Global International Waters Assessment

Barents Sea

GIWA Regional assessment 11

Matishov, G., Golubeva, N., Titova, G., Sydnes, A. and B. Voegele

Global International Waters Assessment

Regional assessments

Global International Waters Assessment

Regional assessment 11
Barents Sea

GIWA report production
Series editor: Ulla Li Zweifel
Editorial assistance: Johanna Egerup and Marianne Lindström
Maps & GIS: Niklas Holmgren
Design & graphics: Joakim Palmqvist

Global International Waters Assessment
Barents Sea, GIWA Regional assessment 11

Published by the University of Kalmar on behalf of
United Nations Environment Programme

ISSN 1651-940X

University of Kalmar
SE-391 82 Kalmar
Sweden

United Nations Environment Programme
PO Box 30552,
Nairobi, Kenya

CITATIONS
When citing this report, please use:
UNEP, 2004. Matishov, G., Golubeva, N., Titova, G., Sydnes, A. and B. Voegele. Barents Sea, GIWA Regional assessment 11. University of Kalmar, Kalmar, Sweden.

Printed and bound in Kalmar, Sweden, by Sunds Tryck Öland AB.

Contents

Executive summary

The Barents Sea is a unique Arctic marine ecosystem, characterised by distinct bathymetry and bottom topography, a large oceanic shelf, an extensive polar front, high productivity, and a high abundance and diversity of flora and fauna. The majority of the Barents Sea drainage basin is located in Russian territory, with small parts located in Norway and Finland. As the meeting point between the Atlantic and the Arctic Oceans, and Western Europe and Russia, the Barents Sea has attracted significant attention from many politicians and researchers, who are interested in its biological resources, its oil and gas reserves, as well as the potential risks of radioactive pollution.

The most pressing issues for the Barents Sea ecosystem were identified as the overexploitation of fish, oil spills, radionuclide contamination, and the modification of ecosystems by invasive species. Overexploitation of fish was considered as the most important issue since the major commercial fish stock (cod and haddock) are exploited beyond safe biological limits. Currently, the impacts of pollution by oil spills and radioactive wastes remain slight. However, due to the expansion of the oil and gas industry in the region, as well as increased shipments of oil and gas through the Barents Sea, the risk of accidental oil spills is likely to increase in the near future. There are also apprehensions that storage facilities for radioactive wastes could result in radioactive contamination of the environment, as the Murmansk Region houses more radioactive wastes than any other region in the world. With respect to the modification of ecosystems, there are concerns that the invasive Red king crab will compete with native species for forage reserves, which could result in the decrease of commercial fish stocks of the Barents Sea. Another problem, linked to oil transportation, is the risk of unintentional introduction of alien species in the ballast water of oil tankers.

Causal chain analyses conducted for each of the four main issues illustrated clear links between environmental and socio-economic impacts, and described how factors such as economic incentives, governance arrangements, politics, and the lack of knowledge are often major root causes for the identified problems. The absence of effective long-term plans and legislation was identified as a recurring root cause for many issues. A set of policy options for dealing with the issues of overexploitation, modification of ecosystems, and future threats from oil spills and radioactive contamination have been recommended. However, it should be noted that in practice, the implementation of the policy options will require a substantial amount of time and resources.

It is recommended that new regulations for different sectors should be adopted and enforced, along with rigorous adherence to existing international agreements. For example, there is a need for a long-term strategy for the handling and storage of radioactive wastes. With respect to fisheries, implementing and enforcing appropriate standards for fisheries management will require careful conflict resolution by the Joint Norwegian-Russian Fisheries Commission. Because parties have expressed commitments towards international agreements for the conservation and management of the marine environment, including the Convention on Biodiversity, the UN Fish Stocks Agreement, and the World Summit on Sustainable Development, it is assumed that the management of fisheries in the Barents Sea will improve over time.

This report presents the results of the UNEP/GIWA Assessment for the Barents Sea region as concluded during four workshops. The first two workshops were conducted in Murmansk, Russia, in September 2001 and February 2002. In these two meetings, only Russian experts participated. Since a small part of the Barents Sea drainage basin belongs to Norway and Finland, partners were found in Norway on the recommendation of the Programme authorities, and the last two workshops were carried out with support from Norwegian partners, one in Tromsø, Norway, in February 2003 and the other in Murmansk, Russia, in October 2003. The Task team was made up of local experts having a wide and long-term expertise concerning the environmental and socio-economic impact assessment in the Barents Sea region. In their work, the experts used various data obtained from a wide range of different international programmes and projects carried out in the region. The results provided are based on the conclusions from the Russian Task team, with support from the Norwegian experts and other invitees.

Abbreviations and acronyms

AC	The Arctic Council
ACIA	Arctic Climate Impact Assessment
AEPS	Arctic Environmental Protection Strategy
AMAP	Arctic Monitoring and Assessment Program
APPE	Arkhangelsk Pulp and Paper Enterprise
ARIA	Arctic Environmental Impact Assessment
BASIS	Barents Sea Impact Study
Bpa	Biomass precautionary approach
BaP	Benza Pyrene
CAFF	Conservation of Arctic Flora and Fauna
COP	Chlorine organic pesticides
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenylethane
DDT	Dichlorodiphenyltrichloroethane
EC	European Community
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPPR	Emergency Prevention, Preparedness and Response
EU	European Union
FAO	United Nation's Food and Agriculture Organization
GDP	Gross Domestic Product
GIWA	Global International Waters Assessment
α-HCH	alpha-hexachlorocyclohexane
γ-HCH	gamma-hexachlorocyclohexane
HRW	Hard Radioactive Wastes
IASC	International Arctic Science Committee
ICES	International Council for the Exploration of the Sea
IUCN	International Council of Conservation of Nature
ISM	Institute of Community Medicine
IUPAC	International Union of Pure and Applied Chemistry
JAMP	Joint Assessment and Monitoring Program
JSC	Joint Stock Company
KSCRAS	Kola Scientific Center Russian Academy of Sciences
LME	Large Marine Ecosystem
LRW	Liquid Radioactive Wastes
MAC	Maximum Allowable Concentration
MAHMS	Murmansk Region Administration for Hydrometeorology and Environment Monitoring
MMBI	Murmansk Marine Biological Institute
MSY	Maximum Sustainable Yield
NEFCO	Nordic Environment Finance Corporation
NGO	Non-Governmental Organisation
OCPs	Organochlorine pesticides
OPA	Oil Pollution Act
PAHs	Polycyclic Aromatic Hydrocarbons
PAME	Protection of the Arctic Marine Environment
PCBs	Polychlorinated biphenyls
PINRO	Polar Scientific Research Institute of Fisheries and Oceanography
POPs	Persistent Organic Pollutants
RF	Russian Federation
RSFSR	Russian Soviet Federative Socialist Republic
RTE	Repairing and Technological Enterprise
SDU	Sustainable Development and Utilisation
SDWG	Sustainable Development Working Group
SFT	Norwegian Pollution Control Authority
SNF	Spent Nuclear Fuel
SPA	Scientific and Production Association
TAC	Total Allowable Catch
UNEP	United Nations Environment Programme
VMS	Vessel Monitoring Systems
VNIRO	All-Russian Research Institute of Fishery
VOC	Volatile Organic Compounds
USSR	Union of Soviet Socialist Republics

List of figures

List of tables

Regional definition

This section describes the boundaries and the main physical and socio-economic characteristics of the region in order to define the area considered in the regional GIWA Assessment and to provide sufficient background information to establish the context within which the assessment was conducted.

