	Strict protection	Nature reserve / Wilderness Area
II	Ecosystem conservation and recreation	National Park
III	Conservation of natural features	Nature Monument
IV	Conservation through active management, habitat/species	Management Area
V	Landscape, seascape, conservation and recreation	Protected Landscape/Seascape
VI	Sustainable use of natural ecosystems	Managed Resource Protected Area

Protected areas

Protected areas in the Russian Federation
The Law on Protected Areas, adopted by the Government of the Russian Federation on 15 February 1995, defines the following seven types of protected nature in Russia:

State nature reserves (Zapovednik), including biosphere nature reserves. IUCN category I.
Highest level of protection. The objective is to conserve biodiversity and to maintain protected ecosystems in a natural state, for ecological monitoring and research, education and training of personnel of conservation organizations. Within these areas it is prohibited to undertake any economic activity which may affect the development of natural processes, threaten the state of natural ecosystems and objects, or which is unrelated to the implementation of the reserves' objectives. Zapovedniks are managed by federal bodies such as the State Committee of the Russian Federation for Environmental Protection, Russian Academy of Sciences and universities.

National parks. IUCN category II.
Established in areas of special ecological, historical and aesthetic value and intended for environmental, recreational, educational, scientific and cultural activities. Various different activities may take place in these parks through a zoning system, determined by an individual act for each park. Each national park operates on the basis of an individual regulation approved by the federal body which manages the park.

*State nature reserves/sanctuaries/wildlife refuges (*Zakazniks). IUCN category III-V. Partial limitations on land use are introduced to preserve natural ecosystems or their components. Zakazniks may be established at the federal or regional level and the responsibility is shared by the State Committee for Environmental Protection, regional, district and autonomous sectors and local committees. Zakazniks are numerous, more easily created than zapovedniks and national parks, and have more flexibility in terms of protection regimes.

Nature parks. IUCN category III-V.
Established according to the decision of regional authorities. Their objective is to conserve natural landscapes and provide opportunities for outdoor recreation.

Nature monuments. IUCN category III-IV. Individually valuable natural objects, protected in order to maintain their natural condition. They may be established at the federal or regional level and are managed by the land-owner of the protected area or in coordination with other persons.

Botanical gardens and parks. Intended for biodiversity conservation by developing plant collections as well as for scientific and educational activities. May be established at the federal or regional level.

Health resort areas. Protected to maintain natural resources and objects used for medicinal purposes (muds, mineral waters, beaches, microclimate, etc.).

Protected areas in Norway
The first Norwegian Law on Nature Conservation was

Figure 3.9: Proposed coastal marine protected areas along the North-Norwegian coast. Protected by 2005 at earliest. (References, see pp.148-151).

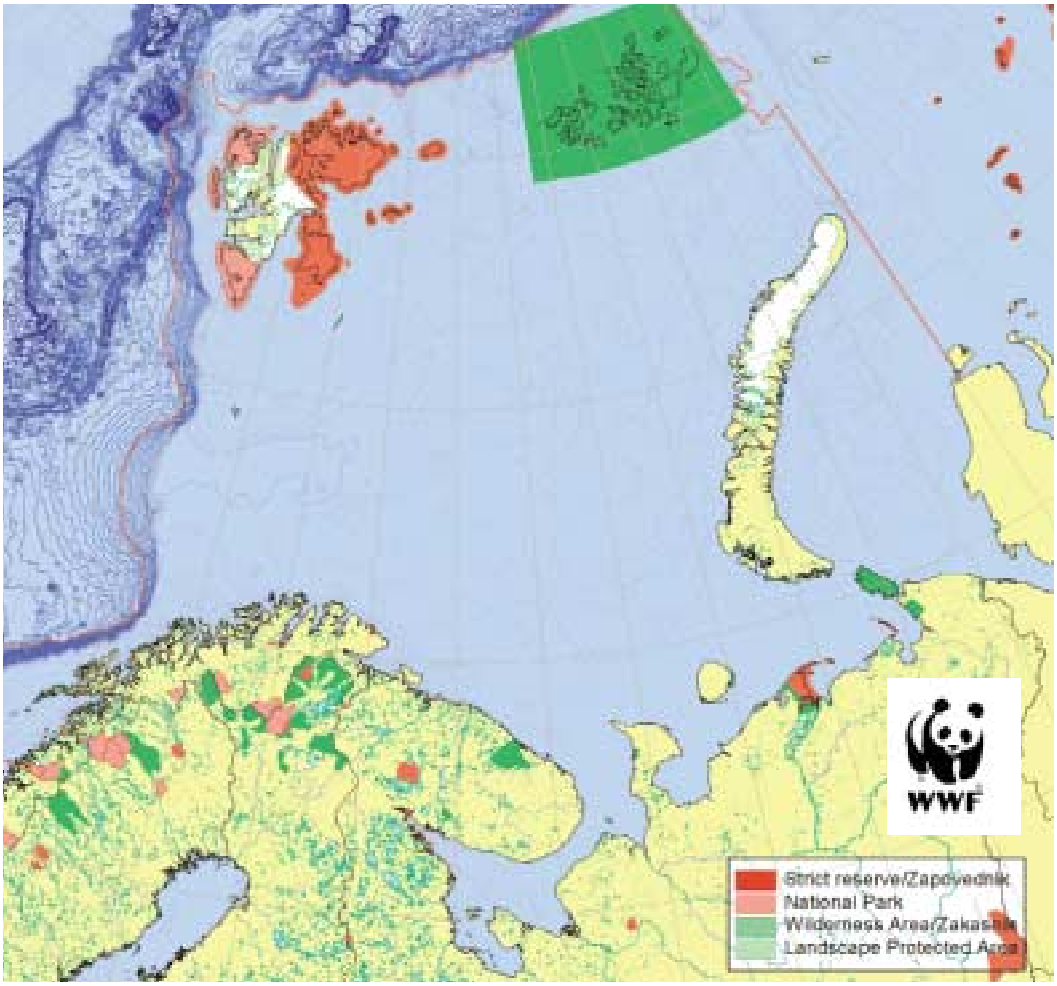


Figure 3.10: Protected areas in the Barents Sea region. Dark red = IUCN category I, Light red = IUCN category II, Dark green = IUCN category IV, Light green = IUCN category V. (References, see pp.148-151).

adopted in 1910. The present law is from 1970, and recognizes the following categories of protected areas: *Nature Reserves (naturreservat)*. IUCN category I. Areas of unspoilt or nearly unspoilt nature, or special nature types of particular scientific or pedagogical interest, or of a distinctive type. An area can be protected with no access to the public in parts of the year, and it can be protected for particular purposes, as forest reserves, seabird reserves, wetland reserves among others. While Russian zapovedniks are often relatively large with very restricted access, most Norwegian nature reserves are usually open to the public for all or at least parts of the year, and are traditionally of very small size. Within the ecoregion, the large nature reserves on Svalbard with limited access constitute a noticeable exception.

National Parks (nasjonalpark). IUCN category II. Established to protect large unspoilt or nearly unspoilt areas, or distinct or beautiful nature areas on land owned by the state. Private land bordering such areas can also be included in a national park together with the state-owned areas. In national parks, the landscape with plants, animal life, and natural and cultural heritage sites is protected against development, pollution and other encroachments. The parks are open to the public throughout the year, as part of the motive for establishing them is to offer recreation and outdoor life in unspoilt nature.

Nature Monuments (naturminne). IUCN category III. Established to protect geological, botanical or zoological objects of scientific or historical interest, or distinct objects. The area around the object can be protected as well, if this is necessary for efficient protection of the object. The oldest type of Norwegian management categories, it was used in particular to protect single large trees, but is hardly used in Norway anymore for biological objects.

Animal, Bird or Plant protection areas / biotope protection (Dyre-, Fugle- eller Plantefredningsområde / biotopvern). IUCN category IV.
Established with the purpose of giving strict protection to a particular feature of interest. A common example is the seabird protection area. When species protection is combined with biotope protection, the same degree of protection as in a nature reserve is achieved. The practical difference is that a biotope protection area can be established not only under the nature conservation act, but also under the wildlife act.

Landscape Protection Areas (landskapsvernområde). IUCN category V.
Established to protect distinct or beautiful natural or cultural landscapes. Within these areas no activity is allowed which can alter the character of the landscape in a significant way. Recreation and sustainable use of natural resources (for instance firewood cutting and livestock grazing) is permitted, and often necessary to maintain cultural landscapes. Landscape protected areas are often used as buffer zones around nature reserves or national parks.

Species protection areas (artsvern). This type of protection does not include the physical area where the protected species lives. It is used to protect species from harvesting, and can be applied locally or for the whole country. Not much used anymore (mostly for plants; animal species protection is obtained through the wildlife act).

There are at present no areas in the ecoregion designed particularly with the objective of protecting marine biodiversity values, with one exception. In 2003, the Røst Reef - the world's largest known deep-water coral reef - was protected by Norwegian authorities against bottom trawling through the coral protection regulation of 1999. However, 26,000 km^2 out of the 42,000 km^2 Franz Josef Land federal zakasnik are marine, and around Svalbard 31,424 km^2 of ocean are protected as part of the national parks and nature reserves on the archipelago (72% of the waters within the territorial zone). A draft protection plan for coastal marine areas was published by the Norwegian Directorate for Nature Management in 1995. In 2003, an advisory committee proposed 36 areas of high priority to be included in the future protection plan (see map next page). At present 12 areas covering 7,777 km^2 are among the prioritised areas within the borders of the Norwegian part of the ecoregion (DN 2003). The final proposition has been scheduled for 2005. Possible offshore marine protected areas will be considered after that time.

Overviews of protected areas in the ecoregion are given in the subregion descriptions in the next chapter. Altogether, the marine protected areas in the ecoregion sums up to 59,000 km^2. With a total sea area of 2,200,300 km^2, this means that 2.7% of the marine realm has some kind of protection. The total land area (islands) within the ecoregion is 182,000 km^2, of which 54,560 km^2 or 30% is protected.

Solitary coral. Photo: Kåre Telnes

4. IDENTIFYING PRIORITY AREAS FOR BIODIVERSITY CONSERVATION IN THE BARENTS SEA ECOREGION

The Barents Sea biodiversity workshop – St. Petersburg, Russia

WWF arranged a two-day workshop on 13-14 May 2001, in an educational centre in the village of Pavlovsk outside St. Petersburg. The purpose of the workshop was to have Russian and Norwegian biologists identify and map priority areas for the maintenance of biodiversity in the ecoregion, and to produce descriptions of the biodiversity values in each area. The experts were also invited to discuss a long-term biodiversity vision for the Barents Sea ecoregion.

In the list below, participants are listed alphabetically. The letters in italics show which thematic group of biodiversity the person assigned himself or herself to (F=fish, M=marine mammals, P=plankton/ice edge organisms, B=benthos, S=seabirds).

Barnacle Goose. Photo: WWF-Canon / Klein & Hubert

John Alvsvåg	Institute of Marine Research, Bergen (post-workshop consultant)	F
Stanislav Belikov	Institute for Nature Protection, Moscow	M
Andrei Boltunov	Institute for Nature Protection, Moscow	M
Vladimir Chernook	Polar Research Institute for Marine Fisheries and Oceanography (PINRO), Murmansk	M
Natalia Chernova	Zoological Institute, Russian Academy of Sciences, St. Petersburg	F
Sabine Christiansen	WWF International, NE Atlantic Programme, Bremen	P
Anton Chtchoukine	KE Association, St. Petersburg	F
Nina Denisenko	Zoological Institute, Russian Academy of Sciences, St. Petersburg	B
Stanislav Denisenko	Zoological Institute, Russian Academy of Sciences, St. Petersburg	B
Andrew Derocher	Norwegian Polar Institute, Tromsø	M
Morten Ekker	Directorate for Nature Management, Trondheim	S
Bjørn Frantzen	Svanhovd Environmental Centre, Svanvik	F
Kirill Galaktionov	Zoological Institute, Russian Academy of Sciences, St. Petersburg	S
Valentina Galtsova	Zoological Institute, Russian Academy of Sciences, Moscow	B
Maria Gavrilo	Arctic and Antarctic Museum, St. Petersburg	S
Olga Gerasimova	formerly Polar Research Institute for Marine Fisheries and Oceanography (PINRO), Murmansk; now consultant to RPO WWF	P
Salavat Goumerov	KE Association, St. Petersburg	
Olga Kiyko	Russian Federal Research Institute ”Ocean Geology”, St. Petersburg	B
Yuriy Krasnov	Murmansk Marine Biological Institute, Murmansk	S
Dmitry Lajus	Zoological Institute, Russian Academy of Sciences, St. Petersburg	F
Tore Larsen	WWF International, Arctic Programme, Tromsø	
Vladimir Melentiev	Nansen Centre for Remote Sensing, St. Petersburg	M
Vadim Mokievsky	P.P. Shirsov Institute for Oceanology, R. Acad. of Sc., Moscow	F
Andrei Naumov	Zoological Institute, Russian Academy of Sciences, St. Petersburg	B
Vladimir Pogrebov	Arctic and Antarctic Institute, St. Petersburg	B
Lyudmila Poroshkina	State Comm. for Nature Resources, Nenets Auton. District, Naryan-Mar	S
Peter Prokosch	WWF International, Arctic Programme, Oslo	M
Cecilie von Quillfeldt	Norwegian Polar Institute, Tromsø	P
Roustam Sagitov	Baltic Fund for Nature, St. Petersburg -	
Tatjana Savinova	Akvaplan-Niva, Tromsø	B
Olga Shtemberg	Marine Committee, Ministry for Nature Resources, Moscow	B
Vassily Spiridonov	WWF Russian Programme Office, Moscow	P
Hallvard Strøm	Norwegian Polar Institute, Tromsø	S
Aleksandr Studenetsky	Ministry for Science and Technology, Moscow	M
Geir Helge Systad	Norwegian Institute for Nature Research, Tromsø	S
Aleksandr Tzetlin	Biological faculty, Moscow State University	F
Maria Vorontsova	International Foundation for Animal Welfare, Moscow	M
Nikita Vronsky	Arctic Circle Foundation, Moscow	
Jury Zakharov	ZAO Ecoproject, St. Petersburg	

Technical arrangement group:

Polina Agakhanjants	St. Petersburg Association of Naturalists, Baltic Fund for Nature
Valentina Buchyeva	St. Petersburg Association of Naturalists, Baltic Fund for Nature
Anastasia Gordeeva	St. Petersburg Association of Naturalists, Baltic Fund for Nature
Aleksei Zavarzin	St. Petersburg Association of Naturalists, Baltic Fund for Nature
Aleksandr Karpov	St. Petersburg Association of Naturalists, Baltic Fund for Nature
Aleksei Poloskin	St. Petersburg Association of Naturalists, Baltic Fund for Nature
Aleksei Sagitov	Baltic Fund for Nature

Step 1: A subregional classification of the Barents Sea Ecoregion

The overarching aim of this report is to give a presentation of biodiversity in the Barents Sea: which species can be found, where are they found, in what state are the populations at present, and which areas are most vital for their continued survival. This chapter presents the results from the St. Petersburg workshop, where experts on marine mammals, seabirds, fish, plankton and benthic organisms focused on the last of these questions, and identified (nominated) areas of particular value, based on a set of criteria presented on the next page. The process of identifying priority areas for biodiversity conservation was divided into three steps. First experts were asked to delineate subregions within the Barents Sea ecoregion. This was done to facilitate analysis of species assemblages and habitat types; to understand the relative importance of biodiversity features at different biogeographical scales, and to assure the representation of all major habitat types in the priority areas. The second step was to identify key habitats for major wildlife taxa, including birds, marine mammals, plankton, fish and benthos. The third step was to combine the information from the thematic maps in order to identify overall priority areas for the maintenance of the full spectrum of biodiversity in the ecoregion.

The map shows subregions in the Barents Sea as identified at the St. Petersburg workshop. The subregions were delineated after considerations of biological, biogeographic, oceanographic, and practical criteria. Subregions stand out with their own particular environmental conditions. Geographic representativity is a goal when nominating priority areas, because even areas with only a few species may be distinctive in terms of distribution, genetic diversity, rarity and other characteristics.

The degree of genetic diversity in the ecoregion is not well known, but the fact that many species are extremely numerous and may appear in several different habitats/ niches indicates that it may be high. In the overview on the next page, each subregion is given with its map number and main water type.

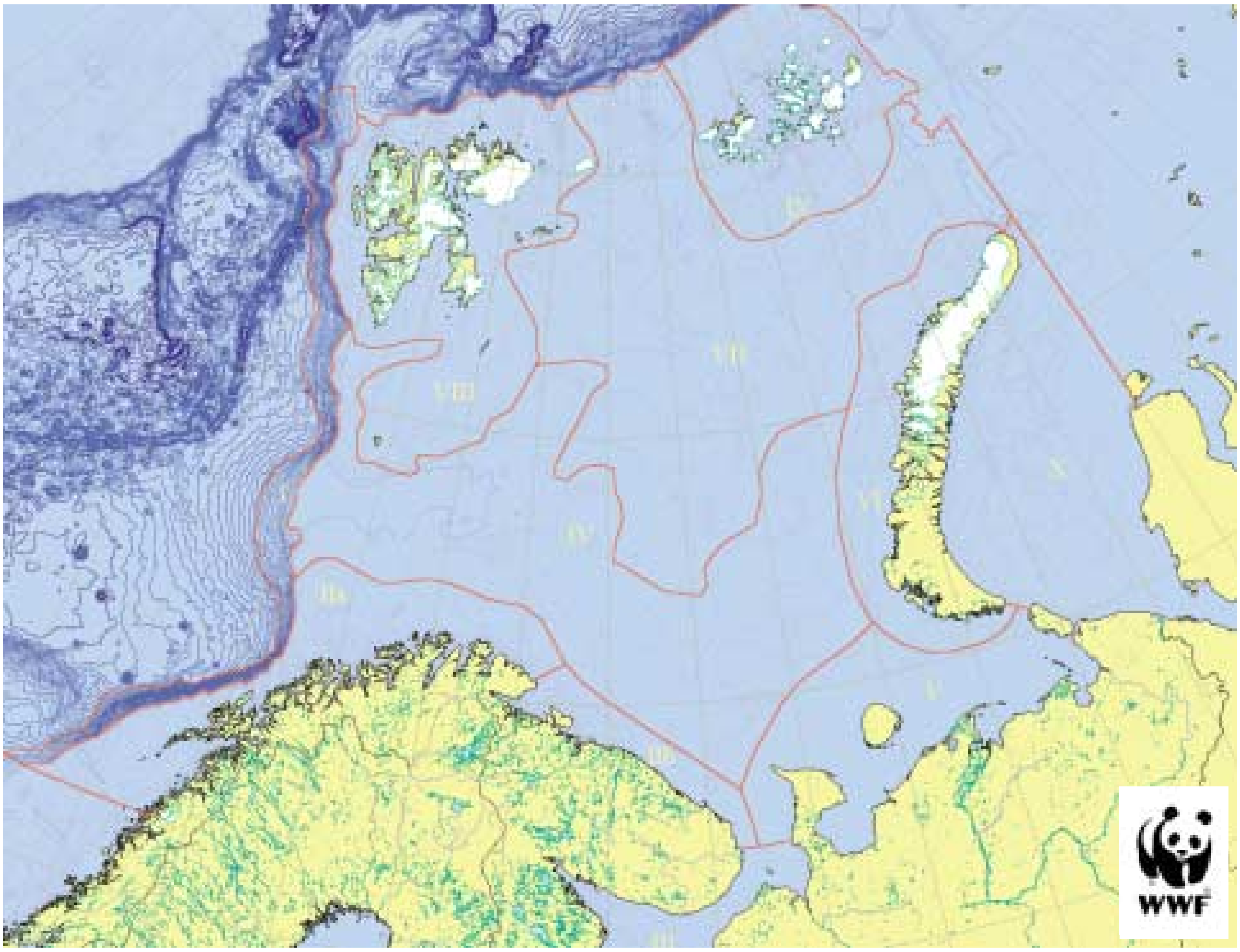


Figure 4.1: Map showing representative subregions in the Barents Sea Ecoregion identified according to biological, biogeographic and oceanographic criteria at the WWF workshop in St. Petersburg, 2001.

I	- Western shelf edge: Atlantic water.
II	- Norwegian and Murman coasts: Coastal water (1a: Norwegian coastal current, 1b: Murman current).
III	- White Sea: Coastal water.
IV	- Central Barents Sea south of the Polar Front: Atlantic water.
V	- Pechora Sea: Coastal and Arctic water.
VI	- Western Novaya Zemlya waters: Arctic water, some influence of Atlantic water at the western coasts.
VII	- Central Barents Sea north of the Polar Front: Arctic water.
VIII	- Svalbard waters and the Spitsbergen bank: Arctic water, some influence of Atlantic water at the western coasts.
IX	- Franz Josef Land waters: Arctic water.
X	- Kara Sea: Arctic water, greatly influenced by riverine freshwater input.

Step 2: Nominating valuable areas for particular biodiversity components

The list below was presented to the participants at the St. Petersburg workshop as the criteria to use when nominating valuable areas for the maintenance of their particular field of biodiversity. The criteria are adapted from different sources, and overlap to some degree. Nominated areas should meet some of the criteria, but not necessarily all. Numbers do not reflect priority. Based on how well each nominated area was considered to meet the criteria, the expert groups were asked to assign a priority value to the areas (I-IV, where I is the highest priority). The priority values are given in the area descriptions.

CRITERIA FOR SELECTING NOMINATED AREAS

1. Naturalness:
The area has a high degree of naturalness, and species and biotopes are still in a very natural state as a result of the lack of human-induced disturbance or degradation.

2. Representativity:
The area contains a number of habitat/biotope types, habitat complexes, species, ecological processes or other natural characteristics that are typical and representative for the ecoregion as a whole or for the subregion.

3. High natural biological diversity:
The area has a naturally high variety of species (compared to similar habitat features elsewhere), or includes highly varied habitats and communities (compared to similar habitat complexes elsewhere).

4. Productivity:
The area has a high natural productivity of the species or features represented, contributing to sustain species or ecosystems.

5. Ecological significance for species:
The area has important breeding/spawning, nursery or juvenile areas.The area has important feeding, moulting, wintering or resting areas.

6. Dependency:
Species, groups of species, or an ecosystem depend on ecological processes occurring in the area (e.g. a migration corridor or other area critical to the lifecycle of species or groups of species)

7. Source area:
The area contributes to the maintenance of essential ecological processes or life-support systems (e.g. a source of larvae for downstream areas)

8. Uniqueness:
An area is "one of a kind". Habitats of endemic, rare or endangered species occurring only in one area are an example; another is areas of rare or outstanding ecological or evolutionary phenomena.

9. Sensitivity:
The area contains a high proportion of very sensitive or sensitive habitats or species.

Sources: IUCN, OSPAR, WWF

Marine mammals: nominated areas

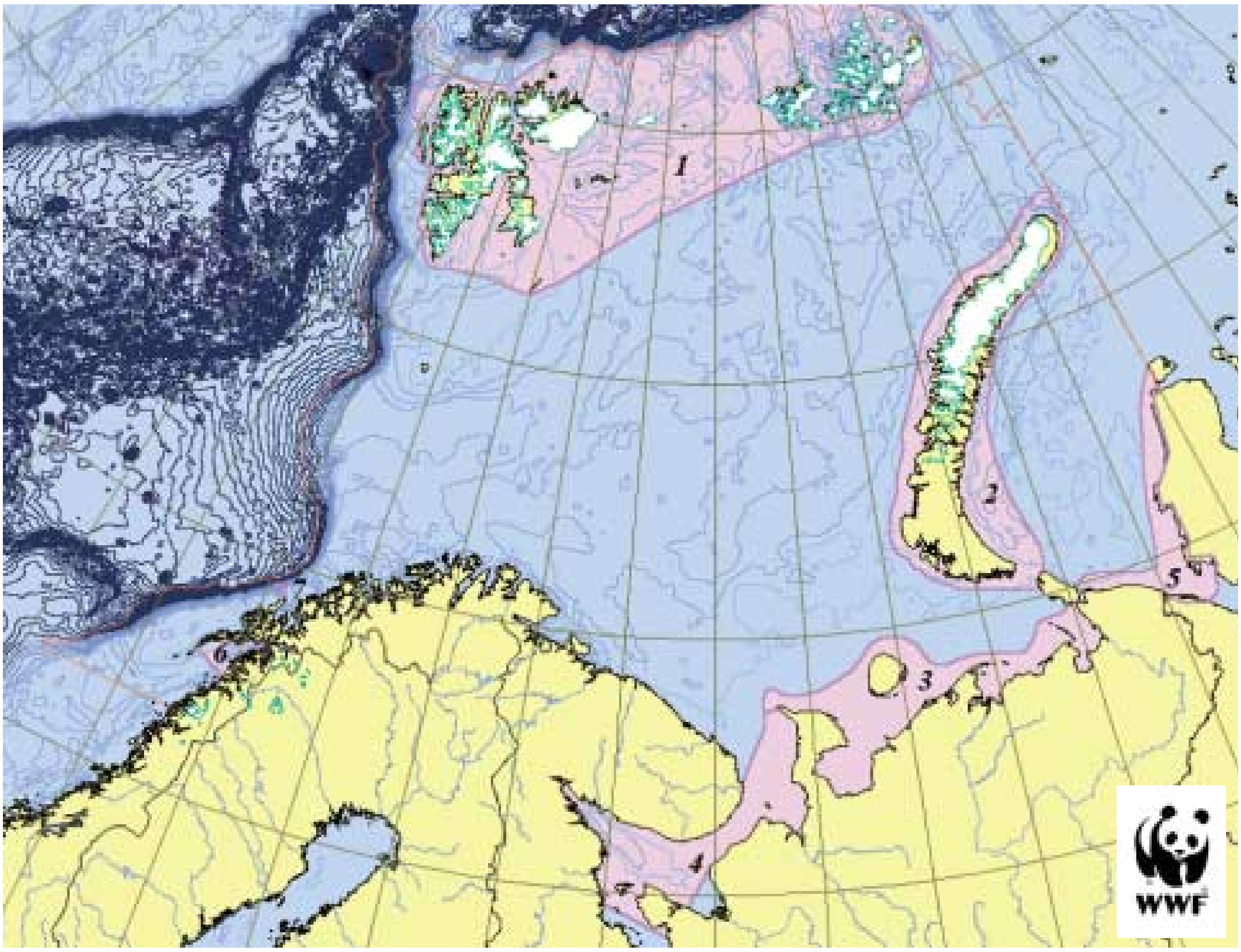


Figure 4.2: Areas nominated for marine mammals.

Area 1 - Svalbard and Franz Josef Land
The area constitutes the most important polar bear breeding, feeding, mating and migration areas in the ecoregion. Kongsøya in the Svalbard archipelago is considered a global "crown jewel" for polar bears, along with Wrangel Island (Russia) and Cape Churchill (Canada). The whole area has a high degree of naturalness and representativeness, with a minimum of human disturbance and no harvest of most marine mammals (with a few exceptions: minke whale, bearded seal and ringed seal). In addition to the world's northern-most population of harbour seals, the area also has a high diversity of marine mammals, including ringed seal, bearded seal, narwhal, bowhead whale and walrusi; many of them are linked to the marginal ice zone. The area is a migration corridor to the polar pack-ice in summer. It is difficult to split this large area into smaller parts, as it holds common populations of several species.
Priority: I

Area 2 - Novaya Zemlya
Novaya Zemlya has a high degree of naturalness, as vast areas have not, or only to a very small degree, been disturbed by human activities. It represents a border zone between the cold, Arctic Kara Sea to the east, and the warm, subarctic/arctic Barents Sea to the west. The northeastern shores of the Severny (north) Island are an important denning and nursery area for polar bears. Belugas (white whales) spend summer in the Kara Sea, migrating through three relatively narrow "channels" on their way to the important western wintering grounds on the Barents Sea coast: the Kara Gate to the south, the Matochkin Strait between the northern and southern islands, and around Mys Zhelanya to the very north. The same passages are used also by other marine mammals, such as the walrus. Six walrus haoulouts are known along the western and northern shores of Novaya Zemlya, but the number is probably higher. Compared to area 1, biodiversity is moderate.
Priority: I

Area 3 - Nenets coast/Pechora Sea
The area has a high degree of naturalness, as it is only moderately disturbed at present. It is representative of arctic shallow seas, with estuaries and brackish water, and holds main breeding and wintering areas of beluga as well as a vulnerable, small, southern population of walrus. There are walrus haulouts on Dolgiy Island. The area is important for southern ringed seals, and ice conditions are suitable for seal breeding. In total, productivity for marine mammals is high.
Priority: II

Area 4 - White Sea
The White Sea is the most important breeding site of harp seals in the northeastern Atlantic, functioning as a pupping, moulting and mating area for roughly estimated two million seals. The White Sea holds its own population of belugas, with the Solovetsky Islands as one of the most important of several breeding areas. Ringed seals breed in the same areas; mainly in the Kandalaksha Bay, the Onega Bay and around the Solovetsky Islands.
Priority: I

Area 5 - Kara Sea
Breeding area for ringed seals. Summer and wintering area for a small population of walrus. Considered a possible recovery area for the heavily depleted walrus populations in the ecoregion. The area is also important for migrating belugas, and stands out as an important feeding area for this species.
Priority: III

Area 6 - Lofoten/Vestfjorden
The inner part of the Vestfjorden area is the deepest fjord in northern Norway (725 m). It is also the wintering site for the entire stock of Norwegian spring-spawning herring (approximately 10,000,000 tons), attracting several hundred killer whales during autumn and early winter. Other whales also gather in the area, most notably minke whales as well as long-finned pilot whales and some of the smaller toothed whales. At least six different whale species have been observed. The high concentration of killer whales in the inner fjord system was discovered only 15 years ago, and over the past years the killer whales seem to gradually have increased their winter "home range" to the outer parts of the Vestfjorden area as far as the Lofoten Islands.
Priority: II

Area 7 - Andøya shelf
The continental shelf ends very abruptly and depth reaches 2,000 meters only some 40 km outside the Vesterålen archipelago. Local bathymetry and ocean currents have made conditions particularly attractive near Andøya for sperm whales on foraging trips in the North Atlantic. Large numbers of male sperm whales concentrate in this small area to feed.
Priority: IV (because of its small size)

Bearded seal. Photo: Peter Prokorsch

Seabirds : Nominated areas

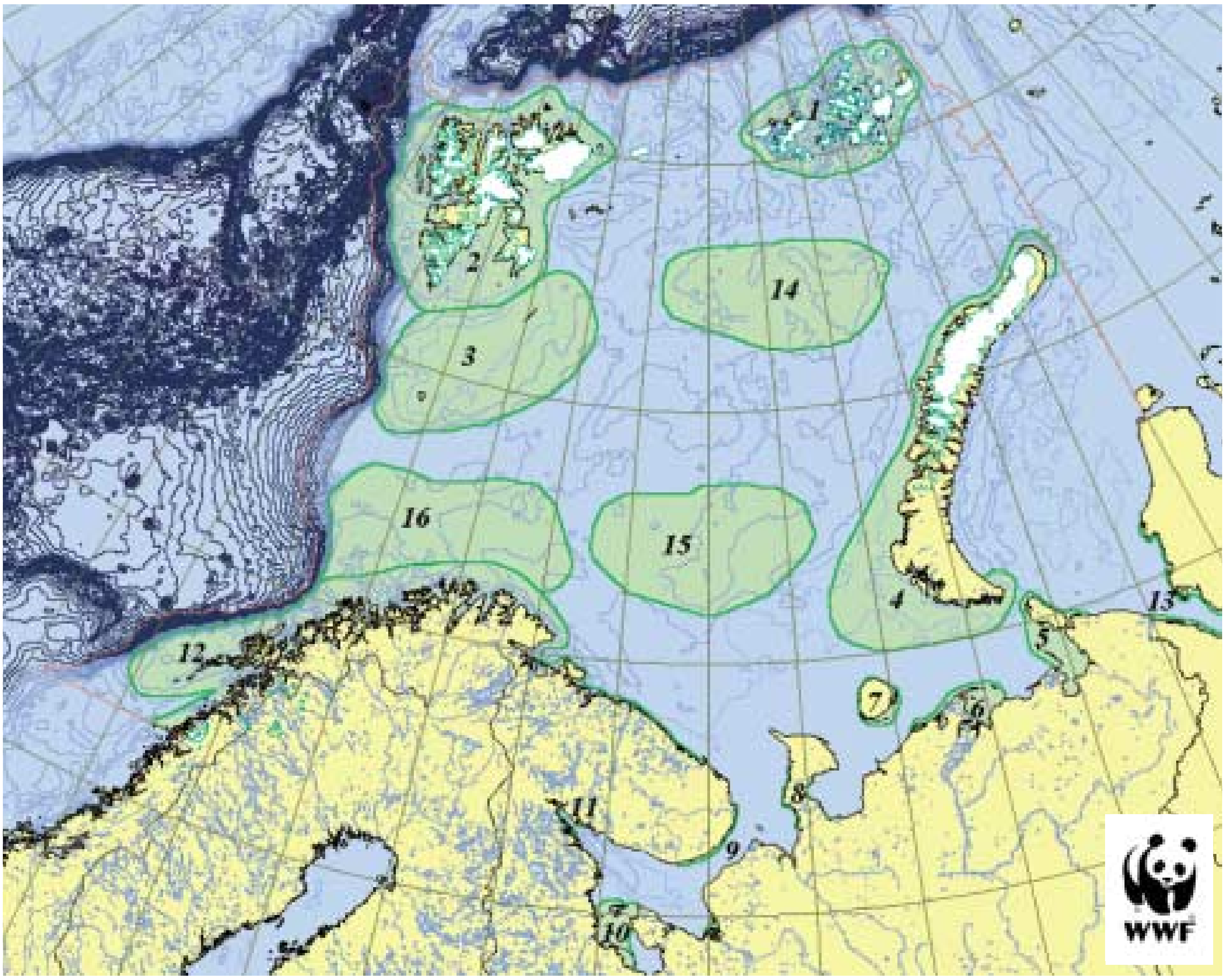


Figure 4.3: Areas nominated for seabirds.

Area 1 - Franz Josef Land
A high number of seabird colonies are concentrated within the archipelago, among them the largest colonies of ivory gulls in the ecoregion. The polynyas opening around the archipelago support wintering seabirds.
Priority: II

Area 2 - Svalbard
The southern and western parts of Svalbard are some of the world's most densely populated seabird areas, with numerous colonies and a high number of breeding birds, probably in the range between 2 and 3 million breeding pairs. These include the world's northernmost breeding colonies of puffin and razorbill, as well as a number of not well studied ivory gull colonies, increasing populations of arctic geese, and five breeding areas of grey phalarope.
Priority: I

Area 3 - Western Polar Front and Bjørnøya
Bjørnøya is one of five localities in the ecoregion with more than 300,000 breeding pairs of seabirds. The most numerous species are common and Brünnich's guillemots and kittiwakes, with a number of additional breeders, including the great northern diver.
Priority: I

Area 4 - Western Novaya Zemlya
Several seabird colonies are found on the steep parts of the western coast of Novaya Zemlya, but the highest number is on the Yuzhny (south) Island. Only two of the colonies hold more than 100,000 breeding pairs today, but according to investigations done in the first half of the last century, several colonies were much larger in size. The waters in the area southwest of the islands are important feeding grounds for auks both in and outside the breeding season, especially in the post-breeding

moulting period. Novaya Zemlya holds large populations of arctic breeding geese and ducks. Wintering areas for seaducks are found mainly to the southwest, although the Novozemelsky polynya may also be of importance. Species of particular interest: Barnacle goose, Steller's eider, bewick swan, peregrine falcon.
Priority: I

Area 5 - Vaigach - Yugor
This area is one of the most important moulting areas for seaducks in the ecoregion. Large flocks of king eiders and common scooters have been counted from the air, the largest concentrations south of Dolgiy Island holding perhaps 20,000 individuals, and another near the Cape Belkovskiy numbers ca. 15,000. The area is also important as a stopover site for ducks of other species, as well as geese. The highest concentrations seem to be at the northwest shore of the Yugorskiy Peninsula, around the Dolgiy Island group, and in the Khaypudurskaya Bay. The shores of the mainland also hold several areas of importance for migrating waders from the tundra areas to the east, and Vaigach Island is known to be an important moulting area for bean and white-fronted geese. Other species of particular interest include the white-tailed eagle and the peregrine falcon.
Priority: I

Area 6 - Pechora Bay
The bay area is a breeding area of vital importance for several waterbird species, as well as an important staging area for moulting and migrating birds. Bewick swans breed in large numbers in the Pechora delta, and the Korovinskaya Bay is known to hold large concentrations of moulting swans as well as pre-migrating aggregations (up to 10-15,000 individuals of bewick and whooper swans have been reported). The western Pechora Bay also holds large pre-migration aggregations of ducks and geese. Species of particular interest include the bewick swan, lesser white-fronted goose, white-tailed eagle, peregrine falcon, gyrfalcon and golden eagle.
Priority: II

Area 7 - Kolguev Island
Known to be an important breeding area for geese (including barnacle geese). Large numbers of bean and white-fronted geese moult in the area. The shallow waters to the south are an important moulting site for sea ducks. Other species of particular interest include the bewick swan, lesser white-fronted goose and peregrine falcon.
Priority: III

Area 8 - Kanin Peninsula
The Kanin Peninsula is an important stopover site for migrating geese from Siberia and arctic Russia, as well as for the threatened lesser white-fronted geese populations of Scandinavia. Barnacle geese were detected breeding here in the 1980s, and in 1991 even some brent goose nests were found (the most southerly known), in a colony of 400-450 barnacle goose nests.
Priority: III

Area 9 - Terskiy Coast
An important moulting and stopover site for seaducks. In winter, a polynya opens along the shore and is an important wintering site for eiders. The common eider is most numerous, but the winter population of Steller's eider is also notable.
Priority: III

Area 10 - Onega Bay
Approximately 1,900 large and small islands and skerries are found in this shallow area, which hosts approximately 40,000 pairs of breeding birds in summer, and a total of 150 bird species through different times of the year. Seabird colonies are small but many, and include significant proportions of the Russian breeding populations of species such as razorbill (3,000 pairs) and lesser black-backed gull (1,700 pairs). The most numerous species is the arctic tern, with ca. 15,000 pairs. The Onega Bay is the most important area in the White Sea for migrating and wintering birds, and a very large proportion of the White Sea breeding population of eiders (30-40,000 birds) and black guillemots (ca. 10,000) spend the winter in the several stable polynyas in the area.
Priority: III

Area 11 - Kandalaksha Bay
The area includes the inner, coastal parts of the Kandalaksha Bay, comprising hundreds of small and a few larger islands. The total number of breeding seabirds is somewhere in the range of 15-20,000 pairs, with eider being the most common species (ca. 5,000 pairs), followed by herring and common gulls.
Priority: I

Area 12 - Norwegian and Murman coast
This vast area holds a continuous series of seabird colonies, some of which are among the largest and most species-rich in the world. The total breeding population is around 3,000,000 pairs, with the main bulk west of the Varanger fjord. This distribution reflects the fact that the spawning grounds of several important fish stocks are found along the Norwegian coast, and that fish larvae are transported north along the coast with the Norwegian Coastal Current before they end up in the Barents Sea. Herring larvae are the staple food of the 2,000,000 pairs of puffins, of which one fourth is concentrated in the small Røst archipelago in the far end of the Lofoten Islands. The other most numerous species are kittiwake (well over 500,000 pairs), herring gull (100,000 pairs), eider (50,000 pairs), as well as a number of other gulls,

terns and auks. Moulting seaducks gather in the coastal areas and in the fjords, locally in large concentrations. Between 20 and 30,000 mergansers (*Mergus merganser*) moult in the mouth of the Tana River, and around 10,000 eiders moult in the inner Porsangerfjord. Shallow parts of the coastline are important migration stopovers on the East Atlantic Flyway for waders and arctic geese not following the eastern (Baltic) flyway: The inner parts of Porsangerfjord and Balsfjord may hold 20-30,000 (or even more) knots (*Calidris canutus*) in early May, while pink-footed geese forage on the outer Vesterålen islands in flocks of some thousands. Major wintering areas for seaducks are the Murman coast from Svyatoy Nos to Mys Teriberskiy, the coast of the Varanger Peninsula and the adjacent fjords (eastern coast of Finnmark), and the islands and skerries of Troms. Eastern Finnmark alone may hold 50,000 eiders, 30,000 king eiders, 40,000 kittiwakes, 20,000 herring gulls and 4,000 black guillemots in February-March. It has been estimated that of the total European winter populations, 75% of the king eiders, 30% of the Steller's eiders, and 90% of the white-billed divers winter on the northern Norwegian coast. Offshore wintering alcids have not been counted, but occur in considerable numbers. The world's largest population of white-tailed eagle breeds in the area, which also holds viable populations of peregrines and gyrfalcon.
Priority: I

Area 13 - Baidaratskaya Bay
Important migration stopover sites for waders on the East Atlantic Flyway along the shore, as well as a migration and moulting area for marine ducks and geese. Brent geese and eiders breed along the coast, and after a recent expansion of the red-breasted goose, some colonies of this species have also been found close to the coast.
Priority: III

Area 14 - Northern Open Barents Sea
The eastern ice edge in late summer is an important feeding area for seabirds migrating from breeding colonies in the eastern Barents Sea. Juvenile Brünnich's guillemots accompanied by moulting adults probably also migrate to this area, where concentrations of feeding seabirds are found.
Priority: III

Area 15 - Southern Open Barents Sea
Feeding area for large populations of seabirds migrating from breeding colonies in the eastern Barents Sea. Juvenile Brünnich's guillemots accompanied by moulting adults probably also migrate to this area, where concentrations of feeding seabirds are found.
Priority: III

Area 16 - Tromsøflaket and Nordkappbanken
Wintering area for seabirds (mainly alcids) from the eastern and northern Barents Sea, counting several tens of thousands Brünnich's guillemots and little auks. The post-breeding migration of juvenile guillemots from seabird colonies in Northern Norway and Bjørnøya meet in this area in late summer/early autumn. Enormous numbers of fish larvae drift by Tromsøflaket in summer, and are to some degree held back and made available to seabirds for a prolonged period due to a complex system of eddies.
Priority: II

Area 17 - Dvina estuary
Important staging area on the East-Atlantic Flyway. Spring staging area for arctic geese and Bewick's swan.
Priority: III

Common guillemot. Photo: Peter Prokorsch

Puffin. Photo: Peter Prokorsch

Plankton and Ice Edge organisms : Nominated areas

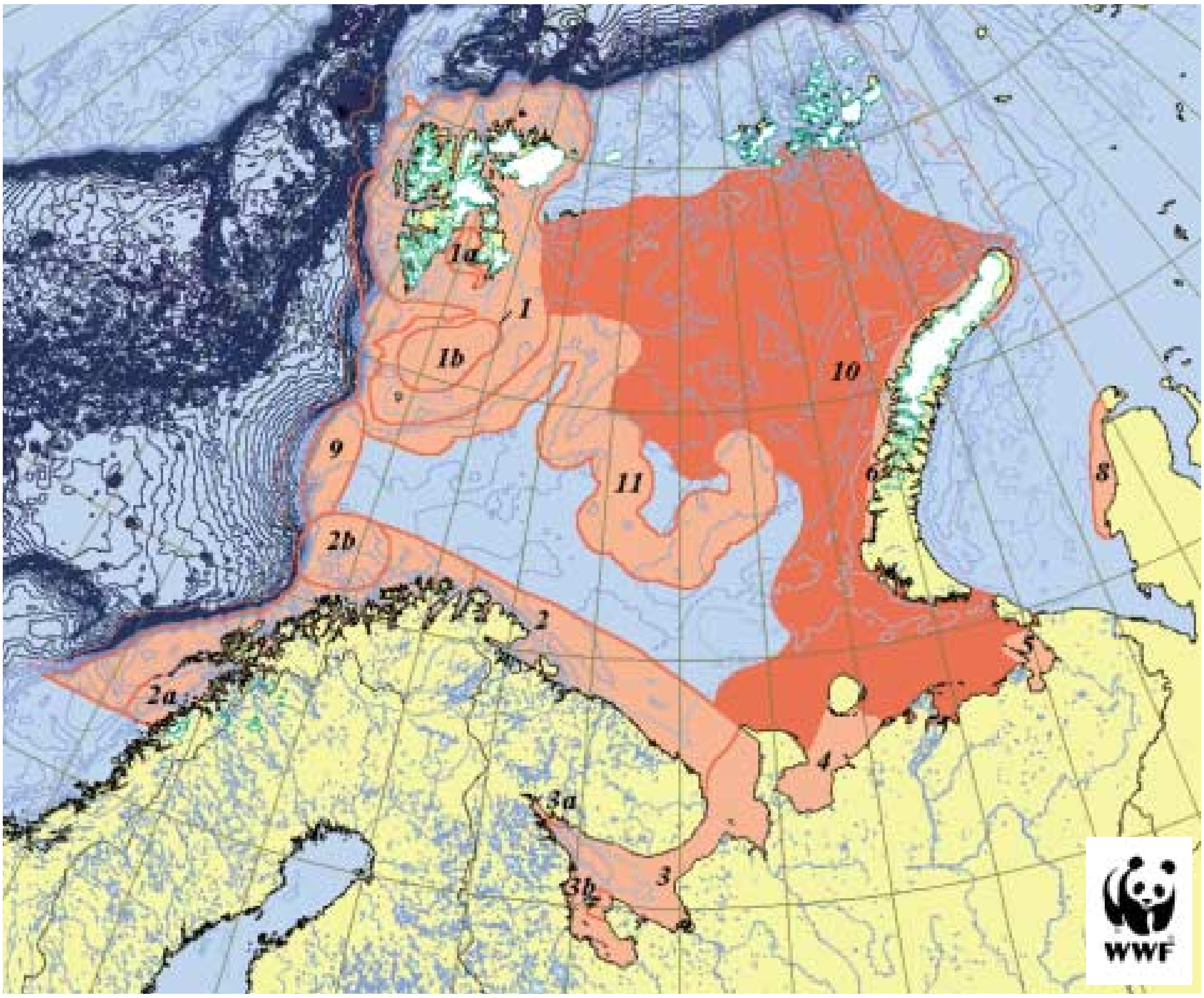


Figure 4.4: Areas nominated for plankton and ice edge organisms.

Note:
When selecting nominated areas with high plankton production, different criteria than those handed out at the workshop had to be used. Frontal areas (the Polar Front and others), the Marginal Ice Zone (MIZ), polynyas, bank areas, shelf areas and coastal areas are likely to have high production. Furthermore, latitude, ocean currents, ice condition, water depths, degree of freshwater input and so forth are factors which have to be taken into consideration. Usually, several factors work together. The driving forces of high production are different in different areas. Yearly production in an area is very much dependent on when the spring bloom starts, how deep it goes and its duration. The group has not set priority values for the nominated areas.

Area 1 - The Svalbard area
The area is influenced by arctic and Atlantic water; has a pronounced Polar Front, shallow bank areas and polynyas; and is limited in the west and the north by the continental slope. Atlantic-boreal, arctic, neritic and oceanic phyto- and zooplankton species occur.

1a - Storfjorden: A latent heat polynya, where brine-enriched bottom water is formed. Important for global ocean currents. Close to the southern extension of the sea ice. High primary production. Potential monitoring site for climate change, both geophysical and biological.

1b - Spitsbergen Bank: A shallow area where vertical mixing processes to the bottom take place all year round, with sufficient light conditions for production. Early start of the spring bloom (March-April, as soon as the ice melts). Yearly primary production is one of the highest in the area. Most of the production is transported to the benthic fauna.

Area 2 - Coastal waters off northern Norway and Murman coast
Fjords and coastal areas off northern Norway have high productivity. (Delay of spring maximum, as reflected by species composition, is going from south to north.) Variations between the fjord areas are mainly caused by differences in topographical features, wind conditions, and drainage from the watercourses bordering the fjords. Along the coast, three factors are responsible for determining vertical stability conditions: Interaction between the Atlantic and coastal waters, wind conditions during the spring season, and some local hydrographical conditions. Coastal water is always stratified, at least along the Norwegian coast (further east, in the shallow areas around Kolgujev, the stratification is almost broken down during winter), therefore the phytoplankton bloom starts as soon as the light intensity is sufficient, sometimes during April. Large concentrations of *Calanus finmarchicus* off Lofoten.

Area 3 - The White Sea
The area is characterized by a combination of two types of communities, neritic boreal and offshore arctic.

3a: Solovky Islands: Frontal area due to freshwater input, high productivity of phyto- and zooplankton, herring feeding area.

3b: Kandalaksha Bay: Tidal front, high productivity of zooplankton, herring feeding area.

Area 4 - Cheshskaya Guba
The bay is a shallow area with high primary productivity supported by different sources. We assume that the productivity is dependent on the biogenic input from the catchment area (there is a pronounced abrasion of the shore) and/or warming of the water column in spring/summer down to the bottom. The area probably supplies surrounding areas with organic material. Since benthic communities are of distinct boreal nature, it may be assumed that the plankton community is also very similar to boreal communities (e.g. North Sea) in spite of high latitude location.

Area 5 - Khaipudyrskaya Guba
Indications of high primary productivity, probably also important for surrounding areas.

Areas 6,7 and 8 - Western coastal areas of Novaya Zemlya, north-east coast of Novaya Zemlya, and west coast of Yamal
A series of recurrent polynyas presumably provides high primary productivity, supporting large concentration of *Calanus spp.*, polar cod and seabird colonies.

Area 9 - Bjørnøya channel western shelf edge
High productivity and concentration of zooplankton; feeding area for fish larvae (cod, haddock, redfish). A combination of production in the area and advection.

Area 10 - The Marginal Ice Zone (MIZ)
High primary production. The main factor controlling the start of the spring phytoplankton bloom at the ice edge is the vertical stability, which is strongly dependent on ice melting. The timing of the melting depends on its southern extension during winter (whether it is south of the Polar Front or not). Usually, it starts in the middle of April. The meltwater layer increases to 15-20 m during summer and early autumn. The transition layer is sharp, but diminishes in sharpness with increasing distance from the ice edge. The spring bloom follows the ice edge as it retreats northwards, as late as until September, typically in a 20 -50 km wide zone. A big portion of the production sinks out of the euphotic zone. Ice algae also contribute to the total production of the area. Ice algae blooms often start earlier than phytoplankton blooms. The MIZ has high concentrations of zooplankton, marine mammals and sometimes seabirds, and is a major feeding area for polar cod. The main zooplankton species is the copepod *Calanus glacialis*.

Area 11 - The Polar Front
The Polar Front is a nutrient-rich frontal area with high primary production. It is of great importance as a foraging habitat for guillemots and other seabirds. The Polar Front is more distinct in the western than in the eastern Barents Sea, where mixed water masses extend over large areas.

The development of the spring bloom differs north and south of the Polar Front due to deeper vertical mixing south of the Polar Front, and therefore greater possibility for diffusion of new nutrients into the mixed layer. However, the species composition and the succession of the most important spring phytoplankton species north and south of the Polar front are quite similar. In Atlantic water south of the Polar Front which has not been covered by ice in winter, stratification develops when the sun begins to warm the surface layer. Stratification progresses slowly, but reaches down to 50-60 m by means of turbulent mixing during summer. The spring bloom starts in the first half of May and progresses slowly during May and June. In the eastern Barents Sea, the spring bloom is delayed by one to two weeks due to colder water. Yearly primary production is higher than in most ice-covered areas, and most of it is transported to pelagic levels in the food chain. The main zooplankton species are copepods (*Calanus finmarchicus*) and krill (*Thysanoessa inermis* and *T. raschii*). Production north of the Polar Front is described under nominated area no. 10 (MIZ).

Polar bear on pack ice. Photo: WWF-Canon / Jack Stein Grove

Fish : Nominated Areas

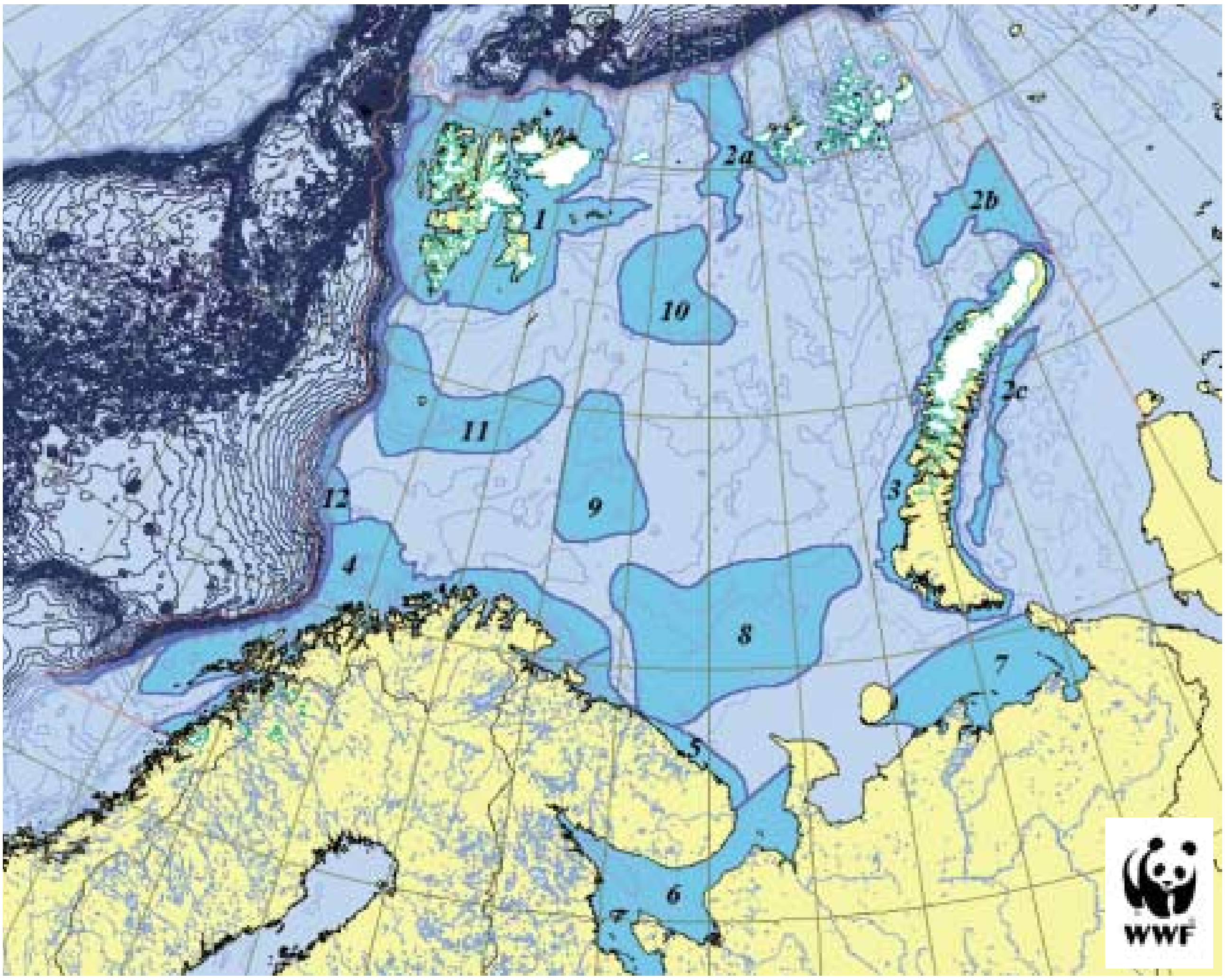


Figure 4.5: Areas nominated for fish.

Area 1 - Svalbard coastal areas
Southern and western parts of Svalbard are influenced by Atlantic water from the south, resulting in a varied fish fauna on the gradient between boreal and arctic life. The area has a high degree of naturalness, and species and biotopes are still in a natural state over vast areas as a result of the lack of human-induced disturbance or degradation. The area has important breeding/spawning and nursery areas, mainly in the southern waters. Dense concentrations of fish larvae show that the polar cod has a main spawning site south of Svalbard, but the exact location of this site is not known.
Priority: II

Area 2 a, b and c - Arctic trenches
These remote sites are not well known, but investigations indicate a specialized, though not very rich fish fauna.
Priority: III

Area 3 - Novaya Zemlya coastal areas
Species and biotopes are still in a very natural state as a result of the lack of human-induced disturbance or degradation outside some very minor locations. The area has a high variety of species, both benthic and fish, compared to similar arctic habitats elsewhere. The Zhelanya Cape as well as the straits represent ecologically interesting migration corridors between the Arctic Kara Sea and the Atlantic-influenced Barents Sea.
Priority: II

Area 4 - Lofoten and Finnmark coast.
This is the most important spawning area in the ecoregion, and one of the top spawning areas for economically important fish species in the world. Cod, herring and capelin, as well as haddock and saithe, have their spawning sites concentrated here, and billions of fish larvae from the Norwegian coast are fed into the Barents

Sea ecosystem every year through the coastal currents. North of Troms, the eddies of the Tromsø bank may hold 90% of the yearly production of cod larvae for two summer months (June-July). The area contributes to sustain species and ecosystems elsewhere in the Barents Sea. Near the shore, vast areas of kelp forests are valuable nursing areas for coastal fish populations. Near North Cape, a more arctic influence becomes visible, introducing new species as one progresses north and east. Cold-water relics are found in the deep, inner parts of some fjords, for example a population of polar cod in Porsangerfjord which may have survived in deep, cold water (- 1.1^{o}C) since the last glaciation (Christiansen 1999).
Priority: I

Area 5 - Murman coast
The Murman coast has a rich and varied fish fauna with components of both Atlantic boreal and arctic origin. The Murman current, the continuation of the Norwegian coastal current, holds large numbers of fish fry and juvenile fish from the western spawning sites before they disperse into the nursery areas on the great banks of the southeastern Barents Sea. A belt of kelp forests secure rich fish faunas along the coast to the mouth of the White Sea. A rare example of evolution through isolation is the Kildin Island cod (*Gadus morhua kildinensis*) found only in the brackish Mogilnoe Lake.
Priority: I

Area 6 - White Sea
The isolated position of the White Sea, its diverse bottom topography and the locally rich input of freshwater has given rise to a particular and varied fish fauna. Cod and Pacific herring have evolved endemic subspecies in the area, and form a basis for rich local fisheries.
Priority: I

Area 7 - Pechora Sea
The Pechora Sea is a shallow and very productive area, known for its wealth of benthic organisms. However, the hydrology of the area does not support highly productive pelagic ecosystems, and the fish fauna is not particularly rich or diverse. The most abundant species is the polar cod, coming in from the eastern Barents Sea and the Kara Sea in autumn, to prepare for subice spawning in winter. The navaga (*Eleginus navaga*) is another abundant species with similar habitat preferences, but primarily spawning close to the coast. The Pechora Sea holds a number of arctic and eastern species not found elsewhere in the ecoregion. Another characteristic is the large number of anadromous fish spawning in the rivers, particularly the Pechora River (whitefish such as *Coregonus lavaretus, C. nasus, C. sardinella, C. autumnalis, C. peled* and *Stenodus leuchichtus nelma*, as well as Atlantic salmon). The Pechora River salmon stock was among the largest in the World some years ago, but has decreased considerably and some of the tributaries are no longer used for spawning. The area has a high degree of naturalness, and species and biotopes are still in a natural state as a result of lack of human-induced disturbance or degradation. There has been little commercial fishery, and hardly any bottom trawling in the area.
Priority: I

Area 8 - Southern banks system
The Murman Rise/Kanin Bank/Goose Bank is a system of productive bank areas vital as a nursery and juvenile area for many of the large, ecologically and economically important fish stocks of the Barents Sea (cod, capelin, haddock). The area contributes to sustain species and ecosystems elsewhere in the ecoregion.
Priority: III

Area 9 - Central Bank
This is a large bank area situated at the Polar Front, with a high diversity of fish species. Several bottom-dwelling species, both Atlantic and Arctic, prosper on a rich benthic fauna. Important feeding area for economically important species, both juveniles and adults.
Priority: II

Area 10 - Great Bank
Large bank area receiving a large degree of input from the marginal ice edge during spring and summer. High diversity of arctic fish species, including several bottom-dwelling species due to the rich benthic fauna.
Priority: III

Area 11 - Southern Spitsbergen Bank
A very rich and highly productive bank area at the Polar Front. Pelagic and benthic production results in very dense fish populations, and the area is one of the best year-round fishing areas in the ecoregion. The edge of the bank area has a complex topography, and there is a system of eddies where Arctic and Atlantic watermasses meet. The number of fish species is high.
Priority: I

Area 12 - The western shelf edge
Enhanced productivity at the shelf edge attracts fish and fish-eating animals, and there is a general year-round high density of several fish species in the southern part of the area. A high diversity of demersal fish occupy the shelf edge in large numbers, such as catfish, brosme and Greenland halibut, as well as cod, haddock, redfish and others. A particular feature of interest is the only arctic deep sea vent in the world, the Håkon Mosby mud volcano, at 72^{o}N, 14^{o}45'E and 1250 meters deep.
Priority: I

Norwegian Arctic Cod. Photo: Tore Larsen

Benthic organisms : Nominated areas

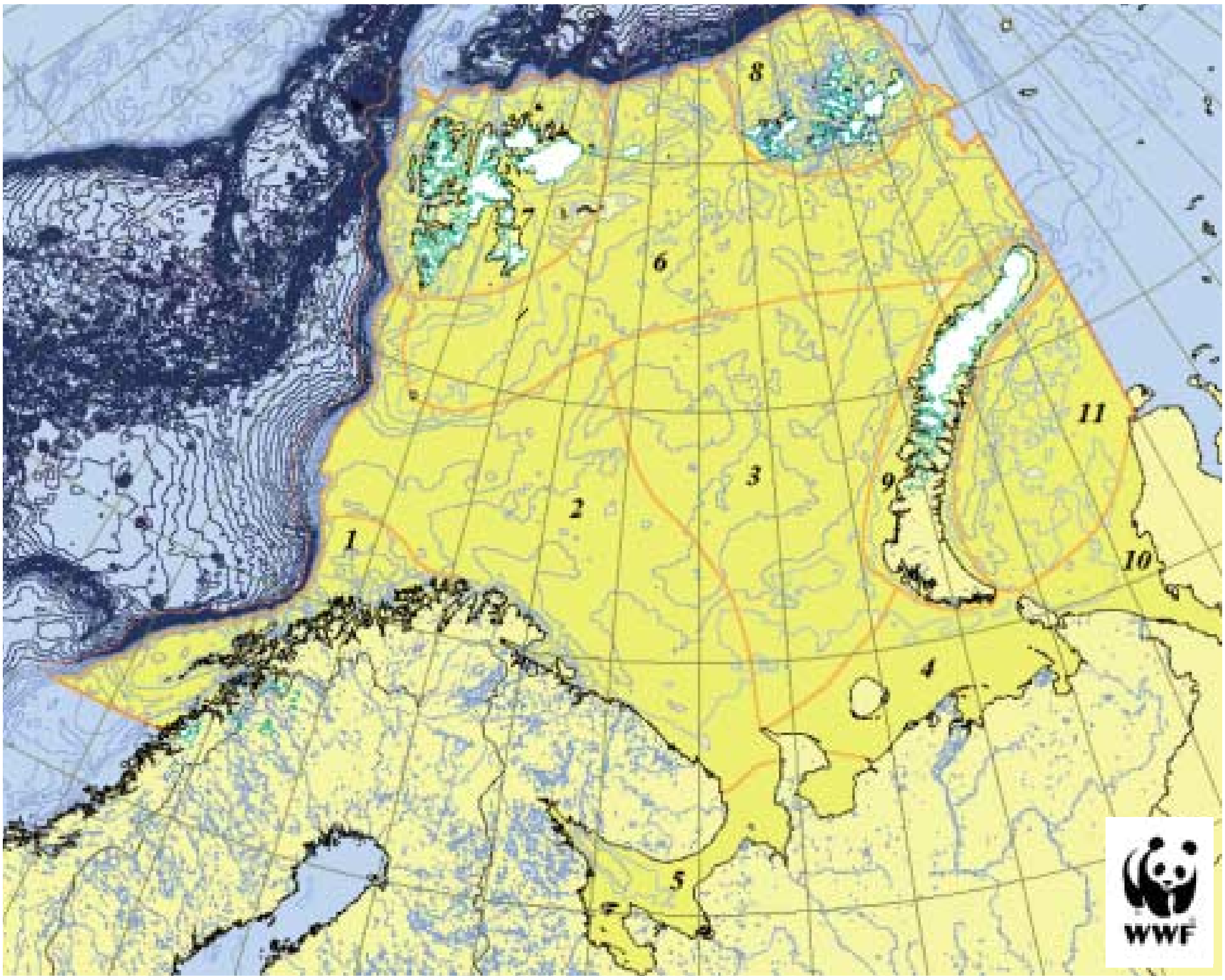


Figure 4.6: Areas nominated for benthic organisms.

Note:
Biomass is a poor indicator of biodiversity. However, biomass has been a basic measure in the Russian benthic surveys, which have delivered very long and valuable data series (and were not originally designed for mapping biodiversity). Biomass values mentioned below include shells and other hard parts. This influences the interpretation of biomass distribution, as areas dominated by bivalves (particularly in the southeast) get disproportionately high biomass values. Further field studies are needed to map the benthic diversity of the Barents Sea and to complement existing information.

Area 1 - North-Norwegian coast and Tromsøflaket
A coastline with a narrow shelf influenced by Atlantic water. Primarily boreal fauna, with some arctic relics in deep fjords. Influenced by warm Atlantic water, the coastal areas have by far the richest benthic biodiversity in the ecoregion. In the intertidal zone, one m^2 may house 150 species and 80,000 individuals (Moe et al. 2000).
Priority: I

Area 2 - Western central Barents Sea
A transition zone between boreal and arctic waters, reflected in benthic fauna composition. In the southeastern part of the Spitsbergen Bank biomass often exceeds 1,500-2,000 g/m^2, with averages between 200 and 1,500 g/m^2 made up mainly of echinoderms, barnacles and bryozoans (Idelson 1930, Antipova 1975, Kiyko and Pogrebov 1997). The deep parts of the area, in the Bjørnøya channel, have rather poor diversity and low productivity. The highest benthic diversity is found on shoals and hard bottom along the Murman coast, which is among the most diverse areas in the ecoregion. Biomass is also high, exceeding 1,500 g/m^2 offshore of

the Seven Islands (strong dominance of bivalves like *Chlamys spp*. and *Modiolus spp.*). The area holds the northernmost coral reef in the world.
Priority: II

Area 3 - Eastern central Barents Sea
The area is characterized by deep waters, with boreal-arctic and arctic benthos. The Central Bank in the western part is among the most productive units (up to 300 g/m^2), but even here species diversity is rather poor. Deep parts (Northeast and Southeast Basins) have a biomass of no more than 25 g/m^2.
Priority: III

Area 4 - Pechora Sea
This is a shallow, high productivity area with exceptional biomass values, particularly in the Kara Gate and the Yugorskiy Shar strait. Up to 10-12,000 g/m^2 have been measured, but samples are very much dominated by bivalves (giving a high biomass score relative to other areas where soft organisms prevail).
Priority: I

Area 5 - White Sea
The White Sea is effectively isolated from other parts of the ecoregion except from the connection through the Funnel. The benthic fauna has high diversity, is relatively unique and productive, and is probably of high ecological significance.
Priority: I

Area 6 - Northern Barents Sea
This is a low productivity area influenced by arctic water. Benthic biomass is in general low, but particularly so in the Northeast Basin and other deep parts.
Priority: IV

Area 7 - Svalbard coastal area
The arctic archipelagos are characterized by high benthic biodiversity, particularly around Svalbard with the most pronounced influence of Atlantic water. The Svalbard coast is highly productive (biomasses of more than 2,000 g/m^2, dominated by soft-bodied organisms, are common), and the diversity is high. The southwestern coast and the Storfjorden area hold the highest number of species, both near shore and in deeper waters.
Priority: I

Area 8 - Franz Josef Land
The arctic archipelagos are characterized by high benthic diversity. Franz Josef Land stands out both in terms of productivity and biodiversity, in spite of its northern position.
Priority: I

Area 9 - Novaya Zemlya
Even with its eastern position, Novaya Zemlya has a diverse and productive benthic fauna. Biodiversity is particularly high in the extreme north, south and east of the Matochkin Shar strait, and towards the Kara Gate. Benthic biomass in some places exceed 1000 g/m^2 at the western shore, while the eastern shore is charecterized by maximum values of 200-400 g/m^2.
Priority: I

Area 10 - Baydaratskaya Bay
The Baydaratskaya Bay in the southernmost, inner part of the Kara Sea is a shallow, but rather low productivity area with a high degree of naturalness. The highest diversity is found on hard bottoms and small depths close to the Yugorskiy Shar strait. This is also where productivity highest (more than 500 g/m^2), in addition to some other productive fields in the center of the area (Kiyko and Pogrebov 1997). Bivalves dominate, particularly *Tridonata spp.*, *Serripes spp*. and *Ciliatocardium spp.*.
Priority: III

Area 11 - Kara Sea
The Kara Sea is a low productivity sea characterized by arctic conditions and constant stratification of water layers due to large riverine input of fresh water. The area has low species diversity, particularly in the places most influenced by the large Siberian rivers and in the northern part of the Novaya Zemlya (Voronin trench). Here, biomass may be as low as 10 g/m^2. The richest diversity is found on hard bottoms and small depths close to the Kara gate.
Priority: IV


Sea slug. Photo: Kåre Telnes


Anemone. Photo: Kåre Telnes

Step 3: Identifying overall priority areas

The five thematic groups nominated, delineated and gave priority value to 58 areas within the ecoregion. The degree of overlap between nominated areas varied from very high in some parts of the ecoregion, to very little in other parts. A high degree of overlap indicates that the area is valuable for several aspects of biodiversity, and that it should be given particular attention and priority in our attempts to maintain the biodiversity of the Barents Sea. Apart from the priority value ranking (I-IV) of nominated areas made by each of the five thematic groups (marine mammals, seabirds, fish, benthos and plankton), the degree of overlap between different themes should therefore also be considered when attempting to tease out the most valuable areas in the Barents Sea from a biodiversity perspective.

The identification of Priority Areas was done by digitizing all the nominated areas from each thematic group, and overlaying them as different themes in GIS. Each individual area was assigned a score based on the value given to it by the thematic group. High priority areas (Priority I) were assigned the top score of 4 points, the lowest priority areas (Priority IV) were assigned a score of 1 point. When overlapping all the five themes, an area could therefore get a maximum priority score of 5 x 4, or 20 points, if all thematic groups had nominated the same area and given it the highest score.

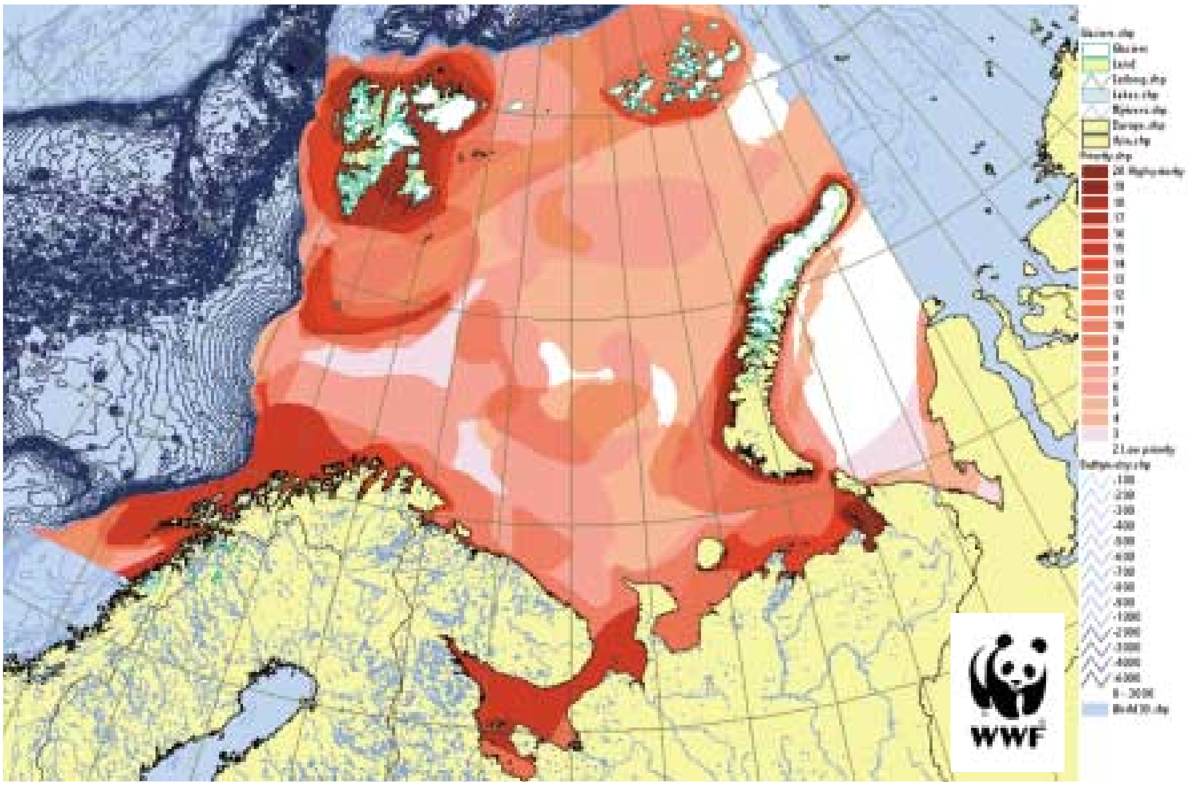


Figure 4.7: The map identifies areas of high value for biodiversity based on the nominated areas from each thematic group (marine mammals, seabirds, fish, benthos and plankton). Dark colour indicates high priority score.

Unfortunately the map of priority overlap does not give a conclusive answer as to what areas are "the most important" for maintaining biodiversity and ecological processes in the Barents Sea ecoregion. The overlap map may not always give sufficient credit to all areas of high importance for sustaining the productivity and biodiversity of the ecoregion. As an example, a source area of a biological resource spreading into other parts of the ecoregion and entering the food chains there, may receive attention from perhaps only one of the thematic groups (the one dealing with the resource in question). A feeding area for recruits to the large fish stocks in the Barents Sea is vital for the entire ecosystem, but it will hardly be nominated by thematic groups working with mammals, seabirds, benthos or plankton. The challenge is therefore to find out which areas are essential to the ecosystem - despite a lack of priority overlap. The task of doing this was to a large degree left to the experts who participated at the biodiversity workshop. After drawing a preliminary map of priority areas, the thematic maps and the overlap map were sent to all workshop participants for comments. The resulting map of priority areas is represented in Figure 4.7.

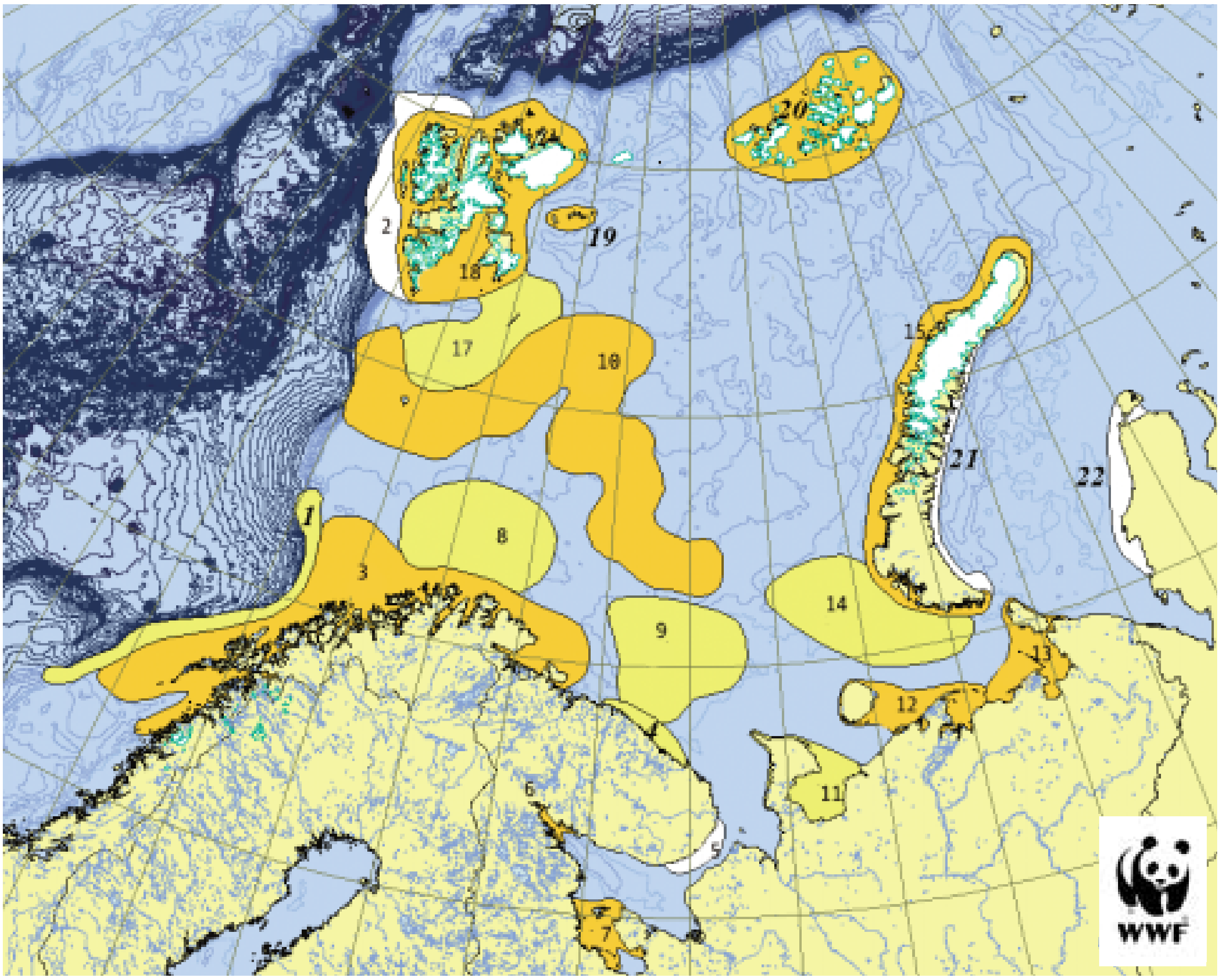


Figure 4.8: The map shows the priority areas for biodiversity conservation in the Barents Sea ecoregion. Dark yellow - very high priority; yellow - high priority; white - priority.

The marginal ice zone is among the most spectacular features of the arctic seas, but difficult to depict on a map. It is a very high priority area, but due to its fluctuating nature it will be treated in the text only.

For each priority area, a so-called "focal species" has been identified. These species are meant to represent a typical biodiversity feature of the area, with a preference for well-known species that exemplify the area's natural values and at the same time are central to the local ecosystem.

A description of subregions and the priority areas are given on the following pages.

Protanthea simplex. Photo: Erling Svensen

5. DESCRIPTIONS OF SUBREGIONS AND PRIORITY AREAS

The following descriptions are based on data already cited in the previous sections. Excepted are the parts on protected areas, which are based on Anon. 2002, Golovkin et al. 2000, Miljøverndepartementet 2000, Nikiforov & Mescherskaya 1999, Ochagov et al. 2001, Sviridova & Zubakin 2000, Theisen & Brude 1998

Subregion I: The western shelf edge

The subregion comprises the edge of the Barents shelf sea, plunging from a depth of 200 meters outside the coasts of Norway and Svalbard, to 3,000 meters or more. The shelf edge is very steep in its northern and southern parts, but descends more gradually at the mouth of the Bjørnøya channel. On its way north along the Norwegian coast, the Atlantic current branches where the shelf edge turns north outside Troms. One branch continues along the shelf edge toward Svalbard, while the other enters the Bjørnøya channel and the central Barents Sea. Where the two branches separate (Tromsøflaket at 72ºN), a complex system of eddies is formed. From the Storfjord channel and further north along the coast of Svalbard, Atlantic water runs parallel to arctic water. This northern end of the Polar Front is situated at the shelf edge. The shelf edge is in itself an example of a frontal system with enhanced productivity due to transport of nutrients into the phototrophic zone.

Priority areas within the subregion:

1. Southwestern Shelf Edge

The Southwestern Shelf Edge plunges from a depth of 200 meters outside the coast of Norway, to 2,600 meters in its deepest and steepest part outside the Vesterålen Islands. The shelf edge is very steep over most of the area, but descends more gradually from 500 meters south of Bjørnøyrenna (Bjørnøya channel).

Outstanding biological features:

3 High productivity and concentration of zooplankton through a combination of high primary production in the area and advection.

3 Enhanced productivity at the shelf edge attracts pelagic fish and fish predators, and there is a general year-round high density of organisms in the area.

3 Demersal fish occupy the shelf edge in large numbers, such as catfish, brosme and Greenland halibut, as well as cod, redfish (Sebastes) and others. Breeding seabirds forage at the shelf edge, making daily feeding trips of up to 130 km from colonies at the Norwegian coast.

3 Moulting auks gather in late summer and autumn flocks at the shelf edge to feed, particularly west of Tromsøflaket.

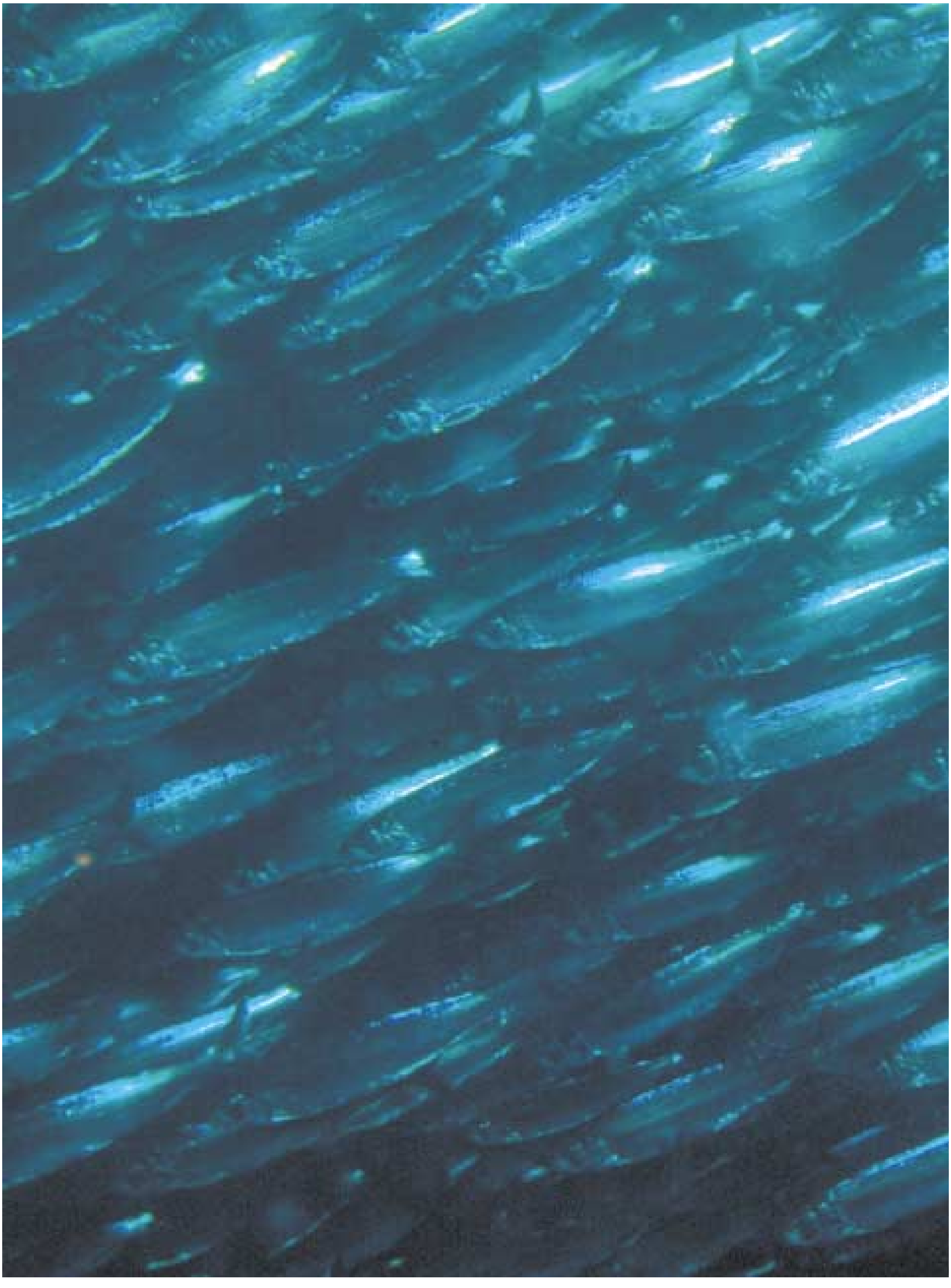
3 Zooplankton, squid, and fish attract sea mammals such as minke whales, sperm whales, dolphins and others. The extremely steep shelf edge outside Andøya is particularly attractive to sperm whale males feeding on deep sea squid.

3 The world's only arctic deep sea vent, the Håkon Mosby mud volcano, at 72°N, 14°45'E and 1,250 meters deep. Discovered in 1995, the "volcano" supports an ecosystem of chemosynthetic bacteria, other invertebrate organisms and fish, through methane seeping from the seafloor.

3 The world's largest known deep-water coral reef, the Røst Reef, was discovered in May 2002. The reef measures approximately 45 X 3 kilometres and is situated between 67° 36.2' N, 009° 32.9' E and 67° 17.3' N, 008° 57.1' E, mainly at depths between 300 and 400 meters in a steep and rugged zone of the continental shelf.

Current conservation status:

On January 4th 2003 the Norwegian Minister of Fisheries enacted the Coral Protection Regulation, which gives the Røst Reef special protection against bottom trawling. A seasonal trawl-free zone also exists at the shelf edge from Vesterålen (Andøya) to mid-Troms.



Norwegian spring spawning herring. Photo: Erling Svensen

Current resource use:
Important region for commercial fisheries, both coastal vessels and large trawlers. Minke whale hunting. Tourism.

Current threats:
Fisheries. Regulations identify depths at which trawlers are allowed to work, but these regulations are difficult to enforce. Marine biologists and fishermen report that trawlers often violate the regulations, and lower their gear beyond allowed depths in order to trawl the sloping bottom.

Oil development is a potential threat.

Focal species: Sperm whale *(Physeter macrocephalus)*

2. Northwestern Shelf Edge

The area comprises the northern edge of the Barents shelf sea, plunging from a depth of 200 meters outside the coast of Svalbard, to the 1,000 meter line. The shelf edge is very steep, and continues to around 3,000 meters. From the Storfjord channel and further north along the coast of Svalbard, Atlantic water runs parallel to arctic water. The northern end of the Polar Front is situated at the shelf edge. The shelf edge is in itself an example of a frontal system with enhanced productivity due to transport of nutrients into the phototrophic zone.

Outstanding biological features:

3 Nowhere else do warm ocean currents reach as far north (80°N at the coast of Svalbard).

3 Enhanced productivity at the shelf edge attracts fish and fish-eating animals; both breeding and moulting auks from the Svalbard colonies gather in flocks at the shelf edge to feed.

3 Zooplankton, squid, and fish attract sea mammals such as minke whales, sperm whales and dolphins. *Calanus hyperboreus* which has a very high fat content (70% of body mass is lipids) attract several of the large baleen whales from the Atlantic Ocean in summer.

3 A diversity of demersal fish occupy the shelf edge in large numbers, such as catfish, brosme and Greenland halibut, as well as cod, redfish and others.

Current conservation status:
None.

Current resource use:
Important region for commercial fisheries, mainly targeted at demersal species.

Current threats:
Fisheries. Regulations identify depths at which trawlers are allowed to work, but these regulations are difficult to enforce. Marine biologists and fishermen report that trawlers often violate the regulations, and lower their gear beyond allowed depths. These actions pose a threat to a.o. the Barents Sea stock of Greenland halibut, which is particularly associated with the shelf edge.
Priority: III

Focal species: Greenland halibut *(Reinhardtius hippoglossoides)*

Subregion II : The Norwegian coastal current and the Norwegian and Murman coasts

The western, Norwegian part belongs to the boreal zone dominated by Atlantic water, while the eastern zone (approximately from the Varanger peninsula eastwards) is arctic-boreal, influenced by colder water from the north and east. The ecoregion is at its narrowest outside Andøya, where the continental shelf ends very abruptly and depth reaches 2,000 meters only 43 km from shore. On the shelf, several banks and deeper areas are inter-mingled (Fugløy Bank, Tromsø Bank, Ingøy Trough, North Cape Bank, Djuprenna). The bottom topography greatly affects the distribution and movement of water masses along the coast: The Norwegian coastal current, which runs along the entire Norwegian coast, takes on a rather irregular pattern when it reaches the Tromsø Bank. The current goes clockwise around the bank, but counter-clockwise around Ingøy Trough nearby, and in both areas several small whirls are formed temporarily, holding passively drifting plankton and fish larvae on site. The Tromsø Bank may hold as much as 90% of the yearly production of Barents Sea cod larvae in June and July. In the northern part of the North Cape Bank, whirls form with a retention time of approximately two months.

These whirls are made in the highly productive transistion zone between the coastal current and the parallel-flowing Atlantic current (the North-Atlantic drift). The Atlantic current flows northward along the Norwegian continental shelf, branching in two when the shelf edge turns north outside Troms. One branch continue along the shelf edge toward Svalbard, while the other enters the Bjørnøya channel and the Barents Sea. It also sends a small branch around the Tromsø bank, from where it follows the Norwegian coastal current eastwards. The coastal current is named the Murman current when it enters Russian waters. It meets with water from the White Sea before it enters the southeastern Barents Sea, where the last traces of warm Atlantic water in some years may reach as far as the coast of Novaya Zemlya.

Salinity and temperature of the Barents Sea water masses fluctuate markedly from year to year, due to variations in the amount of Atlantic water flowing north along the Norwegian coast. The Atlantic current is of vital importance to maintain the relatively mild climate in Northern Europe and the Barents Sea ecoregion. Compared to other areas at the same latitude, mean air temperature is 5-10°C higher (Loeng & Ingvaldsen 2001) (North Cape on the Norwegian mainland is the same latitude as Scoresby Sund in Greenland and Barrow in Alaska). In the outer Lofoten islands, water temperature typically varies from 10-12°C in September to 3-5°C in March. The Murman current holds a lower temperature, usually below 10°C in summer. Winter ice forms in the eastern end of the subregion, and is often landfast at Mys Svyatoy Nos and further east.

Priority areas within the subregion:

3. Norwegian coast and the Tromsø bank

The coast of the area can roughly be divided in three parts: To the south, it is dotted with innumerable small islands and skerries; in the middle (from Lofoten to western Finnmark) it is dominated by fewer, but larger islands, and further north there are few islands, but a number of deep fjords. The coastal landscape is dominated by alpine mountain; the highest island reaches 1,276 meters (Andøya in Troms county). Unlike most of Europe, the Norwegian coast is dominated by rock substrate, interrupted by pebble areas and occasional sandy beaches and small river deltas, mainly in the fjords. Practically the entire length of the shoreline is covered by kelp forests, housing a variety of invertebrate and vertebrate species. The complex coastal topography also helps securing a high production of a variety of stationary organisms. Biogeographically, this boreal zone is dominated by Porifera and Brisaster community types, with Lophelia communities as a special, characteristic feature. The area from Lopphavet (on the border between Troms and Finnmark) to Sørøya is biogeographically very interesting, as this is the northernmost area with relatively warm Atlantic water (Direktoratet for Naturforvaltning 1995)

Three Norwegian counties border the area, all of them with the main bulk of their human population situated along the coast: Nordland, with 239,280 inhabitants in 1998 (6.2 persons per km^2); Troms, with 150,288 inhabitants (5.8 persons per km^2); and Finnmark, with 74,879 inhabitants (1.5 persons per km^2). Communities are typically scattered, only five cities hold more than 10,000 citizens (Tromsø in Troms county is the biggest, with 48,000). The Russian part of the coastline belongs to the Murmansk Oblast. It is sparsely populated, though with a notable increase in population on the eastern side of the Rybach Peninsula, where the bases of the Northern Fleet are situated. The foundation of almost all settlements along the coast has been extraction of fish resources from the coastal waters and the banks offshore. Many small settlements have been abandoned during the last 30 years, mainly resulting from the shift in fisheries toward offshore trawlers, on-board processing of the fish, and landings of the catch far from its origin.

Outstanding biological features:

3 The world's biggest colony of puffins (*Fratercula arctica*) on small islands in the Røst archipelago. At its present level of 500,000 breeding pairs, the total population is approximately 1.2 million. Due to the collapse of the overfished spring-spawning herring stock in the 1960s, the puffin colony is today probably less than half of its historical maximum size.

3 The total seabird breeding population is around 3,000,000 pairs. Herring larvae are the staple food for the 2,000,000 pairs of puffins. The other most numerous species are kittiwake (well over 500,000 pairs), herring gull (100,000 pairs), eider (50,000 pairs), as well as a number of other gulls, terns and auks.

3 The spawning area of the world's biggest cod stock is concentrated in the Lofoten and Vesterålen area (as well as very important spawning areas of other gadoids, like saithe and haddock).

3 The Tromsø bank may hold as much as 90% of the yearly production of Barents Sea cod larvae in June and July.

3 The world's most northern coral reef, found at approximately 71º10' North.

3 The world's most powerful saltwater streams (Saltstraumen and Moskenesstraumen), with very rich benthic faunas.

3 The world's most concentrated wintering population of herring; most of the spring-spawning herring stock (approximately 10,000,000 tons) spends two to three winter months in the Tysfjord/Vestfjorden area (attracting large numbers of killer whales, and at least five other whale species). The area also hold the world's most northern lobster population.

3 The world's largest stock of Atlantic salmon. The Tana River is at present the world's most productive salmon river, while the Alta River has the biggest average fish size.

3 Large areas of kelp forests, dominated by giant kelp (*Laminaria hyperborea*). On the rocky, exposed coasts, kelp forests cover altogether 5,000 km^2 in Norway, a significant proportion of which is found in the ecoregion. The kelp forests are rich in benthic life, and are important nursery areas for many species of fish. Kelp forests of similar biodiversity value are probably only found along the Chilean coast.

3 The world's largest population of white-tailed eagle breeds along the Norwegian coast (roughly 2,000 pairs and increasing), with the main bulk of the population within the ecoregion.

3 Large aggregations of wintering seabirds along the coast (marine ducks) and offshore (alcids)

3 Large aggregations of moulting seabirds in the fjords and in open water. Between 20 and 30,000 mergansers (*Mergus merganser*) moult in the mouth of the Tana River.

3 Important migration stopovers on the East Atlantic Flyway: The inner parts of Porsangerfjord and Balsfjord may hold 20-30 000 (or even more) knots (*Calidris canutus*) in early May, as well as high numbers of other waders both in spring and autumn.

Current conservation status:
A selection of candidates for Marine Protected Areas were proposed along the Norwegian coast in 1995, 15 of these within the ecoregion. In February 2003 an expert group including a.o. environmental NGOs and aquaculture interests appointed by the Ministry of Environment, presented a prioritised list of areas to be protected. These recommendations will form the basis for selecting and enforcing a set of coastal MPAs, probably by 2005. The 11 recommended areas within the ecoregion are: Tanafjord (1,153 km^2), Andfjord (2,692 km^2), Inner Porsangerfjord (398 km^2), Lopphavet (2,234 km^2), Karlsøy (377 km^2), Rystraumen (17 km^2), Rossfjordstraumen (13 km^2), Tysfjorden (314 km^2), Kaldvågfjorden & Innhavet (89 km^2), Saltstraumen (19 km^2) and Karlsøyvær (192 km^2). The total marine area of the potential MPAs is 7,777 km^2.

Today, 46 coastal (terrestrial) nature reserves with marine relevance have been established along the Norwegian coast, mainly islands and skerries with seabird breeding colonies, or wetlands important for breeding or migrating birds. The areas are generally small. See box for details:

FINNMARK:

14 seabird nature reserves protected in 1983 (IUCN category I). Total area 151 km^2, of which 21.8 km^2 marine:

Loppa	(total 2.4 km^2, marine part 0.005 km^2)
Andotten	(total 0.25 km^2, marine part 0.15 km^2)
Storgalten	(total 1 km^2, marine part 0.65 km^2)
Lille Kamøya	(total 1.6 km^2, marine part 1 km^2)
Eidvågen	(total 0.2 km^2, marine part 0.05 km^2)
Reinøykalven	(total 1.8 km^2, marine part 1 km^2)
Hjelmsøya	(total 4.3 km^2, marine part 2.1 km^2)
Gjesværstappen	(total 7.2 km^2, marine part 5.5 km^2)

Sværholtklubben	(total 2.2 km^2, marine part 1.5 km^2)
Omgangsstauran	(total 7.8 km^2, marine part 3.9 km^2)
Kongsøya, Helløya og Skarvholmen	(total 2.8 km^2, marine part 2.05 km^2)
Makkaurhalvøya	(total 116 km^2, marine part 2.5 km^2)
Hornøya og Reinøya	(total 2 km^2, marine part 0.5 km^2)
Ekkerøya	(total 1.6 km^2, marine part 0.9 km^2)

19 marine wetland nature reserves (IUCN category I), all except one protected in 1991. Total area 85.4 km^2, of which 65 km^2 marine:

Stabbursnes	(1983; total 16.2 km^2, marine part 14 km^2). Ramsar area.
Krokelvosen	(total 0.14 km^2, marine part 0.06 km^2)
Sørsandfjorden	(total 1.6 km^2, marine part 0.1 km^2)
Nordsandfjorden	(total 0.9 km^2, marine part 0.2 km^2)
Saksfjorden	(total 0.8 km^2, marine part 0.3 km^2)
Svartbotn	(total 2.2 km^2, marine part 0.2 km^2)
Sanden	(total 0.87 km^2, marine part 0.24 km^2)
Hjelmsøysandfjorden	(total 1.1 km^2, marine part 0 km^2)
Børselvosen	(total 3.2 km^2, marine part 2.4 km^2)
Viække r/Vakkare	(total 0.6 km^2, marine part 0 km^2)
Adamsfjord	(total 1.3 km^2, marine part 1 km^2)
Kinnaroddsandfjorden	(total 1.6 km^2, marine part 0.6 km^2)
Vestertana	(total 0.85 km^2, marine part 0.8 km^2)

TROMS:

3 seabird nature reserves (IUCN category I). Total area 27.05 km^2, of which 0.67 km^2 marine:

Nord-Fugløy	(1975, total 21.3 km^2, marine part 0 km^2)
Gapøya	(1976, total 4.5 km^2, marine part 0 km^2)
Store Follesøya	(1990, total 1.25 km^2, marine part 0.67 km^2)

1 bird protection area (IUCN category IV):

Lille Follesøya	(1990, total 0.65 km^2, marine part 0.15 km^2)

1 area with zoological species protection (IUCN category IV):

Nord-Fugløy marine areas	(1975, total area not known, marine part not known)

1 landscape protection area (IUCN category V):

Skipsfjord	(1978, total 52 km^2, marine part 10 km^2)

NORDLAND:

3 seabird nature reserves (IUCN category I). Total area 90.4 km^2, of which 78.89 km^2 marine:

Bliksvær	(1970, total 40 km^2, marine part 36.5 km^2)
Skittenskarvholmene	(1974, total 0.4 km^2, marine part 0.39 km^2)
Karlsøyvær	(1977, total 50 km^2, marine part 42 km^2)

2 wetland/bog nature reserves (IUCN category I). Total area 59.4 km^2, of which 26.5 km^2 marine:

Skogvoll	(1983, total 53 km^2, marine part 25 km^2)
Gimsøymyrene	(1983, total 6.4 km^2, marine part 1.5 km^2)

2 areas with zoological species protection (IUCN category IV). Total area 203 km^2, of which 197 km^2 marine:

Bliksvær	(1983, total 103 km^2, marine part 97 km^2)
Karlsøy marine area	(1983, total 100 km^2, marine part 100 km^2)

The total area of protected areas with marine relevance in the three counties is 668.9 km^2, of which the marine part makes up 400 km^2. The Russian Ainov Islands (part of the Kandalakshsky Zapovednik) add to the sum with 12.2 km^2 (9 km^2 marine). Fisheries are regulated through a number of closure areas and flexible trawl-free zones.

Current resource use:

Fish and marine mammals of the Barents Sea have been the foundations for human settlements in the area. The dependence on fish resources still prevails. Although other means of living have gradually become more important during the last fifty years, nearly all of the small villages and settlements along the coast depend heavily on fisheries.

The Norwegian fleet of small coastal vessels was not subject to quota limitations until 1989. This fleet has been reduced by two thirds in the last ten years, due to the Norwegian policy of favouring offshore trawlers. Most of the large trawlers (particularly the factory trawlers) are registered in Western Norway, far south of the ecoregion. Overfishing has become a permanent threat to most fish stocks in the region.

The use of marine mammals is not important anymore, after overharvesting brought the most important species to the brink of extinction. Today's level of Norwegian minke whale and seal hunting is heavily subsidised. Quotas are set to 20,000 harp seals, 10,300 hooded seals and 655 minke whales (as of 2000).

Kelp harvesting on a large scale is a relatively new activity in Norway. Due to the destruction of large areas of kelp forests by sea urchins, kelps are not harvested to any extent in Northern Norway (only locally south of the Lofoten area).

Current threats:

Pollution from the petroleum sector. Oil and gas development in the Norwegian Barents Sea constitutes a threat both during exploration and any future development phase. Oil has been found in wells drilled as close as 60 km from shore. In case of an accident, the shortest estimated drift time for an oil spill from these wells is 36 hours to Gjesværstappen, the second largest seabird colony in the ecoregion. The Snøhvit gas field has been opened for production, and this is likely to facilitate development of other gas and oil fields nearby. Oil production in this area could result in the release of oil directly into the ecoregion's most dense concentration of cod larvae at Tromsøflaket, where 95% of a year's production of cod larvae may be present in summer. This is also close to the spawning sites of several economically and ecologically important fish species. Also Lofoten - Vesterålen is highly vulnerable to an oil spill.

Ship-based pollution. The coastline in the area is among the most hazardous in the world, with rough weather and innumerable islands, skerries and rocky shallows. A network of ship lanes between the islands is necessary in order to cover the multitude of harbours along the coast, and groundings and collisions occur frequently, with oil spills as a result. It has been estimated that three large oil tankers will pass along the Barents coast every day of the year by 2010.

Nuclear waste. Russia is planning to import nuclear waste from Europe, as well as to facilitate transport from Europe to Japan via the Northern Sea Route. In both cases, the radioactive material will be shipped along the Barents coast.

Overfishing. Throughout the years, overfishing has seriously depleted some of the most economically important fish stocks in the ecoregion. Today, five of the nine most important fish stocks in the Barents Sea are fished more than recommended. There are serious concern about local stocks of coastal cod and the strong decline in redfishes. Repeated overfishing of important stocks has caused several collapses in seabird populations. The puffin colony on Røst is presently less than half its 1980 level, and the common guillemot population has decreased to a fraction of its former size probably because of overfishing and drowning in fish nets.

Destruction of benthic communities. Offshore benthic communities have been damaged by intensive bottom trawling. The extent of the damage is not known, but may be extensive. Offshore trawlers are known to destroy coral reefs intentionally to get easier access to fish resources, thereby destroying important nursery areas and biodiversity hotspots. The Norwegian Institute for Marine Research has estimated that between one third and half of the reefs have been impacted by destructive fishery practices, and local fishermen complain that catches of in particular redfishes (*Sebastes* spp.) have declined drastically after trawling activities near coral reefs. Deep-water corals only grow 0.5-1.0 cm per year, and a reef needs a very long time to regrow after damage. Kelp (Laminaria) trawling is not performed in the region, partly because sea urchins have already done so much damage to the kelp forests. Ascophyllum nodosum is harvested locally north to Lofoten, but regrowth is good and the activity is considered to have little or no negative impact (Fosså 2000).

Introduction of alien species. A number of alien species have been introduced to the Russian north as part of Soviet plans for improving nature's yield. The most notable example is the Kamtchatka king crab, released at Teriberka in the 1960s and now spreading with alarming speed along the Norwegian coast up to Svalbard . The impact of this giant crab on other parts of the benthic community is not known, but it has become a very numerous species in coastal areas.

Tourism. Whale watching takes place at an increasing number of sites with commonly agreed rules of conduct, but several boats of different sizes may be continuously present during daylight hours, following single whales or flocks of killer whales closely as they surface or round up schools of herring.

Focal species: Puffin *(Fratercula arctica)*

4. Murman Coast

The Russian part of the subregion shows a gradual transition from the western fjord areas to a smooth, low-lying, shallow coastline typical for the southeastern Barents Sea, but remnants of the western fjord and skerries system are still present. Groups of small islands and capes are found along the coast of the area. The complex coastal topography helps to secure the high production of a variety of benthic organisms. Biogeographically, the arctic-boreal Murman coast is marked by a mixture of shallow water complexes with predominance of *Strongylocentrotus, Astarte borealis, Cardium spp.* and others. Practically the entire length of the shoreline is covered by kelp forests, housing a variety of invertebrate and vertebrate species.

The Kola Peninsula is entirely within the Murmansk Oblast, with a total population of 1.1 million people, 92% of which live in 12 cities and 20 small towns (average 8.3 inhabitants/km^2). Prior to the 1917 revolution, Murmansk was only a small village. The population has grown very rapidly since the end of World War II, and the city of Murmansk is the region's administrative center, with nearly 400,000 inhabitants. Main occupations are within mining & industry, fisheries, and the military.

Outstanding biological features:

3 Seabird colonies, although not very large compared to other parts of the ecoregion, generally hold a broad range of species because distribution ranges of eastern and western species meet.

3 Seabird colonies sustain viable populations of rare raptors like peregrine falcon and gyrfalcon. Healthy, possibly increasing population also of the white-tailed eagle.

3 Important migration, moulting and wintering areas for marine ducks (in particular Steller's eider) and other seabirds (mainly auks and divers). While the most important moulting areas have been identified east of Mys Svyatoy Nos, wintering areas are concentrated between Mys Svyatoy Nos and Mys Teriberskiy.

3 High diversity of benthic species, with a particularly rich area centered at Mys Teriberskiy. The highest benthic diversity is found on shoals and hard bottom - this area is among the most diverse in the ecoregion. Biomass is also high, exceeding 1,500 g/m^2 offshore the Seven Islands (with a strong dominance of bivalves like *Chlamys spp*. and *Modiolus spp*.).

3 Several important spawning rivers for the Atlantic salmon.

3 One endemic subspecies of fish– Kildin Island cod (*Gadus morhua kildinensis*) in brackish water on Kildin Island.

Current conservation status:

The Kandalakshski zapovednik is split in two main parts, one of which covers 135 km^2 in three localities on the Murman coast: The two Ainov Islands at the western coast of the Rybachi Peninsula (12 km^2, hereof 9 km^2 marine); the eight Gavrilovskie Islands (16 km^2, hereof 15 km^2 marine) and the Seven Islands (Sem Ostrovov, 107 km^2, hereof 100 km^2 marine).

The Lake Mogilnoe Natural Monument on Kildin Island is a relic brackish-water lake of 0.17 km^2.

The Nottinsky riverine Zakasnik of 158 km^2 protects a salmon population in the Kola Bay area.

Current resource use:

The fishing industry used to be the most successful industry operating in the region. In 1997, the Murmansk Oblast supplied 16 percent of Russia's fish production. The Murmansk Trawl Fleet owned 86 fishing vessels fishing in the Barents Sea, in the Northwest Atlantic, and in the waters around the African continent. The Murmansk Trawl Fleet used 19 percent of the Russian-

Norwegian quota for fishing in the Barents Sea. Today, the world's largest fish processing plant in Murmansk is hardly in use at all. Seventy to eighty percent of the catch of Murmansk fishing companies is exported to Norway, Denmark, Germany, Canada, and Great Britain. Most of the fish processing takes place in these countries. Smaller processing units are operating in Murmansk and the local production is increasing.

Important economic species are cod, plaice, halibut, herring and salmon. King crab fisheries are developing into a locally important industry after the introduction of this species to the Murman coast in the 1960s. Clams are also harvested, and plans exist for the harvesting of sea urchins. The use of marine mammals is not important anymore, after overharvesting brought the most important species to the brink of extinction. Kelp harvesting is a traditional way of using natural resources, but today's range of activities is unknown.

Current threats:
Pollution. Local pollution from settlements is a problem because of the lack of sewage processing facilities. The problem is most notable in the Kola fjord and bay area, where sewage from half a million people is released with little or no treatment. Routine and accidental releases from local industry also contribute. The Kola fjord today is a biologically devastated area, but other fjords and bays are also in a poor state. A submarine reactor melt-down in the Ara Guba naval harbour in 1989 released 74 TBq to the sea, and an area of one km^2 in the bay was contaminated.

Ship-based pollution. As Russia is increasing its oil exports it has become necessary to explore new possibilities for transportation to the markets in the west. In the Kola fjord, close to the city of Murmansk, oil transported in smaller vessels from the White Sea and the Pechora Sea is being transferred to large tankers with a capacity of up to 100,000 tons. This activity is expected to increase dramatically in the coming years, and capacity is currently being expanded (Frantzen & Bambulyak 2003). If the pipeline from eastern Russia to Murmansk, with a capacity of as much as 100 million tons of crude oil per year, is constructed as planned, tankers carrying 250,000 tons of oil will frequent the ecoregion on a daily basis (Frantzen & Bambulyak 2003). Apart from ships using local ports, ship traffic from any part of the Russian north to western Europe pass along the Murman coast.

Overfishing. Heavy fishing pressure on young cod and other gadoids, affecting recruitment rates (see area 5).

Nuclear waste. The Murman coast holds the world's highest density of nuclear reactors, due to the high number of nuclear submarines and ships of the Northern Fleet stationed in the area. Decommissioned reactors, exhausted fuel cores and other solid and liquid waste are stored in highly improper facilities, often outdoors. At the naval base in Gremikha, solid radioactive waste in the form of reactor cores and fuel elements, together with 2,000 m^3 of liquid waste, is being improperly stored. There is a continuous risk of leaks. Russia is planning to import nuclear waste from Europe, as well as to facilitate transport from Europe to Japan via the Northern Sea Route. In both cases, the radioactive material will be shipped along the Murman coast.

Destruction of benthic communities. Offshore benthic communities have been damaged by intensive bottom trawling (Denisenko 2001). The extent of the damage is not known, but may be extensive. Dredging for Iceland scallop *Chlamys islandica* is developing in the area. The species collapsed 15 years ago on the Bjørnøya bank after only a few years of fishing, and researchers fear that the same thing will happen again here. Destruction of bottom communities also occurs because of dumping of waste and dredged materials.

Introduction of alien species. A number of alien species have been introduced to the area as part of Soviet plans for improving nature's yield. The most notable example is the Kamtchatka king crab, released at Teriberka in the 1960s, now spreading along the coast and to the banks. The impact of this giant crab on other parts of the benthic community is not well known, but it has already become very numerous.
Priority: II

Focal species: Iceland scallop *(Chlamys islandica)*

Subregion III: White Sea

The White Sea belongs to the arctic-boreal zone, and is characterized by a particular Portlandia arctica community in the deep areas, and a mixture of shallow-water communities on hard and soft bottom. It is enclosed by land on all sides, except for the channel-like connection to the Barents Sea (the Funnel or Gorlo). The limited exchange of water and a large amount of fresh-water runoff results in oceanographic features quite different from the rest of the ecoregion; for instance a lower salinity (10-30‰) and sea temperatures reaching 12-15ºC in summer and below zero in winter. Land-fast ice forms along the shore and in bays in winter, and drift ice in the open sea. The White Sea is ice-free only for five months a year, except for polynyas forming particularly in Onega Bay.
The shores of the White Sea vary from steep cliffs in

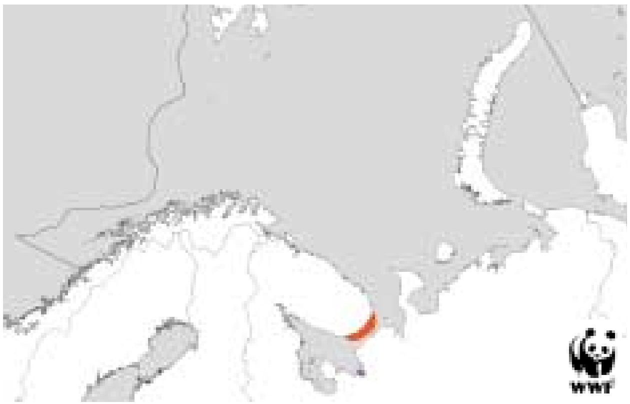
parts of the eastern coast, to low shores covered with forest. The taiga extends even to the larger islands. Kandalaksha Bay to the west, and Onega Bay to the south, together contain more than 2,000 small islands. Although reaching a depth of 340 meters, the average depth of the White Sea is only 67 meters - and about one third of the sea is shallow with depths of about 30 meters. Both in the Onega Bay and in the Mezinsky Bay, the tidal zone is several kilometers wide. Blue mussels appear locally in concentrations of up to 50 kg/m^2. The White Sea holds some of the world's most productive Atlantic salmon spawning rivers. Both the Severnaya Dvina and the Varzuga River held an estimated population of 60,000 spawning individuals in the mid 1900s. The Varzuga now holds an estimated 25 to 40,000 spawners and is considered stable, while the situation for the Dvina is more vulnerable (10 to 30,000 spawners today). Cellulose factories in the Dvina Bay catchment area have made the last kilometers of the Severnaya Dvina highly toxic, through regular "accidental" releases of mercury and other heavy metals, lignin, and organochlorine compounds. Cleaning facilities are almost absent. To protect salmon stocks, two riverine zakazniks have been established on the Kola Peninsula: Varzuga riverine zakaznik (387 km^2) protects the Varzuga River salmon population, while the Ponoi riverine zakaznik (1 500 km^2) protects the Ponoi River salmon population. A number of endemic fish subspecies have been described from the White Sea, such as the White Sea herring *Clupea pallasi maris-albi* (of Pacific origin) and the White Sea cod *Gadus morhua maris-albi*.

As Russia is increasing its oil exports it has become necessary to explore new possibilities for transportation to the markets in the west. Since 2002 oil has been transported by railway to several ports in the White Seawhere they supply small to medium sized oil tankers. In the summer of 2003 experiments were also carried out to see whether the White Sea Channel is suitable for oil transport. Although it is impossible to predict the extent of oil transportation in the White Sea in the future, it seems likely that all ports in the White Sea with railway connection and sufficient depth will be involved in the increased exportation of Russian oil to the west, including Vitino, Onega Bay, Severodvinsk and Archangelsk (Frantzen & Bambulyak 2003).

Administratively, the White Sea is surrounded by Murmansk Oblast to the north, the Karelian Republic to the west, and Arkhangelsk Oblast to the southeast and east. The marine part of the protected areas in the White Sea amounts to 521 km^2 altogether. Several terrestrial protected areas border the White Sea.

Priority areas within the subregion:

5. The Funnel



The area borders low shores covered with forest on the Kola Peninsula. Shallows extend from the shore, reaching a maximum depth of less than 100 meters in the central part of the Funnel.

Outstanding biological features:

- Breeding, moulting and mating area for the Barents Sea population of harp seal, and the most important breeding site of harp seals in the Northeastern Atlantic. Russian scientists estimated the number of newborn pups in the area to be somewhere between 240-350,000 in 1998, suggesting a total population in the ecoregion of approximately two million animals.

- Migration corridor for a number of species, among them herring and beluga (white whale). In summer, the resident beluga population of 800 individuals increases to 2,500-3,000, due to visitors from the Barents Sea stock.

- An important moulting and stopover site for seaducks. In winter, a polynya opens along the shore and is an important wintering site for eiders. The common eider is most numerous, but the winter population of Steller's eider is also notable.

- Important Atlantic salmon spawning rivers, such as the Ponoy River in the north (ca. 25,000 spawners) and the Strelna River to the south of the area.

Current conservation status:
None.

Current resource use:
Fisheries and marine mammal hunting have been the foundations for human settlement along the White Sea coasts, particularly in the northern areas. The harp seal hunt in winter/spring is still vital to several of the small settlements along the Funnel, and their economies are to a large degree based on the yearly harvesting of harp seal

and salmon. The most important economic fish species are herring and salmon, with cod, navaga and different species of whitefish taken as well.

Tourism is developing, although hindered by economic problems, and the White Sea area has for many years been popular for recreation. During the last ten years, "salmon tourism" has developed in the largest rivers: Parts of rivers, or entire tributaries, have been reserved exclusively for foreign tourists who leave hard currencies in expensive and luxurious camps - sometimes displacing local people, who have traditionally fished the rivers there.

Current threats:

Overfishing. Lack of enforcement has lead to overfishing of economically important species. Poaching has been identified as the main threat to salmon stocks, and is more important than all other threats together. Lajus & Titov (2000) estimate that poaching reaches 50% of the total salmon catch.

Tourism is developing in the area, and may need to be regulated to some extent. Salmon tourism causes concern when tour companies bribe local officials in order to expel local people from their traditional fishing areas.

Ship traffic. An increasing number of ships carrying oil from various ports in the White Sea are expected to pass through the area in the very near future. Apart from oil pollution from busy ship lanes and waste disposal from ships, another threat appears in areas where both ship routes and animals concentrate. Ship traffic to and from the harbours of Kandalaksha, Onega, Arkhangelsk and Severodvinsk plays an important role disturbing wildlife both in open water and in icebreaker leads through polynyas. A significant traffic of submarines goes between Severodvinsk and other military ports outside the area. Ships may disturb flocks of flightless moulting ducks, break fast ice in the breeding grounds of harp seals, or disturb polynyas with winter flocks of seabirds or sea mammals.

Diamond production from land and sea bottom is developing (until today production in the Funnel has been on hold).

Seal harvesting. The harvest of harp seals is subsidised by the government, and has been an important part of the local economy in small settlements along the coast. The harvest is not currently a threat at the population level. However, this may change due to the effect of climate changes on ice conditions, and as a result monitoring is very important.

Priority: III

Focal species: Harp seal *(Phoca groenlandica)*

6. Kandalaksha Bay

The area is dominated by low shores covered with forest, the taiga extending even to the larger islands. Kandalaksha Bay contains hundreds of small and a few larger islands. Although reaching a depth of 300 meters in the eastern end, the inner part of the area is shallow and influenced by runoff from several small rivers. The city of Kandalaksha with 49,000 inhabitants (1996) is situated in the inner end of the bay, with local industry that includes an aluminium smelter, fish processing plants and timber factories. The vast beds of eelgrass in the bay disappeared in the late 1960s.

Outstanding biological features:

3 The area is dotted with small islands and skerries, housing a high number of seabird colonies. Although generally of small size, the 355 colonies hold a breeding population of 15-20,000 pairs. Of a wide range of species, the eider is the most numerous, with a population of ca. 5000 pairs.

3 The resident White Sea population of beluga (white whale) has one of its primary summer areas in the outer part, near the Umba River.

3 Important high density breeding site of ringed seal.

3 Important Atlantic salmon spawning rivers, such as the Umba River in the north (ca. 8,000 spawners) and the Keret River to the south of the area.

3 A stable polynya near the large islands in the southeastern bay is an important wintering site for marine mammals and seabirds.

3 The tidal front system in the bay results in elevated production of plankton, and the area is important as a herring feeding site.

3 Rich benthic fauna, both in terms of diversity and density.

Current conservation status:
Murmansk Oblast. The main branch of the Kandalakshskiy zapovednik is situated in the inner part of the Kandalaksha Bay. It consists of 358 small islands and open water, covering a total of 208 km^2. Mudflats of Palkina Bay natural monument (Lechebnye Griazi Palkinoi Guby) within the municipality of Kandalaksha cover 4 km^2 in the littoral zone. Keret' Island zakaznik in the Karelian part of the Kandalaksha Bay covers 21 km^2.

Current resource use:
Woodworking and the timber industry are important local industries, developing during the last fifty years after World War II. The growth of the largest cities is based largely on industrial activities, although there are numerous settlements based on the yearly harvesting of salmon.

The most important fish species are herring and salmon, with cod, navaga and different species of whitefish taken as well. Another notable species of economic value is the Pacific salmon species *Oncorhynchus gorbusha*, which was introduced to the White Sea as part of Soviet plans for improving nature's yield, and today is spawning in most of the rivers of the White Sea. Seabird hunting and egg collection has turned into a common activity due to the economic crisis in Russia.

Tourism is developing, although hindered by economic problems, and the White Sea area has for many years been popular for recreation. During the last ten years, "salmon tourism" has developed in the largest rivers: Parts of rivers, or entire tributaries, have been reserved exclusively for foreign tourist who leave hard currencies in expensive and luxurious camps - sometimes displacing local people, who have traditionally fished there.

Current threats:
Overfishing. Lack of enforcement has lead to overfishing of economically important species. Poaching has been identified as the main threat to salmon stocks, and is more important than all other threats together (Lajus & Titov 2000).

Hunting and egg collection have eradicated several seabird colonies, particularly near densely populated areas. This activity has increased considerably since 1994. If the economic situation remains difficult for several years to come, this sort of household hunting is likely to develop further and affect even the nature reserves and other protected areas. Some of these have already been emptied.

Tourism is developing, and may affect seabird colonies in particular. Salmon tourism causes concern when tour companies bribe local officials in order to expel local people from their traditional fishing areas.

Activities on the seashore and river basins, such as deforesting, timber rafting (releasing harmful resin substances), and timber processing. Cleaning facilities are almost absent. The vast beds of eelgrass (*Zostera marina*) in the bay disappeared in the late 1960s, followed by a heavy decrease in the biomass of three-spined sticklebacks (*Gasterosteus aculeatus*) and a subsequent fall in the arctic tern population from 6000 to 2000 pairs.

Pollution from cities, ports and ships is a threat. Oil pollution from busy ship lanes can cause heavy mortality in the dense aggregations of seabirds wintering in polynyas, as well as among breeding birds in the archipelagoes.

Ship traffic. In 2002, the port of Vitino was approved for year-round transportation of oil. In 2003 the expected transport volume was 3.5 million tons, but with minor improvements the volume could soon be increased to more than 6 million tons per year (Frantzen & Bambulyak 2003). The harbour is situated very close to the Kandalakshskiy zapovednik, and the risk of an oil spill is probably high as the oil terminal is exposed to strong winds and currents. Ships may disturb flocks of flightless moulting ducks, break fast ice in the breeding grounds of ringed seals, or disturb polynyas with winter flocks of seabirds or sea mammals.

Introduction of alien species. The salmon parasite *Gyrodactylus salaris* seems to be responsible for the demise of Atlantic salmon from the Keret River, formerly one of the best salmon rivers in the inner White Sea.

Focal species: Eider *(Somateria molissima)*

7. Onega Bay

The taiga extends even to the larger islands. Onega Bay contains approximately 1900 small and large islands. In the Onega Bay, the tidal zone is several kilometers wide. Blue mussels appear locally in high concentrations. The area is ice-free only for five months a year (except for polynyas forming at several sites in the bay), but mussels and other benthic life avoid the eroding effect of ice due to the richness of rocks and boulders along the shores. The largest city is Onega, one of the oldest ports in Russia, with 26,000 inhabitants in 1996. Forestry is essential to this city, which held 35 sawmills in 1995.

Outstanding biological features:

3 The waters around the Solovetsky Islands is one of the most important of several breeding sites for the resident population of beluga (white whale), consisting of at least five local populations numbering altogether 800 individuals with specific breeding sites and migration routes. In summer, the White Sea houses 2,500-3,000 animals, due to visitors from the Barents Sea stock.

3 Important high density breeding site of ringed seal at the Solovetsky islands and the inner part of the bay.

3 A very high number of seabird colonies. Although each of them small, the 333 colonies hold an estimated 40,000 pairs of breeding birds. They include significant proportions of the Russian breeding populations of a.o. razorbill (3,000 pairs) and lesser black-backed gull (1,700 pairs). The most numerous species is the arctic tern, with ca. 15,000 pairs. A total of 150 bird species is recorded through different times of the year.

3 The Onega Bay is the most important area in the White Sea for migrating and wintering birds, and a very large proportion of the White Sea breeding population of eiders (30-40,000 birds) and black guillemots (ca. 10,000) spend the winter in the several stable polynyas in the area.

3 The area holds a number of endemic subspecies, such as the White Sea herring *Clupea pallasi maris-albi* (of Pacific origin) and the White Sea cod *Gadus morhua maris-albi*.

3 The tidal zone is several kilometers wide. Both meadows, tidal flats and open sea are important staging areas on the East Atlantic Flyway.

3 A local front system near the Solovky Islands due to freshwater input results in high productivity of phyto- and zooplankton, and the area is a vital feeding area for a.o. herring.

3 Rich benthic fauna, both in terms of diversity and density. Blue mussels appear locally in concentrations of up to 50 kg/m^2 (A. Naumov, pers. comm).

Current conservation status:

Karelian republic.

The Kuzova Islands zakaznik includes a group of 13 larger and several small islands, covering 9 km^2 land and 25 km^2 water (Ramsar site).

The Onega Bay Ramsar site is covered in part by a set of Karelian zakazniks: The Sorokskiy, the Shui-Ostrov and the Von'domskiy. Most of their area is terrestrial, and the extent of the marine parts is uncertain.

Arkhangelsk Oblast.

The Solovky Islands are protected as a cultural heritage site (cultural-natural museum zapovednik), covering 347 km^2 land area (Ramsar site). Cape Belushiy on Bolshoi Solovetskiy Island is a natural monument, known for summer concentrations of white whales. This area has recently been covered by a special protective regime "without official status".

Current resource use:

Woodworking and the timber industry have been the most important base for settlement in the area, particularly during the last fifty years after World War II. The growth of the largest cities is based largely on industrial activities, although there are numerous settlements based on the yearly harvesting of salmon and seals.

The most important economic fish species are herring and salmon, with cod, navaga and different species of whitefish taken as well. Another notable species of economic value is the Pacific salmon (*Oncorhynchus gorbusha*), which was introduced to the White Sea as part of Soviet plans for improving nature's yield, and today is spawning in most of the rivers of the White Sea. As everywhere else in the ecoregion, overfishing has become a permanent threat to several fish stocks. Seabird hunting and egg collection have become a problem locally, although not in a scale comparable to Kandalaksha bay. Tourism is developing, although hindered by economic problems, and the White Sea area has for many years been popular for recreation.

Threats:

Pollution from cities, ports and rivers is considerable. Riverine pollution from industry (particularly the cellulose industry) and other industrial activities in the watershed is a problem in most of the White Sea. Oil pollution from busy ship lanes can cause heavy mortality in the dense aggregations of seabirds wintering in polynyas, as well as among breeding birds in the archipelagoes and on the vast tidal flats. Dumping of ammunition and poisonous chemical agents from the Second World War has been reported.

Ship traffic. Onega Bay was approved for oil transport in the ice-free season from 2003. Oil will be transported by smaller vessels to a large tanker functioning as a floating terminal. According to plans, tankers between 20 and 80,000 tons will be transporting oil from the terminal and the maximum capacity has been estimated to 5 million tons per year (Frantzen & Bambulyak 2003). In addition to the risk of an oil spill, ships may disturb flocks of flightless moulting ducks, break fast ice in the breeding grounds of harp and ringed seal, or disturb polynyas with winter flocks of seabirds or sea mammals.

Overfishing. Lack of enforcement has lead to overfishing of economically important species. Poaching has been identified as the main threat to salmon stocks, more important than all other threats together (Lajus & Titov 2000). The Kem River used to hold up to 10,000 spawning salmon, but the population seems to be largely lost today. The situation in the Onega River is not known.

Tourism is developing, and may affect seabird colonies in particular. Apart from direct disturbance, man-induced forest fires in the breeding season has become a problem in places. Although not necessarily linked to tourism, salmon poaching in the rivers is a problem. Lajus & Titov (2000) estimate that poaching reaches 50% of the total salmon catch in the White Sea. Implementation of local protection regulations is lacking.

Activities on the seashore and river basins, such as deforesting, timber rafting (releasing harmful resin substances), and timber processing, are threats. Although not as bad as in the Dvina bay catchment area, the cellulose industry is the single most important polluter. Sewage treatment facilities are almost absent.

Focal species: Blue mussel *(Mytilus edulis)*

Subregion IV: Central Barents Sea south of the Polar Front

Arctic-boreal, delimited to the north by the Polar Front. The subregion is defined as the part of the Barents Sea (minus the Norwegian and Murman coast subregion) dominated by Atlantic water. Several banks at less than 200 meters depth are intermingled with deeper areas, resulting in a complex bottom topography influencing the direction and distribution of currents. The banks are important feeding areas for the large fish stocks of the Barents Sea, due to higher densities of benthic organisms. Oil and gas resources in the region are extensive, but their development will require considerable investment. According to local research estimates, prospective oil fields could potentially yield up to 40 million tons in the next 10-15 years. The world's largest gas condensate field, Shtokmanovskoye, is located on the Barents Sea shelf, 600 kilometers off the coast of the Kola Peninsula. Its gas production potential is estimated at 3 billion cubic meters.

Priority areas within the subregion:

8. North Cape Bank

This area is part of a complex seafloor landscape of banks and deeper areas intermingled north of the Norwegian coast (Fugløy Bank, Tromsø Bank, Ingøy Trough, North Cape Bank, Djuprenna). The bottom topography greatly affects the distribution and movement of Atlantic water masses into the Barents Sea. At 2-300 m, the North Cape Bank is not among the most shallow banks, but it is an important feeding area for the large fish stocks of the Barents Sea.

Outstanding biological features:

3 The world's northernmost sea area influenced by warm oceanic currents.

3 Important feeding area for fry and young fish of several large fish stocks.

3 Numerous large and small eddies, particularly where different water masses meet, influence the distribution and abundance of plankton and fish larvae, keeping them on site for prolonged periods.

3 The area remains ice-free throughout the year, and is a very important wintering area for seabirds, in particular auks (guillemots) and gulls (kittiwake). The migration of swimming guillemots with chicks from colonies on Bjørnøya and the Norwegian coast meet in this area, but the exact location of concentrations changes from year to year depending on fish resources.

3 Migration routes in the yearly cycle of cod, herring and capelin between the ice edge/Polar Front in the north, and spawning areas to the south of the subregion

Current conservation status:
None.

Current resource use:
Important region for commercial fisheries: Pelagic fishery for herring, trawling for cod and other gadoids, redfish (*Sebastes spp.*), shrimps (*Pandalus borealis*) and others. Minke whale hunting in the Norwegian EEZ (200 nautical miles).

Current threats:
Fisheries. Overfishing has seriously depleted the economically most important fish stocks in the ecoregion ever since offshore trawlers became the most important players in the fisheries sector. Today, five of the seven most important stocks have been fished outside safe biological limits.

Destruction of benthic communities. Offshore benthic communities have been damaged by intensive bottom trawling. The extent of the damage is not accurately known, but according to Russian scientists it may be extensive.

Pollution from the petroleum sector. Oil and gas development in the Barents Sea will constitute a threat both during exploration and in potential future development phases. Gas fields have been identified in the southwestern part of the area, and these are likely to be set into production in the near future (Snøhvit field). This will allow an exploitation of near-shore oil fields which is not feasible at the moment. No effective technology for oil spill response in rough weather exists today.

Pollution. Riverine and atmospheric input from heavily polluted areas in Russia, as well as contamination following the ocean currents from the southwest. Hydro-carbons from the North Sea oil fields and ship transport are already present.

Nuclear waste. Regularly increasing levels of radioactive input from the nuclear waste reprocessing plant in Sellafield have been observed during the last years, and may constitute a real threat.

Focal species: Cod *(Gadus morhua)*

Polar cod. Photo: Rudolf Svensen

9. Banks off Murman Coast

The area comprises the Murman Rise and parts of the Kanin Bank, as well as shallows closer to the Murman coast. The area is clearly influenced by the Atlantic current, although the eastern part of the area is to some degree influenced by sea ice in winter. The banks are important feeding areas for the large fish stocks of the Barents Sea due to the density of benthic organisms, and the area is a vital nursing and juvenile area for several species of fish. Fisheries used to be the most successful industry operating in the region. Oil and gas resources in the region are probably extensive, but their development will require considerable investment.

Outstanding biological features:

3 The Murman Rise/Kanin Bank/Goose Bank is a system of productive bank areas vital as a nursery and juvenile area for many of the large, ecologically and economically important fish stocks of the Barents Sea (cod, capelin, haddock). The area contributes to sustain species and ecosystems elsewhere in the ecoregion.

3 Migration routes in the yearly cycle of cod, herring and capelin between the ice edge/Polar front in the north, and spawning areas to the south of the subregion.

Current conservation status:
None.

Current resource use:
An important area for fisheries. Important economic species are cod, plaice, halibut, herring and salmon. Small coastal vessels have largely been replaced by offshore trawlers (particularly factory trawlers), and overfishing has become a permanent threat to most fish stocks in the region. In 1997, the Murmansk Oblast supplied 16 percent of Russia's fish production. The Murmansk Trawl Fleet used 19 percent of the Russian-Norwegian quota for fishing in the Barents Sea. Today, the world's largest fish processing plant in Murmansk is hardly in use at all. Seventy to eighty percent of the catch of Murmansk fishing companies is exported to Norway, Denmark, Germany, Canada, and Great Britain. Most of the fish processing takes place in these countries.

Current threats:
Overfishing. Cod fishery with fine-meshed nets is seriously depleting the stock of young cod. The permanent overfishing of young, undersized cod in this area represents the most important threat to the survival of the Barents Sea cod population, essential to the ecosystem as well as to the economy of Barents Sea fisheries. Russian enforcement of fishing regulations is poor due to the difficult economic situation (in winter 2000/2001, Russian trawler companies were - allegedly - asked to contribute to fuel and maintenance for one surveillance vessel for the forthcoming season. None of the companies volunteered). According to crew onboard Russian trawlers, enforcement officials are regularly bribed by the companies.

Destruction of benthic communities. Offshore communities have been damaged by intensive bottom trawling and scallop dredging. The extent of the damage is not well known, but according to Russian scientists it may be extensive.

Pollution from the petroleum sector. Oil and gas development in the Barents Sea will constitute a threat both during the present search phase and in future development phases, through oil spills and discharges of produced water that can influence the reproductive ability of fish. Drilling operations in ice-covered waters are particularly demanding, and effective oil spill response techniques in such waters are non-existent. Long-range transported hydrocarbons from the North Sea oil fields, and from ship-transport, are already present.

Pollution. Riverine and atmospheric input from heavily polluted areas in Russia, as well as contamination following the ocean currents from the southwest. Hydrocarbons from the North Sea oil fields and ship transport are already notable. Regularly increasing levels of radioactive input from the reprocessing plant in Sellafield have been observed during the last years.

Focal species: Capelin *(Mallotus villosus)*

10. The Polar Front

The Polar Front is a main hydrographic feature that separates relatively warm and saline water of Atlantic origin in the south from colder and fresher arctic water in the north. The position of the Polar Front is heavily influenced by bathymetry and is clearly identifiable in the western Barents Sea. It is not as distinct in the eastern Barents Sea where mixed water masses extend over large areas. The development of the spring bloom will differ north and south of the Polar Front due to deeper vertical mixing south of the Polar Front. In addition, a less pronounced stratification results in a greater possibility for diffusion of new nutrients into the mixed layer south of the Polar Front. However, the species composition and the succession of the most important spring phytoplankton species north and south of the Polar Front are quite similar. In Atlantic water south of the Polar Front, which has not been covered by ice, the stratification develops when the sun begins to warm the surface layer. The stratification progresses slowly, but reaches down to 50-60 meters by means of turbulent mixing during summer. The spring bloom starts in the first half of May and progresses slowly during May and June. In the eastern Barents Sea, the spring bloom is delayed with one to two weeks due to colder water. Yearly primary production is higher than in most ice-covered areas and most of it is transported to pelagic levels in the food chain. The main zooplankton species are copepods (*Calanus finmarchicus*) and krill (*Thysanoessa inermis* and *T. raschii*).

Outstanding biological features:

3 A nutrient-rich, frontal area with high primary production. It is of great importance as a foraging habitat for birds, marine mammals, fish, benthos and plankton, and is a vital part of the Barents Sea ecosystem.

3 Benthic fauna profit from the high productivity in the area through the "rain" of nutrients from the upper layers. Nearly all large shrimp fields in the central Barents Sea are situated under the Polar Front.

3 The large banks situated at the Polar Front show elevated productivity and a high diversity of fish species. Several bottom-dwelling species, both Atlantic and arctic, are prospering on a rich benthic fauna. Important feeding area for economically important species, both juveniles and adults. A high number of fish and benthic organisms relative to the latitude, particularly on the banks and near the Polar Front.

3 Bjørnøya is one of five localities in the ecoregion with more than 300,000 breeding pairs of seabirds. The most numerous species are common and Brünnich's guillemots and kittiwakes, with a number of additional breeders including the great northern diver.

Current conservation status:

None. Plans for a conservation area on Bjørnøya exist. Fisheries around the island are restricted to shrimp trawling only, in a zone outside four nautical miles from shore.

Current resource use:

Rich fisheries for both pelagic and demersal fish, as well as shrimps.

Current threats:

Overfishing is a permanent threat, both to fish stocks and to the ecosystem. Bottom trawling has disrupted large areas of seafloor, keeping it in a state where early succession species dominate.

Destruction of benthic communities. Offshore benthic communities have been damaged by intensive bottom-trawling. The extent of the damage is not accurately known, but according to Russian scientists it may be extensive. Shrimp trawling with double and triple trawls weighed down by heavy leads devastate bottom communities.

Nuclear waste**.** Regularly increasing levels of radioactive input from the nuclear waste reprocessing plant in Sellafield have been observed during the last years, and may constitute a real threat.

Pollution from the petroleum sector**.** Plans for development of vast oil and gas resources exist. The gigantic gas and condensate field Shtokmanovskoye is located near the eastern part of the area.

Focal species: Brünnich's guillemot *(Uria lomvia)*

Subregion V: Nenets coast and Pechora Sea

(Text based on Gavrilo et al. 2000)

The Nenets coast is dominated by low-lying permafrost tundra, with an extensive network of pools and lakes alternating with sedge meadows and intersected by river channels. Numerous river deltas are an important coastal element, forming estuaries with vast, sandy and unstable banks shifting in location from one year to the next. The tundra generally enters the sea in a shallow intertidal zone that may be several kilometers wide. Most of the subregion has a sea depth of less than 100 m, and shallow banks with depths of two to three meters are widespread. A harsh winter climate and freshwater runoff from the Pechora river (with a catchment area of 322,000 km^2) maintain sea ice cover for an average of seven to eight months a year. A belt of shore-fast ice covers a distance of usually no more than a kilometer off shore, followed by a belt of recurring polynyas. The water column is highly stratified, and in general does not supply rich pelagic communities. The shallow depth also prevent the penetration of nutrient-rich Atlantic water, and the only stable zone of enhanced pelagic productivity is found where the cold-water Litke current from the Kara Sea meets the warmer Barents Sea water. In contrast, the nutrient influx from the Pechora River supports highly productive benthic communities, numbering more than 600 taxa. Biomasses of more than 500 g/m^2 have been recorded in several places; these are among the highest values found in the Barents Sea. Bivalve communities predominate in many shallow areas, providing good foraging opportunities for large assemblies of moulting seaducks as well as a re-establishing southern branch of the Barents Sea walrus stock. The coastline is typically sandy, dominated by *Macoma calcarea, Astarte borealis, Cilliatocardium cilliatum* and *Serripes groenlandicus* community types.

The subregion is administratively a part of the Nenets Autonomous Okrug within Arkhangelsk oblast. Its shores are low-populated tundra, averaging 0.3 persons per km^2. Settlements are few and small, often counting no more than 10-20 houses. There is practically no resident population east of Varandey. Infrastructure is not developed to any extent; the Pechora River is the main communication line, and supports 90% of all transportation. No protected areas have been designed for strictly marine purposes, but a number of islands and coastal areas are included in a network of protected areas in the Nenetsky Autonomous Okrug. Today shipping of oil is taking place from two ports on the Nenets coast: the relatively small Peschanoozersky terminal on Kolguev and the larger Verandej terminal on the main land. In addition, plans exist to build oil terminals close to Indiga (south of Kolguev) and on the Kanin Peninsula (Frantzen & Bambulyak 2003). Oil is mostly being transported out of the area in small tankers that supply larger tankers in ice-free waters. From 2004 it is expected that the first offshore installation will produce oil from the Prirazlomnoye oil field in the Pechora Sea, and there is little doubt that tanker traffic will increase significantly over the coming years.

The Pechora Sea has so far avoided the otherwise widespread destruction of benthic communities by intensive bottom trawling. Targeted bottom trawling for Iceland scallop (*Chlamys islandica*) during the 1990s has however already led to a notable decrease in abundance. The polar cod stock was severely overfished in the eastern Barents Sea in the 1960s and 1970s, and most likely has affected the spawning population of the Pechora Sea.

Priority areas within the subregion:

11. Kanin Peninsula and Cheshskaya Bay

The coast of the Kanin Peninsula is dominated by low-lying permafrost tundra, with an extensive network of pools and lakes alternating with sedge meadows and intersected by river channels. The Cheshskaya Bay is a shallow area with high primary production supported by different sources. Most of the bay has a sea depth of less than 50 m, and shallow banks with depths of two to three meters are widespread. The productivity may be dependent on biogenic input from the catchment area (there is a pronounced abrasion of the shore) and/or warming of the water column in spring/summer down to the bottom. The area probably supplies surrounding areas with organic material. The shores of the area are low-populated tundra with few and small settlements. Infrastructure is not developed to any extent.

Outstanding biological features:

3 The Kanin Peninsula is an important stopover site for migrating geese from Siberia and arctic Russia, as well as for the threatened lesser white-fronted goose

populations of Scandinavia. Barnacle geese were detected breeding here in the 1980s, and in 1991 even some brent goose nests were found (the most southerly known), in a colony of 400-450 barnacle goose nests.

3 Very rich benthic communities, both in biomass and species composition.

3 Habitat supporting the population of endemic subspecies of herring (breeding and nursery ground). Since benthic communities are of distinct boreal nature, it may be assumed that the plankton community is also very similar to boreal communities (e.g. North Sea) in spite of high latitude location.

Current conservation status:
The Shoininsky Zakasnik on the western Kanin Peninsula was protected in 1997. It covers 164 km^2, most of it terrestrial, but with a narrow coastal part.

Current resource use:
Not known.

Current threats:
Salmon poaching is widespread, but the status of the salmon rivers is not known.

Shipping. The governor of Nenets AO wishes to build a large oil terminal close to Indiga (Frantzen & Bambulyak 2003). Plans also exist to build an oil installation on the Kanin Peninsula. If carried out, these activities will represent a new threat to the biodiversity of the area.

Focal species: Barnacle goose *(Branta leucopsis)*

12. Western Pechora Sea

The Nenets coast is dominated by low-lying permafrost tundra, entering the sea in a shallow intertidal zone that may be several kilometers wide. The whole area has a sea depth of less than 100 m, and much of it is less than 50 m deep. Shallow banks with depths of two to three meters are widespread. A harsh winter climate and freshwater runoff from the Pechora River (with a catchment area of 322,000 km^2) maintain sea ice cover for an average of seven to eight months a year. A belt of shore-fast ice covers a distance of usually no more than a kilometer offshore, followed by a belt of recurring polynyas. The water column is highly stratified, and in general does not supply rich pelagic communities. In contrast, the nutrient influx from the Pechora River supports highly productive benthic communities, numbering more than 600 taxa. Biomasses of more than 500 g/m^2 have been recorded in several places. Bivalve communities predominate in many shallow areas, providing good foraging opportunities for large assemblies of moulting seaducks as well as a re-establishing southern branch of the Barents Sea walrus stock. Settlements are few and small, often counting no more than 10-20 houses. Infrastructure is not developed to any extent; the Pechora River is the main communication line, and supports most transportation.

Outstanding biological features:

3 Very rich benthic communities, both in biomass and species composition.

3 Kolguev Island is an important breeding area for geese (including barnacle geese), and large numbers of bean and white-fronted geese moult in the area. Other species of particular interest include the bewick swan, lesser white-fronted goose and peregrine falcon.

3 Important stopover sites on the East-Atlantic Flyway in the Pechora Bay, the Bolvanskaya Bay, the Russkiy Zavarot Peninsula, the Sengeyskiy Strait and Kolguev Island. Marine ducks make extensive use of the rich food resources in the shallow sea, and waders and geese abound in the so-called "laidas", the highly productive transition zone between sea and tundra. Birds breeding from Finnmark to Siberia gather in the area to moult or to feed during migration.

3 The presence of walrus mothers with young calves has been reported, indicating that breeding is taking place in the area.

3 Important wintering area for white whale in the waters around Kolguev.

3 The fast ice in Pechora Bay and other bays and inlets is important breeding sites for ringed seals.

3 The Pechora River is a highly productive system, supporting large numbers of several anadromous whitefish (*Coregonus spp.*) species. The river once held the world's largest stock of Atlantic salmon, 50 - 60,000 individuals were caught annually.

3 The world's highest breeding density of Bewick's swans (*Cygnus bewickii*) is found in the delta of the Pechora River.

Current conservation status:
Nenetsky Zapovednik, established in 1997. It covers a total area of 3,134 km², including a marine portion of 1,819 km². It includes the following areas: Northeastern part of Malozemelskaya tundra, Korovinskaya Bay, the Gulyaevskiye Koshkie Islands and Golets Island (as well as Matveev, Dolgiy, Bolshoy Zelenets and Maliy Zelenets Islands in area 11). A two km marine zone around the islands is included in the Zapovednik.

Nenetskiy Zakasnik; a buffer zone west of the Nenetskiy Zapovednik. Terrestrial, bordering on the Korovinskaya Bay in the south and on the Pomorskiy Proliv (channel) to the north.

The Nizhne-Pechorskiy Zakasnik of 1,060 km² (1998, terrestrial) includes two areas:
• The lower flood plain of the Pechora River
• Inner Bolvanskaya Bay

Kolguev Island has been designated a "zone of restricted industrial activities" by the Nenets Autonomous Okrug. Within the zone, any industrial activities are strictly regulated. They need special permissions by the Deputy Assembly and Administration of the okrug.

Current resource use:
The vast Timan-Pechora petroleum province has been developed for many years, producing oil and gas from seven fields on Kolguev Island and on the mainland. The province includes also the Pechora Sea, where several gas fields and a few oil fields have been identified. Commercial fisheries are not much developed, but salmon and whitefish fisheries are important locally.

Current threats:
Pollution from the petroleum sector. Oil and gas development in the Pechora Sea constitute a threat both now and in the future. Oil and gas condensate has been produced on Kolguev Island for a number of years, and has impacted particularly its eastern parts. Different projects will bring offshore oil drilling platforms, shore oil terminals, oil tanker traffic and a network of oil wells on the tundra. The last constitute a threat through oil spills entering the Pechora River and consequently the sea. During the Usinsk oil pipeline accident in August 1994, oil spread all the way to the Pechora delta 700 km downstream. Oil spills in ice-covered waters during winter will have adverse effects through the "absorption" of oil in the ice pack and the consequent release of the oil during spring and summer.

Ship traffic. Today shipping of oil from two oil terminals, Kolguev and Verandej, represents a risk to the biodiversity of the area. When the oil fields in the Pechora Sea begin production, ship traffic through and nearby the area will increase significantly. Oil spills may occur during loading or in the case of ship accidents, but pollution will also increase in general from the increasing traffic.

Nuclear waste. Russia is also planning to import nuclear waste from Europe, as well as to facilitate transport from Europe to Japan via the Northern Sea Route. In both cases, the radioactive material will be shipped through the Pechora Sea immediately north of the area. Plans exist for building a floating nuclear power plant and transporting it to Kolguev Island. The ship Nikel loaded with solid nuclear waste was sunk NW of Kolguev.

Riverine input of pollutants. Riverine input is one of the most important sources of pollution in the Arctic Seas. The Pechora River is the second largest European river draining into the Arctic Oceans, and its phosporus, nitrogen and pollutants content is increasing.

Overfishing. The pelagic gill net salmon fisheries in the North Atlantic Ocean severely depleted the Pechora spawning stock in the 1970s. Gill nets for salmon are now banned, but illegal fishing of salmon during the spawning migration is widespread.

Focal species: Atlantic Salmon *(Salmo salar)*

13. Eastern Pechora Sea

As with areas 9 and 10, the coast is dominated by low-lying permafrost tundra, with an extensive network of pools and lakes alternating with sedge meadows and intersected by river channels. Numerous river deltas are an important coastal element, forming estuaries with vast, sandy and unstable banks banks shifting in location from one year to the next. The tundra generally enters the sea in a shallow intertidal zone that may be several kilometers wide. The area has a high degree of naturalness, as it is only moderately disturbed at present. It is representative of arctic shallow seas, with estuaries and brackish water. Apart from a "trench" southwest of Vaigach Island, the whole area has a sea depth of less than 50 m, and shallow banks with depths of two to three meters are widespread. A harsh winter maintains sea ice-cover for an average of seven to eight months a year. A belt of shore-fast ice covers a distance of usually no more than a kilometer off shore, followed by a belt of recurring polynyas. The water column is highly stratified, and in general does not supply rich pelagic communities. The shallow depth also prevents the penetration of nutrient-rich Atlantic water, and the only stable zone of enhanced pelagic productivity is found where the cold-water Litke current from the Kara Sea meets the warmer Barents Sea water. Benthic communities, in contrast, are well developed. Bivalve communities predominate in many shallow areas, providing good foraging opportunities for large assemblies of moulting seaducks as well as for the southern branch of the Barents Sea walrus stock.

Outstanding biological features:

3 Very rich benthic communities, both in biomass and species composition. Biomass values of 10-12 kg/m^2 have been recorded in bivalve beds in the Kara Gate and the Yugorskiy Shar strait.

3 Very important stopover and junction on the East-Atlantic Flyway. Marine ducks make extensive use of the rich food resources in the shallow sea, and waders and geese abound in the so-called "laidas", the highly productive transition zone between sea and tundra. Birds breeding from Finnmark to Siberia gather in the Pechora Sea to moult or to feed during migration. The drake (male) migration of king eiders and scooters to the area in midsummer is a remarkable phenomenon, counting tens of thousands of birds. Single flocks of 10-15,000 birds have been counted, these may even gather in larger congregations.

3 The area holds main breeding and wintering areas of beluga as well as a vulnerable, small, southern population of walrus. The walrus haulouts on Dolgiy Island are the most southern walrus rookeries in the Atlantic. The area is important for southern ringed seals, and ice conditions are suitable for breeding. In total, productivity for marine mammals is high.

3 Dense concentrations of migrating white whales and other marine mammals occur in the narrow gates north and south of Vaigach Island during spring and summer. The straits are also used by several fish species, sucha as the navaga (*Eleginus navaga*) and polar cod.

3 Indications of high primary production in the Khaipudyrskaya Guba.

Current conservation status:

The Nenetsky Zapovednik, established in 1997, includes Matvvev Island, Dolgiy Island and the Bolshoy and Maly Zelenets Islands (including a marine zone two km from shore).

Vaygach Island is protected as a regional zakasnik (mainly terrestrial), and another zakasnik, the "Bolshezemelskiy" at the western coast of the Yugorskiy peninsula, is in project.

Current resource use:

The vast Timan-Pechora petroleum province has been developed on shore for many years. The province includes also the Pechora Sea, where several gas fields and a few oil fields have been identified. The oil field Prirazlomnoye near the Varandey Peninsula will be the first marine field to be set in production, probably in 2005. Commercial fisheries are not much developed, but salmon and whitefish fisheries are important locally.

Current threats:

Pollution from the petroleum sector. Petroleum development is progressing from today's land-based activities towards the many offshore fields. From 2004 it is expected that the first offshore installation will produce oil from the Prirazlomnoye oil field just outside the Varandej Penninsula. The field is expected to produce approximately 7 million tons per year over a period of 20 years. Oil and gas development in the Pechora Sea represents an environmental threat both during the exploration and production phases. Different projects under development will bring offshore oildrilling platforms, shore oil terminals, oil tanker traffic, and a general increase in infrastructure (for instance an artificial island outside the Varandey Peninsula). Oil spills in ice-covered waters during winter will have adverse effects through the "absorption" of oil in the ice pack and the consequent release of the oil during spring and summer.

Ship traffic. The first oil was shipped from the new Varandej terminal in 2000. In 2003 it is expected that a total of 1.5 million tons of oil will be transported from the terminal and for 2015 the expected volume is 12 million tons per year (Frantzen & Bambulyak 2003). When the oil fields in the Pechora Sea are set in production, oil is likely to be transported by ship to the European market. Plans indicate the use of several small, ice-class tankers to supply larger tankers in ice-free waters. Oil spills may occur during loading and in case of ship accidents, but pollution will also increase in general from the increasing traffic. Apart from the direct effects of pollution, ships may disturb flocks of flightless moulting ducks, break fast ice in the breeding grounds of the ringed seal, or disturb polynyas with winter flocks of seabirds or sea mammals.

Nuclear waste. In Russia plans exist to import nuclear waste from Europe, as well as to facilitate transport from Europe to Japan via the Northern Sea Route. In both cases, the radioactive material will be shipped through the Pechora Sea and the Kara Gate.

Riverine input of pollutants. Riverine input is one of the most important sources of pollution in the Arctic Seas. The Pechora River is the second largest European river draining into the Arctic Oceans, and its contents of phosporus, nitrogen and pollutants content is increasing.

Focal species: King eider *(Somateria spectabilis)*

Subregion VI: Novaya Zemlya and western coast with banks

Arctic and High Arctic. Species-poor intertidal communities, mixed shallow water communities with *Cardium spp., Astarte spp.* etc. Novaya Zemlya is the northern extension of the Ural Mountains, dividing the European and Asian continents. It is made up of two main islands, Yuzhni (south) Island and Severny (north) Island, divided by the Matochkin Strait. The two islands stretch for a distance of 900 kilometres between roughly 70º30' and 77ºN, and cover approximately 82,000 square kilometres. A number of smaller islands, particularly in southwest, cover a surface of approximately 1,000 square kilometres. Most of the northern, and parts of the southern island, is covered by glaciers, and permafrost reach 300 to 600 meters below ground. The highest mountain on Novaya Zemlya is 1,547 meters above sea level. The western coast of the islands is characterized by low, but steep cliffs.

Novaya Zemlya forms a natural barrier between the Arctic oceans of Europe and Asia. The Barents Sea is influenced by the warm North Atlantic current, while the Kara Sea is a typical arctic sea, ice-covered for most of the year. But even the western coast of Novaya Zemlya experiences a rather short period of nearly ice-free conditions (from July to October). The climate on Novaya Zemlya is characterized by a short summer (July-August), but the warming effect of the North Atlantic current causes relatively high winter temperatures. The northern part of Novaja Zemlya lies within the arctic desert zone, and is dominated by its central ice cap surrounded by coastal mountains with outlet glaciers, foothills, and plains of coastal arctic desert. Outlet glaciers of the Novozemelsky ice cap calf directly into the sea at several places. The glaciers form ice barriers up to several tens of meters in height, from which large blocks of ice break off from time to time.

The first traces of human settlement on Novaya Zemlya are of neolithic origin, but historically the settlements have been dominated by seasonally visiting hunters and trappers. Norwegian activity on the islands caused official Russian concern, and triggered a formal claim and subsequent population of the islands. The first Nenets families were settled on Novaya Zemlya in 1877. There were two main areas of settlement on the southern island; Beluchaya Bay on the western coast, and Rossanaya Bay on the southern tip. The Nenets subsisted on fishing and hunting, but after the decision of using Novaya Zemlya as a testing field for nuclear weapons, the 104 Nenets families were deported to the mainland in 1954, mainly to the Pechora tundra and the town of Naryan Mar. There are two major military settlements on Novaya Zemlya today. Belushiya Guba holds approximately 4,000 inhabitants, mainly military personnel employed at the test fields and their families. The other settlement is situated at the Matochkin Strait, where there is a considerable harbour serving vessels of the Northern Fleet. There is also a meteorological station at the Matochkin Strait. Novaya Zemlya is part of the county of Arkhangelsk, but has been under military administration since the test sites were set up in 1954. In 1991, the administration was - in theory - transferred back to the Arkhangelsk oblast. For all practical purposes, however, the armed forces is still in command of the archipelago. Due to their presence, ecosystems have remained fairly undisturbed, and surprisingly little of Novaya Zemlya has been transformed by nuclear testing and other former military activities.

Priority areas within the subregion:

14. Southeast Barents Sea

Arctic-boreal, the most remote part of the ecoregion notably influenced by Atlantic water. The area comprises shallow banks at less than 50 meters of depth as well as areas deeper than 200 meters, resulting in a complex bottom topography influencing the direction and distribution of currents. The banks are important feeding areas for the large fish stocks of the Barents Sea, due to high densities of benthic organisms. Oil and gas resources in the area are extensive, but their development will require considerable investment.

Outstanding biological features:

3 The most important spawning area for polar cod in the ecoregion.

3 Important feeding area for young fish of several large fish stocks, particularly on the Goose bank.

3 Important feeding area for Novaya Zemlya auks both in and outside the breeding season, not least in the post-breeding moulting period. Wintering area for marine ducks.

3 The area is part of the important western wintering grounds for white whales from the Kara Sea, as well as the Barents Sea population.

Current conservation status:
None.

Current resource use:
Pelagic fishery for polar cod. Other fisheries.

Current threats:
Pollution from the petroleum sector. Oil and gas development in the Barents Sea will constitute a threat both during the present search phase and in future development phases. Drilling operations in ice-covered waters are particularly demanding, and effective cleaning techniques in such waters are non-existent.

Ship traffic. When the oil fields in the Pechora Sea are set in production, oil is likely to be transported by ship to the European market. Plans indicate the use of several small, ice-class tankers to supply larger tankers in ice-free waters. Oil spills are likely during loading and in case of ship accidents, but pollution will also increase in general from the increasing traffic.

Nuclear waste. Russia is planning to import nuclear waste from Europe, as well as to facilitate transport from Europe to Japan via the Northern Sea Route. In both cases, the radioactive material will be shipped through the Kara Gate, and the ships are likely to pass through the southern part of the area.

Destruction of benthic communities. The Gusinaya Bank (Goose Bank) has been degraded through heavy trawling for scallops.

Focal species: Polar cod *(Boreogadus saida)*

15. Western and Northern Novaya Zemlya Coast

Arctic and High Arctic, Novaya Zemlya forms a natural barrier between the Arctic oceans of Europe and Asia. The Barents Sea is influenced by the warm North Atlantic current, while the Kara Sea is a typical arctic sea, ice-covered for most of the year. Novaya Zemlya has been under military administration since nuclear test sites were set up in 1954. For all practical purposes, the armed forces are still in command of the archipelago. Ecosystems have remained fairly undisturbed, and surprisingly little of Novaya Zemlya has been transformed by nuclear testing and other former military activities.

Outstanding biological features:

3 Vast areas undisturbed by human presence. Apart from military bases, only single locations on the southern shores have historically been settled by man. The ecosystems remain today more or less in their original state (with some exceptions, caused by hunting expeditions beginning in the middle of the 1800s, and raiding of seabird colonies).

3 High species diversity for an arctic island: For example, 66 bird species have been recorded nesting on Yuzhni Island, and 39 on Severny Island. The total number for more isolated Svalbard is 33.

3 Novaya Zemlya holds large populations of arctic breeding geese and ducks. Wintering areas for seaducks are mainly to the southwest, although the Novozemelsky polynya may also be of importance.

3 Several rare or endangered species are found here, including white-tailed eagle, ivory gull, white-billed diver, Steller's eider, red-breasted goose, Bewick's swan, wolf, wolverine, walrus and polar bear.

3 Seabirds colonies are spread along the western coast, including the largest colonies in the eastern Barents Sea. The total breeding population of Brünnich's guillemot in the 1920s was estimated to around 5 million pairs; due to raiding by Norwegian and Russian ship crews and commercial use in Norwegian soap industry, less than one million pairs remained in 1950. Although these estimates are very uncertain, they suggest that there is a potential for population increase. The waters in the area SW of the islands are important feeding grounds for auks both in and outside the breeding season, not least in the post-breeding moulting period.

3 A series of recurrent polynyas presumably provides high primary productivity supporting large concentration of *Calanus spp.*, polar cod and seabird colonies.

3 Exceptional bivalve productivity in the Kara Gate, with biomasses up to 10-12,000 g/m².

3 The northeastern shores of the Severny (north) Island is an important denning and nursery area for polar bears. Along the western and northern shores, six walrus haulouts are known.

3 Belugas (white whales) spend summer in the Kara Sea, migrating through three relatively narrow "channels" on their way to the important western wintering grounds on the Barents Sea coast: The Kara Gate to the south, the Matochkin Strait between the northern and southern islands, and around Mys Zhelanya to the very north. The same passages are used also by other marine mammals, such as the walrus.

Current conservation status:
None, but a network of biological and cultural heritage sites are being planned (Boyarsky et al. 2000). If accomplished, the plan covers an area of 34,800 km², of which 7,200 km² are marine. The area has effectively been closed for other activities than military ones.

Current resource use:
None. Military zone.

Current threats:
Nuclear waste. Novaya Zemlya was a nuclear testing ground from 1954 to 1990. No elevated levels of radioactivity are detectable today, except for sediments in the Chernaya bay (underwater testing area).

Disturbance. Former inhabitants and visitors to the islands had a massive impact on seabird colonies close to settlements (hunting, egg collection). Today only a few military sites are inhabited. On the other hand these are rather built-up, with dense local road networks, harbours and military installations. Military presence is likely to cause impacts locally, particularly on Gusinaya Zemlya ("Goose Land").

Pollution from the petroleum sector. Oil and gas development in the eastern Barents Sea constitutes a threat both during the present exploratory phase and in future development phases. Different projects under development will bring offshore oildrilling platforms and oil tanker traffic. Oil spills in ice-covered waters during winter will have adverse effects through the "absorption" of oil in the ice pack and consequent release of the oil during spring and summer.

Pollution. Due to biomagnification of long-range transported POPs (particularly PCB), pollution is a problem for species in the upper end of the food chains.

Climate change. Likely to cause notable changes in the local distribution of species and habitats.

Focal species: Walrus *(Odobenus rosmarus)*

Subregion VII: Central Barents Sea north of the Polar Front

Arctic water masses flowing in from the Arctic Sea through the Victoria channel in the North, and from the Kara Sea between Novaya Zemlya and Franz Josef Land, govern the harsh climate in this high-arctic subregion. The bottom topography is a complex mixture of banks and shallows occasionally less than 100 meters deep, intermingled with troughs going to depths of 500 meters in some cases. The bottom topography influences the distribution of ocean currents, and small and large eddies are numerous. The subregion is delimited to the south by the Polar Front. Most of the subregion is ice-covered in winter, the northern two thirds under permanent winter ice. In summer the ice sheet retreats north, and a minimum of ice cover is usually found in September. Only the very northernmost area remains ice-covered year round. Very large gas and condensate fields have been located in the Russian part of the subregion, north to 77ºN. The "loophole" in the southern end of the subregion is an area of unsettled, international sea where foreign fishing vessels (Iceland and others) have been able to escape Norwegian and Russian regulations, and fish intensively for young cod.

Priority areas within the subregion:

16. Ice Edge

The ice edge is the most productive part of the arctic ecosystem, forming a "green belt" from April to August. It is unique among the Priority Areas in that it is constantly moving, progressing south in winter and retreating north in summer. The ice edge shows a very high primary productivity, but this productivity is also following a cyclic pattern. Vertical mixing of water - masses in autumn and winter bring deep sea nutrients to the surface layer, which is later stabilized by its lower salinity due to ice-melting in spring and summer. In this upper part of the nutrient-enriched water column, phytoplankton production is not restrained by vertical mixing of watermasses. As the melting ice edge retreats north, new bodies of water with high winter concentrations of nutrients are continuously exposed, creating an environment with stable water, plenty of light and rich in nutrients. Succeeding the algal bloom is a substantial growth in zooplankton, followed by feeding migrations of plankton-eating fish like capelin, as well as plankton and fish-eating birds and mammals.

The main factor controlling the start of the spring phytoplankton bloom at the ice edge is vertical stability of the water masses. The timing of ice melting depends on the southern extension of the ice during winter (whether it is south of the Polar Front or not). Usually, it starts in the middle of April. The meltwater layer increases to 15-20 m during summer and early autumn. The transition layer is sharp, but diminishes in sharpness with increasing distance from the ice edge. The spring bloom follows the ice edge as this retreats northwards until September, typically in a 20-50 km wide zone. The main zooplankton species is the copepod *Calanus glacialis*. Ice algae will also contribute to the total production of the area. Ice algae blooms may start earlier than phytoplankton blooms, as soon as light conditions are sufficient. A big portion of the ice edge production sinks out of the euphotic zone, entering the benthic food web.

High arctic zooplankton such as *Calanus hyperboreus* may contain as much as 26 times more stored lipids than southern species (70% of an individual's body mass), enabling them to survive in the absence of phytoplankton blooms for a full year. These extremely fatty and energy-rich organisms are vital to seabirds and sea mammals entering the arctic seas in summer to fatten up. Victoria Island between Svalbard and Franz Josef Land house one of the world's largest colonies of ivory gull, with 750 breeding pairs.

Here, the Priority Area is defined as the 20 km zone on both sides of the retreating ice edge from the onset of ice melting in spring, until the plankton bloom is brought to its conclusion in autumn.

Outstanding biological features:

3 Due to its extremely high primary production, sharply delimited in time and space, the marginal ice zone attracts high concentrations of zooplankton, as well as fish, marine mammals and seabirds. The process is vital to the maintenance of the rich arctic ecosystem and its high productivity.

3 Important feeding area of polar cod. After spawning under the ice in the southeastern Barents Sea and near Svalbard in winter, fry and juvenile polar cod follow the ice edge in enormous schools as it retreats north in summer.

3 The three truly arctic whales in the ecoregion , the bowhead, narwhal and beluga, are primarily found at the ice edge. The ice edge is vital as a feeding area and migration corridor for several species of mammals, such as polar bear, ringed seal, bearded seal, bowhead whale, narwhal and other high arctic species.

3 Several thousand auks from Bjørnøya and Svalbard (mainly guillemots and little auk) moult in the area. In winter, they migrate west and are replaced by birds from the eastern Barents Sea. Winter assemblages of 10,000 little auks have been recorded.

3 The algal bloom at the ice edge produce a rain of nutrients over the ocean floor, supporting rich and varied benthic communities on the banks. Sessile filter feeders like bryozoans are particularly diverse in the northern Barents Sea. The benthos support a rich fish fauna on the banks.

Current conservation status:
None.

Current resource use:
Pelagic fishery for polar cod and possibly other fisheries. The ice sets limits for the possibility of exploiting the rich production.

Current threats:
Ship traffic along the ice edge may disturb the rich life of marine mammals and seabirds, and possibly constitute a risk to slow-moving bowhead whales.

Pollution from the petroleum sector. Oil and gas development in the Barents Sea will constitute a threat both through oil spills and discharges. Drilling operations in ice-covered waters are particularly demanding, and oil spills along the ice edge will have adverse effects through the "absorption" of oil in the ice pack and the consequent release of the oil during spring and summer.

Pollution. In this remote and largely undisturbed area, a major threat is long-range transport of toxic chemicals. Due to biomagnification of POPs (particularly PCB), pollution is already a problem for species in the upper end of the food chains.

Climate change. Climate change may severely affect the annual fluctuations of the ice edge, which is very important to the life histories of sea mammals and most other organisms in the ecoregion.

Focal species: Bowhead whale *(Balaena mysticetus)*

Subregion VIII: Svalbard archipelago and the Spitsbergen bank

The Svalbard archipelago consists of several small and five large islands, of which Spitsbergen is the largest. Due to its position at the western shelf edge and the proximity to the northern fringe of the warm Atlantic current, its western coast is arctic-boreal, while the northern and eastern coasts are arctic. The highest air temperature measured is 21.3ºC, the lowest -49.2ºC. Biogeographically, its coast is a mixture of shallow water complexes with a predominance of *Strongilocentrotus*, *Astarte borealis, Cardium* and others. To the south, Bjørnøya (Bear Island) and Hopen are connected to the Svalbard shelf via a shallow ridge, the Spitsbergen Bank, which is less than 50 meters deep in places. Kong Karls Land is a group of islands separated from the rest of Svalbard by the Hinlopen Strait, while Kvitøya in the far estern end is separated from the rest of Svalbard by a 300 meter deep trough and topographically is connected to Victoria Island. While Victoria Island (subregion 6) belongs to Russia, Svalbard is Norwegian territory in accordance with the 1920 Svalbard treaty.

With Bjørnøya at around 74º30'N, Svalbard proper reaches from 76º30'N to nearly 81ºN. Most of the archipelago is covered by glaciers, and is characterized by jagged, alpine mountain areas surrounding dome-shaped glaciers with numerous arms running into valleys or fjords. Glacial activity has formed a shoreline of mainly rocky shores, but there are also several river valleys opening into the sea with wide moraine deposits. After 400 years of human activities in Svalbard waters, the area is still inhabited by relatively few people (ca. 3,000 in three main settlements) and has retained its distinctive character as unspoilt wilderness. Svalbard is quite unique in the world as a wilderness with more or less intact ecosystems, unfragmented by human activities, but still well mapped and with modern infra-structure and easy access to densely populated areas. Compared to other areas at the same latitude, Svalbard has a mild climate and a rich animal and plant life (although, due to its isolated position, there are relatively few terrestrial plant species). No other arctic island has been equally well mapped with respect to biodiversity. Most of the species diversity is connected to the shallow, productive sea areas and the ice edge surrounding the archipelago. Although most of the Svalbard coasts has not been well studied, 1,871 species of benthic macro-organisms (algae, invertebrates and fish) have been recorded. Highly productive waters also give rise to rich fish stocks, a multitude of seabird colonies - particularly along the western coast bordering to the shelf edge - and a variety of sea mammals linked to the moving ice edge. Several mammal species were hunted almost to extinction during the whaling era from 1600 to the 1950s, and in spite of protection some of them have not been able to recover - probably because the patterns of energy flow and the dynamic properties of the eco-systems have been altered permanently.

Priority areas within the subregion:

17. Spitsbergen Bank

Bjørnøya (Bear Island) and Hopen are connected to the Svalbard shelf via a shallow ridge, the Spitsbergen Bank. A large proportion of the 1,871 macrobenthic species identified around Svalbard is connected to this shallow, productive sea area and the ice edge. Highly productive waters also give rise to rich fish stocks, a multitude of seabirds breeding on the only island in the area (Hopen), and a variety of sea mammals linked to the Polar front and the moving ice edge. Several mammal species were hunted almost to extinction during the whaling era from 1600 to the 1950s.

Outstanding biological features:

3 Due to the shallow waters, vertical mixing from top to bottom of the water column take place all year round. This governs an early start of the spring bloom (in March-April, as soon as the ice melts). The yearly primary production is one of the highest in the ecoregion. Most of the production is transported to the benthos, which is accordingly well developed and support dense fish populations.

3 A highly productive area with high biodiversity is the shallow, southeastern part of the Spitsbergen Bank. Here, biomass often exceed 1,500-2,000 g/m^2, the main bulk of which is made up of sponges and bivalves.

3 Dense concentrations of fish larvae show that the polar cod has a main spawning site south of Svalbard, but the exact location of this site is not known.

3 Hopen is one of the most densely populated seabird colonies in the ecoregion, with more than 170,000 breeding pairs concentrated in the steep cliffs of the oblong island.

3 The area is a very important moulting and wintering site for auks. Svalbard birds moult in the area in flocks of several thousands (nearly 200,000 Brünnich's guillemots were recorded north of Hopen in the mid 1980s), while overwintering birds probably come from the eastern Barents Sea (500,000 Brünnich's guillemots recorded within 30 x 30 km).

3 Hopen holds one of the highest known denning concentration of polar bears in the World (35 dens, or nearly one den per km^2, in 1996).

Current conservation status:
None. Bjørnøya was designated as a nature reserve in August 2002, and Hopen in 2003.

Current resource use*:*
The area has been a good fishing ground for generations (cod, Greenland halibut and others). Vast fields of scallops on the Spitsbergen Bank led to heavy investment in scallop trawlers in the 1980s, but the resource was eradicated after only a few years of trawling.

Current threats:
Intensive fisheries are affecting several stocks, a.o. the vulnerable population of Greenland halibut and the shrimp population.

Destruction of benthic communities. Double trawls are used regularly in shrimp fisheries, and experiments have also been performed with triple trawls weighed down by 750 kg V-doors and additional weights of 300 kg. The impact of this appliance on the seafloor can be extensive, particularly from the heavy weights. Bottom trawling for Iceland scallop (*Chlamys islandica*) in the 1980s was brought to an end after only a few years of fishing. The species collapsed, and has not recovered.

Pollution. Svalbard's position relative to ocean currents and winds makes it a "sink" for long-range transported toxic chemicals, such as insecticides and PCB. Due to biomagnification of these POPs, pollution is already a problem for species in the upper end of the food chains. Polar bears suffer from deficiencies in their immune system, and some glaucous gulls and polar foxes have been reported to contain enough POPs for their dead bodies to be treated as special waste.

Climate change: Climate change may severely affect the annual fluctuations of the ice edge, which is very important to the life histories of sea mammals and most other organisms in the subregion.

Focal species: *Calanus finmarchicus*

18. Svalbard Coast

The Svalbard archipelago consists of several small and five large islands, of which Spitsbergen is the largest. Svalbard reaches from 76º30'N to nearly 81ºN. Svalbard is Norwegian territory, in accordance with the 1920 Svalbard treaty. The treaty does however give all members equal rights to exploit natural resources on the islands, and this has (historically) resulted in a number of settlements dominated by different nationalities. Most of these settlements are now abandoned, and the population is concentrated in three main areas.

Outstanding biological features:

3 The southern and western parts of Svalbard is one of the world's most densely populated seabird areas, with numerous colonies and a high number of breeding birds, probably in the range of two to three million breeding pairs. The number is uncertain due to little auk colonies which remain uncensused due to their size and inaccessibility. The bird fauna include the world's northernmost breeding colonies of puffin and razorbill, as well as a number of not well studied ivory gull colonies, and increasing populations of arctic geese.

3 The world's most northern population of harbour seals around Prins Karls Forland, between 78 and 79ºN.

3 Important haulout areas for the recovering Barents Sea walrus population, particularly at Moffen, Kvitøya and Tusenøyane.

3 The Storfjorden polynya is a latent heat polynya, where brine-enriched bottom water is formed. It has high primary production, and a high concentration of marine mammals (such as ringed seal, bearded seal, harp seal, walrus, polar bear, white whale) and large numbers of seabirds.

3 The area is part of (with Franz Josef Land) the most important polar bear breeding, feeding, mating and migration areas in the ecoregion. Kongsøya is an important denning area, considered a "crown jewel" for polar bears along with Wrangel Island (Russia) and Cape Churchill (Canada).

3 The whole area has a high degree of naturalness with a minimum of human disturbance and no harvest of most marine mammals (with a few exceptions: minke whale, bearded seal and ringed seal). It has a high diversity of marine mammals, many of them linked to the marginal ice zone, and the area makes up a migration corridor to the polar pack ice in summer.

Current conservation status:

Excluding the so-called plant protection areas (which actually only protect species of plants), a total land and sea area of 66,424 km^2 is protected on Svalbard. The protected areas go four nautical miles (7.4 km) to sea, making up a marine portion of 31,424 km^2. Provisions have however not been designed with marine biota in mind, and the protection rendered marine areas is therefore very modest.

Current resource use:

Traditionally coal mining has been the most important use of natural resources terrestrially, besides hunting for polar fox (furs), reindeer and seals (meat). The future for coal mining on Svalbard is unclear at present, due to large new coal deposits found at Svea. While the official policy has been to gradually reduce coal mining (due to environmental concerns) and rather build up a strong education and research-oriented community, the present situation is heavy investment in the Svea mine and indeed expansion. Russia is also planning expansion of its mining activities on Svalbard, and the largely state-owned Norwegian mining company Store Norske Spitsbergen Kullkompani has expressed interest in mining for gold.

Fisheries have mainly taken place around the Spitsbergen Bank (cod) and the western shelf edge (Greenland halibut and redfishes), as well as shrimp fisheries in the straits and larger fjords. Tourism is developing quickly on Svalbard, with cruises around the islands in summer.

Current threats:

Fisheries. Fishermen and scientists have warned about the negative situation for shrimp populations. The most marked decrease is in the Svalbard area, where large ice class trawlers with twin and triple trawls are active. The repeated overfishing of capelin and cod has had marked influences on the Svalbard ecosystems.

Three National Parks protected in 1973 (IUCN category II). Total area 17,358 km^2, with a marine part of 7,933 km^2:

Nordvest-Spitsbergen	(total 6,695 km^2, marine part 3,033 km^2)
Forlandet	(total 2,159 km^2, marine part 1,537 km^2)
Sør-Spitsbergen	(total 8,504 km^2, marine part 3,363 km^2)

Three general Nature Reserves, the two largest protected in 1973 (IUCN category I). Total area 49,074 km^2, with a marine part of 23,497 km^2:

Nordaust-Svalbard	(total 34,879 km^2, marine part 15,883 km^2)
Søraust-Svalbard	(total 14,187 km^2, marine part 7,608 km^2)
Moffen	(1983, total 7.7 km^2, marine part 2.9 km^2)

Fifteen seabird Nature Reserves, mainly small islands, protected in 1973 (IUCN category I). Total area 78.8 km^2, with a marine part of 63.9 km^2. Five of them are Ramsar areas.

Skorpa	(total 1.1 km^2, marine part 1 km^2)
Moseøya	(total 1.4 km^2, marine part 1.1 km^2)
Guissezholmen	(total 0.4 km^2, marine part 0.4 km^2)
Blomstrandhamna	(total 0.6 km^2, marine part 0.5 km^2)
Kongsfjorden	(total 7.1 km^2, marine part 6.1 km^2. Ramsar site)
Hermansenøya	(total 4.2 km^2, marine part 2.5 km^2)
Forlandsøyane	(total 5.4 km^2, marine part 4.8 km^2. Ramsar site)
Plankeholmane	(total 1.6 km^2, marine part 1.6 km^2)
Gåsøyane	(total 2.4 km^2, marine part 1.8 km^2. Ramsar site)
Boheman	(total 2.1 km^2, marine part 2 km^2)
Kapp Linne	(total 1.9 km^2, marine part 1 km^2)
Olsholmen	(total 0.5 km^2, marine part 0.4 km^2)
Isøyane	(total 2.3 km^2, marine part 2 km^2. Ramsar site)
Dunøyane	(total 11.9 km^2, marine part 10.6 km^2. Ramsar site)
Sørkapp	(total 36 km^2, marine part 27.9 km^2)

Three terrestrial plant protection areas of 2,515 km^2.

Destruction of benthic communities. Double trawls are used regularly in shrimp fisheries, and experiments have also been performed with triple trawls weighed down by 750 kg V-doors and additional weights of 300 kg. The impact of this appliance on the seafloor can be extensive, particularly from the heavy weights.

Pollution. Svalbard's position relative to ocean currents and winds makes it a "sink" for long-range transported toxic chemicals, such as insecticides and PCB. Due to biomagnification of these POPs, pollution is already a problem for species in the upper end of the food chains. Polar bears suffer from deficiencies in their immune system, and some glaucous gulls and polar foxes have been reported to contain enough POPs for their dead bodies to be treated as toxic waste.

Coal mining. Coal mining companies want to expand today's activities on Svalbard. The main threat is the permanent need for infrastructure such as roads and harbours.

Shipping. Accidental releases of oil from tourist cruisers is a potential threat, as well as the shipping of coal from the Svea mine with 75,000 ton ships through the narrow Aksel sound at the mouth of the van Mijen fjord.

Tourism. Apart from the threats of oil spills from ships, tourism may disturb wildlife and habitats. Heavily degraded terrestrial habitats have resulted from the landing of many thousands of ship passengers on some popular spots such as Gravodden in the Magdalena fjord. Seabird colonies and moulting areas may be particularly vulnerable to the pressure of a growing tourism industry. The local inhabitants on Svalbard have developed an urge for motorized transport, and, apart for household snow scooters, an average of ten such vehicles is leased in Longyearbyen every day of the year.

Climate change: Climate change may severely affect the annual fluctuations of the ice edge, which is very important to the life histories of sea mammals and most other organisms in the subregion.

Focal species: Little auk *(Alle alle)*

19. Kong Karls Land

Kong Karls Land is a group of islands separated from the rest of Svalbard by the Hinlopen Strait. They are effectively isolated from the rest of Svalbard by difficult ice conditions, and have never had permanent human settlement.

Outstanding biological features:

3 Kongsøya is an important denning area for polar bear, considered a world "crown jewel" for the species along with Wrangel Island (Russia) and Cape Churchill (Canada).

3 Four colonies of ivory gull have been recorded on the islands.

Current conservation status:
Part of Søraust-Svalbard Nature Reserve, it was protected in 1973. The island is not open for visitors without a special permit.

Current resource use:
Not known, possibly some shrimp trawling (the Hinlopen Strait has been a favourite site for shrimp trawlers).

Current threats:
None known.

Focal species: Polar bear *(Ursus maritimus)*

Subregion IX: Franz Josef Land

High-Arctic. Franz Josef Land is part of Arkhangelsk Oblast. The archipelago is a group of 191 islands between 79°73' and 81°93' north, and between 37° and 65°50' east. Within a shoreline of 4,425 km, the total land area is 16,135 km^2, of which glaciers make up 85%, or 13,700 km^2. The highest elevation is 620 m above sea level. Franz Josef Land was formally discovered in 1873 by an Austrian expedition aboard the "Tegethoff", commanded by Julius Payer. The first Russian polar station was established in 1929. After periods of activity, most of the military and meteorological bases are today deserted.

The islands are mountainous, of volcanic origin, and largely covered by glaciers, on the coast and on some other open spots one may find mosses, saxifrages and other arctic plants. July is the warmest month, with a mean daily maximum of +4°C and mean daily minimum of 0°C. June and August are the only other months with a maximum temperature above freezing. March is the coldest month, with a mean daily temperature of -24°C. Predominantly eastern winds from September to March, and northern winds from April to August. The mean wind speed varies from 7-8 m/h in summer, to 13-15 m/h in winter (October to February).

Priority areas within the subregion:

20. Franz Josef Land

Outstanding biological features:

3 The archipelago has a high degree of naturalness and representativeness, with a minimum of human disturbance and no regular harvesting of natural resources. It also has a high diversity of marine mammals (such as ringed seal, bearded seal, narwhal, bowhead whale and walrus), many of them linked to the marginal ice zone.

- 3 Important haulout areas for the recovering Barents Sea walrus population, particularly at George Land (Aspirantov Inlet), Northbrook Island (Cape Flora) and Appollonoff Island.

- 3 Several polynyas open on the leeside and between the islands in the archipelago. They are important wintering and feeding areas with high concentration of marine mammals and large numbers of seabirds.

- 3 A high number of seabird colonies are concentrated within the archipelago, among them the largest colonies of ivory gulls in the ecoregion. The polynyas opening around the archipelago support wintering seabirds.

- 3 Franz Josef Land is an essential part of the most important polar bear breeding, feeding, mating and migration area in the ecoregion (Svalbard – Franz Josef Land ice bridge).

- 3 The area is not easily accessible, and although there has been some historical hunting of marine mammals, healthy populations are found of species such as ringed seal, bearded seal, harp seal, walrus, polar bear, narwhal and white whale. The subregion holds the bulk of the remaining bowhead whale population in the ecoregion.

Current conservation status:
The entire archipelago and surrounding waters (a total of 42,000 km^2) was protected as Franz Josef Land Federal Zakasnik in 1994. 26,040 km^2 cover open water.

Current resource use:
None known. Several agencies have plans ready for small-scale ecotourism, but financial issues, difficult access due to ice conditions, and military interests have made it difficult to realize the plans so far.

Current threats:
Pollution. Activity on a number of small military and meteorological bases has left heaps of rubble and garbage, but this degradation is very local.

Climate change: Climate change may severely affect the annual fluctuations of the ice edge, which is very important to the life histories of sea mammals and most other organisms in the subregion.

Destruction of benthic communities. Parts of the seafloor in the central part of the archipelago may have been degraded (S. Denisenko, no details available).
Focal species: Ivory gull *(Pagophila eburnea)*

Subregion X: Kara Sea and eastern Novaya Zemlya

The subregion covers the western part of the Kara Sea, one of the Siberian arctic seas. It is relatively shallow, with large areas less than 50 meters deep in the eastern and southern parts. Running along Novaya Zemlya is the Voronin deep-water trench, reaching 450 meters. The Kara Sea contains cold arctic water, of which some penetrates the narrow Kara Gate south of Novaya Zemlja and enters the Barents Sea. Influx of nutrient-rich ocean water is limited in the Kara Sea, as it is to a very large degree surrounded by land masses. Instead, the system is heavily influenced and altered by the massive influx of freshwater from the Ob and Yenisey rivers (on average 1,350 km^3 per year, 2.8 times as much freshwater influx as in the Barents Sea), causing a characteristic thermohaline stratification inhibiting vertical mixing of water masses. This prevents nutrient-rich bottom water from reaching the upper, sunlit part of the water column, and halts primary production (Decker et al. 1998). Surface water outside the river mouths has a salinity of only 7-10‰, and a temperature of 5-8°C. Below this layer, temperature drops and salinity increases. The influence of the low-salinity surface water can be followed hundreds of kilometers from the Ob and Yenisey river mouths. Biogeographically, the subregion is characterized by *Ophiocten*, *Astarte* and *Ophiopleura* communities, with *Ophiopleura* and *Elpidia* communitites in the trench. The Voronin trench is an arctic deep-sea trench with specific benthic and fish communities, but closer studies remain to be performed.

Sea ice formation starts in September in the northern Kara Sea, which remains ice-covered until June. From October to May, almost the entire Kara Sea is covered by ice. Along the coasts, a belt of fast ice forms, followed by a zone of open water or young ice forming a system of recurring polynyas. Minimum ice extent is in September, but drift ice may be found all year in the northern waters. Bordering the subregion to the east, the coast of theYamal Peninsula is basically low and formed by soft sediments. Going clockwise along the coast, it gradually develops into higher shores and cliffs, reaching a maximum along the northern part of Novaya Zemlya, where among coastal mountains outlet glaciers of the Novozemelsky ice cap calf directly into the sea at several places. Estuaries seem to support the highest biological productivity in the subregion, based on organic matter carried by rivers. The intertidal zone is quite narrow due to small tidal differences, and the littoral zone is very poor in benthic organisms due to the scouring effect of ice. Human settlements are few and small.
Priority areas within the ecoregion:

21. Eastern Novaya Zemlya Coast

Eastern Novaya Zemlya is characterized by high shores and cliffs, reaching a maximum along the northern part, where outlet glaciers of the Novozemelsky ice cap calf directly into the sea at several places between the coastal mountains. The intertidal zone is quite narrow due to small tidal differences, and the littoral zone is very poor in benthic organisms due to the scouring effect of ice. Running along Novaya Zemlya is however the Voronin deep-water trench, reaching 450 meters.

Outstanding biological features:

3 A very high degree of naturalness, with hardly any habitation ever, and very little human activity.

3 Belugas (white whales) spend summers feeding in the Kara Sea, migrating through the straits on their way to the important western wintering grounds on the Barents Sea coast: The Kara Gate to the south, and the Matochkin Strait between the northern and southern islands. The same passages are used also by other marine mammals, such as the walrus.

3 Breeding area for ringed seals. Wintering area for a small population of walrus, considered a possible recovery area for the heavily depleted walrus populations in the ecoregion.

3 Polar bear denning areas north of the Matochkin Strait, the most important sites to be found in the northern part of the area.

3 Ice-edge ecosystems influenced by heavy inflow of fresh water from the Siberian rivers.

Current conservation status:
None. Three of the planned protection areas for Novaya Zemlya will enter the area's waters: Eastern part of Willem Barents Park (part of Novaya Zemlya National Park) in the far north, the Northeastern Novozemelsky Zapovednik on the mid Severny Island, and the Karskiye Vorota Park (part of Novaya Zemlya National Park) at the Kara Gate.

Current resource use:
Hardly any. No pelagic fisheries, and little harvest of anadromous fish.

Current threats:
Nuclear waste. Dumping of nuclear waste went on for several decades in both the Kara and Barents Sea. There is a potential for radioactive contamination from nuclear reactors and other solid waste dumped in four coastal localities in the area. Reactors complete with fuel have been dumped in Abrosimova bay and Stepovogo bay.
Priority: III

Focal species: Ringed seal *(Phoca hispida)*

22. Eastern Kara Coast

The area is relatively shallow, with depths less than 50 meters. It is heavily influenced and altered by the massive influx of freshwater from the Ob and Yenisey rivers.

The coast of theYamal peninsula is basically low and formed by soft sediments. Estuaries seem to support the highest biological productivity in the subregion, based on organic matter carried by rivers. Apart from the Ob mouth at the northeastern border of the area, there are however only small and few rivers entering the area. The intertidal zone is quite narrow due to small tidal differences, and the littoral zone is very poor in benthic organisms due to the scouring effect of ice.
Human settlements are few and small.

Outstanding biological features:

3 The area is an important summer area for Belugas (white whales), standing out from the rest of the Kara Sea because of its value as a feeding area.

3 Breeding area for ringed seals, with particularly high densities in the Malygin strait at the northern end of the Yamal peninsula.

3 Summer and wintering area for a small population of walruses, considered a possible recovery area for the heavily depleted walrus populations in the ecoregion.

3 Recurrent polynyas presumably provide high primary productivity, supporting large concentration of Calanus and polar cod. Seabirds gather in the polynyas in spring, before the start of the breeding season.

3 Important migration stopover sites for waders on the East-Atlantic Flyway along the shore, as well as a migration and moulting area for marine ducks and geese. Brent geese and eiders breed along the coast, and after a recent expansion of the red-breasted goose, some colonies of this species have also been found close to the coast.

3 Ice-edge ecosystems influenced by heavy inflow of fresh water from the Siberian rivers.

Current conservation status:
Beliy Island

Current resource use:
Hardly any. No pelagic fisheries, and little harvest of anadromous fish. Oilfields on the Yamal peninsula border to the area.

Current threats:
Pollution. Russian measurements indicate high concentrations of petroleum hydrocarbons in the mouth of the Ob (4-20 times higher than in the Rhine or the Elbe, Hansen et al. 1996). It has been estimated that of the 200,000 tons of petroleum hydrocarbons entering the ecoregion every year, 60-70% is discharged into the Kara Sea from its enormous catchment area.

***Ship transport*.** Pollution from ships is restricted, but important locally. Transit traffic along sectors of the Northern Sea Route may be developed, after a preliminary period of increasing ship traffic to and from the large rivers.

***Pollution from the petroleum sector*.** A number of gas and condensate fields have been located in the Kara Sea, and increased offshore gas and oil exploration may be expected. A potential gas pipeline from the large fields on the Yamal Peninsula will cross the Baidaratskaya Bay. Development plans for the western shore of Yamal also include a large harbour at the settlement Kharasavey, for shipping of gas from the Kharasavey field.
Priority: III

Focal species: White whale *(Delphinapterus leucas)*

Beluga whale. Photo: WWF-Canon / Kevin Schafer

Atlantic puffin. Photo: WWF-Canon / Michèle D. Praz

6. CONSERVATION FIRST

The St. Petersburg workshop gathered some of the leading experts in various fields of biology, and involved them in the mapping and prioritising process described in the previous chapters. The areas nominated at the workshop, and the resulting Priority Areas outlined here, represent areas and processes considered significant for the conservation of biodiversity in the Barents Sea Ecoregion. They give us a better understanding of where conservation efforts will be particularly important. However, the workshop highlighted not only the rich diversity of life in the Barents Sea, but also the variety of human activities and related factors that do, or potentially could, undermine biodiversity in the ecoregion.

The most important current and potential threats to the ecoregion are summarised in the first part of this report. We know that **overfishing** has led to fisheries crises and changes in marine food webs. The ecoregion has the world's highest density of **nuclear reactors**, many of them inside rusting decommissioned submarines. Even small changes in temperature due to **climate change** are likely to cause large changes in arctic ecosystems, including the Barents Sea. An increasing number of **introduced species** are settling in the ecoregion and may cause severe impacts. In the very near future, **petroleum development** will represent a new major threat to the natural riches of the ecoregion. At the same time **shipping activities** are expected to increase dramatically, due not only to the development of new petroleum fields, but also as a result of the possible opening of the Northern Sea Route for commercial traffic, the development of the Northern Maritime Corridor and the increased transportation of oil from fields further east. Also, the **aquaculture industry** is expected to grow rapidly on both the Norwegian and Russian sides of the Barents Sea, carrying with it new environmental challenges. (Threats to the ecosystems of the Barents Sea have been discussed in a number of publications, see for example: AMAP 1997 and 2002, CAFF 2001, Gavrilo et al. 2000, Hansen et al. 1996, Hop et al. 1998, Klungsøyr et al. 1995, Lønne et al. 1997, Mathisov & Denisov 1999, OSPAR 2000, Sakshaug et al. 1992, Anker-Nillsen et al 2000, von Quillfeldt et al 2002).

In the face of these threats, it will be a tremendous challenge to secure the richness, productivity and diversity of the Barents Sea for future generations. Yet this is still possible. The Barents region now stands at a crossroads most other regions passed decades ago. In the Barents we can still choose how to move forward sustainably. In many other parts of the world the opportunities to balance conservation with development have already been lost.

A critical first step towards protection of a representative set of natural habitats balancing biodiversity with economic and industrial development in the Barents Sea is probably through the establishment of a network of marine protected areas (MPAs). Such a network should be established before new industrial development is to take place in order to provide buffer zones for marine organisms, maintain intact communities, build resilience and safeguard a set of representative marine areas for future generations to study. In WWF, we call this the principle of Conservation First. Conservation First means that there should be no new or expanded large scale developments in the Barents Sea until the areas of highest conservation value have been protected.

Implementing the Conservation First Principle through the establishment of a network of MPAs in the Barents Sea will have three major benefits:

For communities. It protects renewable natural resources and ecosystems that have been the basis for human communities for thousands of years and will be the basis for long-term, sustainable development in the future.

For conservation. It secures the survival of key species, ecosystem components, and processes identified as being important to and representative of the ecoregion. Some areas also have ecosystem functions far beyond the ecoregion itself, for example as havens for migratory species or moderators for larger-scale climate processes.

For business. The process allows conflicts to be identified and resolved before major investments are made, providing certainty and predictability for investors, developers, governments, conservationists, and other stakeholders

MPAs: A multitude of purposes and regulation regimes

The Priority Areas outlined at the St. Petersburg workshop represent areas and processes considered significant for conservation of biodiversity in the Barents Sea. It is our hope that these areas may provide a basis for a future network of marine protected areas in the ecoregion. Such a network may involve a number of different protected areas with a variety of purposes. They may be plain

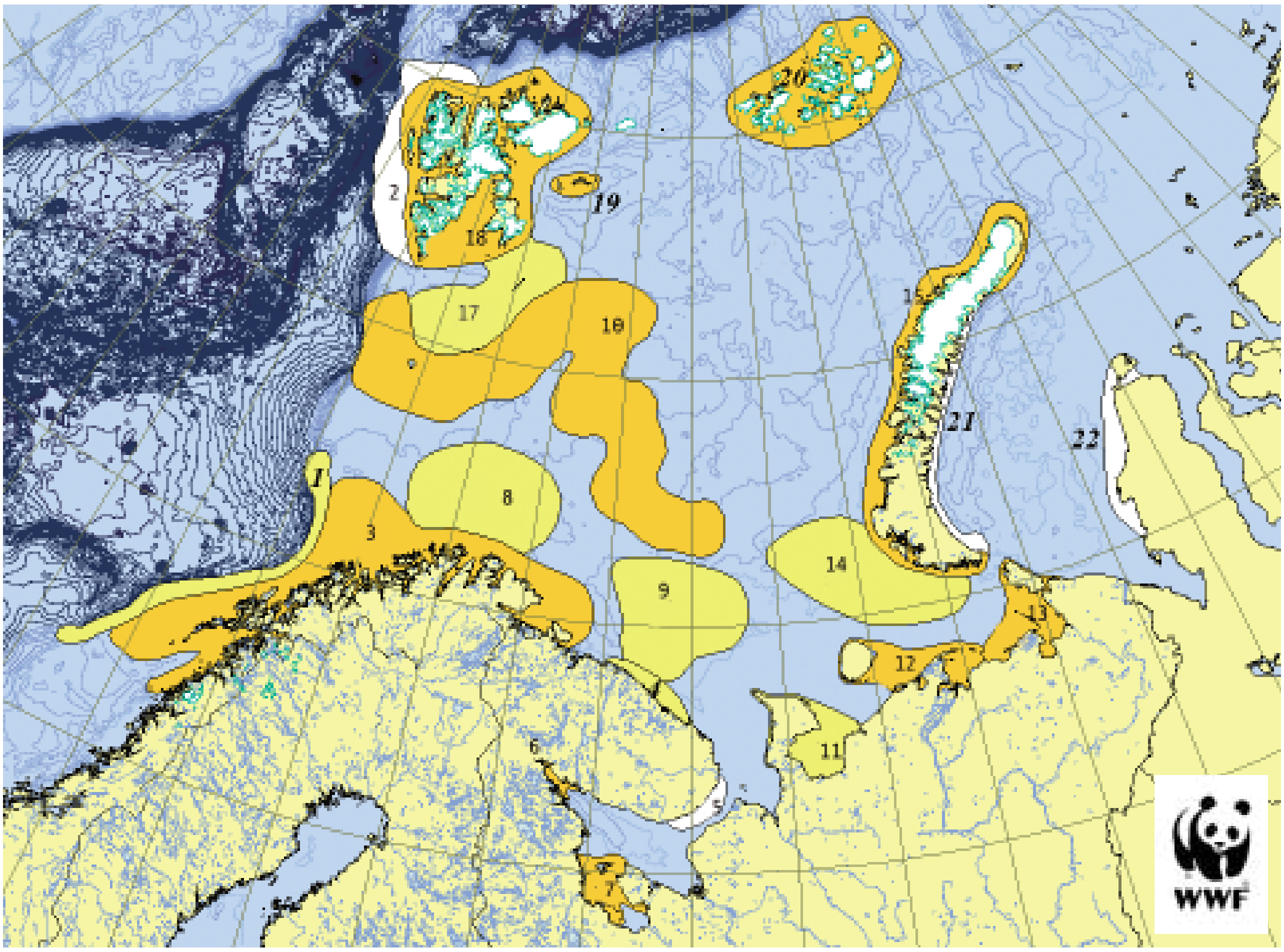


Figure 6.1: Priority areas for biodiversity conservation in the Barents Sea Ecoregion (same as figure 4.7) Dark yellow – very high priority, yellow – high priority, white – priority.

Numbers refer to name of the area: 1 = South-western shelf edge; 2 = North-western shelf edge; 3 = Norwegian coast and the Tromsø bank; 4 = Murman coast; 5 = The funnel; 6 = Kandalaksha Bay, 7 = Onega Bay; 8 = North cape bank; 9 = Banks off Murman coast; 10 = The Polar Front; 11 = Kanin Peninsula and Cheshskaya Bay; 12 = Western Pechora Sea; 13 = Eastern Pechora Sea; 14 = Southeast Barents Sea; 15 = The coast of Western and Northern Novaya Zemlya: 16 = ice edge (not on the map); 17 = Spitsbergen Bank; 18 = Svalbard Coast; 19 = Kong Karls Land; 20 = Franz Josef Land; 21 = Eastern Novaya Zemlya coast; 22 = Eastern Kara coast.

refuges or buffer zones for exploited populations; they may allow for sufficient abundance and diversity of resources needed by other species; they may serve to maintain intact, undisturbed communities and reference areas for environmental monitoring and research; or they may be designed very specifically to enhance reproduction of vulnerable or exploited populations.

By setting aside populations of fish, marine protected areas may help to ensure viable spawning populations in a variable environment like the Arctic, where stock estimates will always be hampered by irregular natural variations. The areas may protect nursery grounds, from which recruitment of adults is secured for large surrounding areas where exploitation of the fish resources takes place. "Safety areas" may be used also as a preventive measure to mitigate population losses or reverse the trend in declining species. Or they may be reserved for traditional uses of marine resources while excluding or limiting intensive commercial exploitation.

Networks of protected areas may include permanent zones of low intensity use around critical biodiversity conservation areas. Some areas are particularly vulnerable to certain impacts from certain activities and need to be protected from these. For example, coral reefs are damaged by bottom trawling and need to be protected against trawling, but not against other fishing practices. Likewise, some areas are particularly vulnerable to oil spills and the establishment of petroleum free zones would be an efficient way to protect them. Such areas may be complemented by temporary protected areas which are closed and opened at different times of the year or under particular conditions, strategically located on the basis of known patterns of species movements or resource availability (such regulation regimes have already been enforced for bottom trawlers).

In the Barents Sea today, most marine protected areas are designed as more or less casual extensions of terrestrial conservation areas. Except for the Røst Reef, none of them have been designed particularly with marine life in mind. The biggest marine protection area in the eco-region - the 31,424 km^2 coastal waters of Svalbard - goes only four nautical miles from shore. Apart from this narrow strip, the Røst Reef and the Franz Josef Land Zakasnik, there is virtually no overlap between present conservation areas in the Barents Sea ecoregion and the priority areas identified in this report.

Dynamic biodiversity hotspots

Temporary safety areas, as mentioned above, may be adjusted to match conditions of physical parameters such as ice extent, and provide buffers for species and populations in the predictably variable temperature, ice and productivity conditions of the Barents Sea. The participants of the St. Petersburg workshop wanted to stress the importance of dynamic ecological systems, and let this be reflected by a high conservation priority to areas like the ice edge. While suggesting that due attention be given to restrictions on human activities in dynamic areas, it was also proposed to expand the definition of dynamic areas to include all frontal zones, including the Polar Front and polynyas. In common for these areas is a high primary production attracting high densities of zooplankton, benthos, fish, marine mammals and seabirds. Areas like the 20-40 km wide "green belt" of the moving ice edge cannot be protected by static regulations, but need very specific and flexible protection measures. Likewise, polynyas also need flexible protection regimes to cope with the problem of shipping routes coinciding with high-productive ice-free areas.

Towards a Conservation Strategy for the Barents Sea Ecoregion

Once a network of MPAs has been implemented, development can be welcomed in a planned and conscious fashion outside of protected areas. However, when addressing the variety of threats on a regional scale, it is clear that setting aside valuable and vulnerable areas will not be enough. To ensure that important ecosystem functions and processes are not being permanently altered, the countries and regional authorities in the ecoregion must actively and cooperatively manage human activities, using the principles of ecosystem-based management.

Ecosystem-based management means managing human uses of an ecosystem so as to maintain its long-term ecological integrity. This means, where necessary, adjusting the way the activities are carried out so that the cumulative impacts of all activities do not alter important ecosystem functions and processes. And further, it means taking an inclusive approach to setting goals and objectives for the ecoregion, recognizing ecosystem interactions, integrating activities across a range of sectors, and respecting the broad range of values society has for the marine environment.

We already have most of the knowledge we need to manage and protect the marine ecosystem of the Barents Sea and its main functions and components. However, it is important to recognize that we will never possess all the facts when making decisions. A highly precautionary approach will therefore always be necessary. Since ecosystems are dynamic, achieving genuine sustainability will require substantial buffers to allow for uncertainties in our understanding and permit the ecosystem to adapt and respond to changes.

The identified priority areas are natural starting points for the development of focused conservation strategies to minimise threats to biodiversity. Our hope is that this assessment will enable policy-makers, natural resource managers and other stake-holders to improve decision-making and to take the necessary steps to conserve the biodiversity of the Barents Sea. With wise management and pro-active planning, it is possible to ensure that the Barents Sea continues to function with all its richness, despite the growth and expansion of infrastructure, industrial activity and resource exploitation

This biodiversity assessment will form the basis for the further development of WWF’s Barents Sea Ecoregion Programme. WWF will develop conservation strategies and implement a series of activities and projects in order to contribute to safeguarding the natural riches of the Barents Sea Ecoregion for future generations.

Walrus colony. Photo: Staffan Widstrand

Seabed community Jan Mayen. Photo: Bjørn Gulliksen

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Ocean currents and Polar Front (Fig. 2.2)

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WWF's Barents Sea Ecoregion Project

WWF is the world's largest nature conservation organisation with close to 5 million members and projects in more than 100 countries. WWF works globally to stop the destruction of nature and to preserve the biodiversity for future generations.

The Barents Sea is selected as one of WWF's ecoregions of highest priority due to its pure and vulnerable environment and high productivity. The Barents Sea is home to numerous populations of seabirds, fish, benthic organisms and sea mammals of global value. The natural resources of the Barents Sea are also the basis for the human settlements in the region, both on the Norwegian and Russian side.

Today, fisheries, petroleum activities, shipping, introduced species, aquaculture, radioactive wastes, long-range pollutants and man-made climate changes all represent considerable threats to the environment and to the industries that exploit the resources of the Barents Sea.

WWF is of the opinion that an open, allround and ecosystembased management is the only way to handle the environmental challenges in the Barents Sea region. WWF's ecoregion-project in the Barents Sea aims to increase the knowledge, create attention and ensure more participation in the resource management of the Barents Sea ecosystems – both in Norway and Russia. The project is led by WWF Arctic Programme in close cooperation with WWF-Russia and the WWF-Norway .

WWF's vision for the Barents Sea is a future where all the different groups and sections of society work together across international borders to make the Barents Sea the leading example of sustainable development and ecosystembased management.

WWF's Barents Sea Ecoregion Programme

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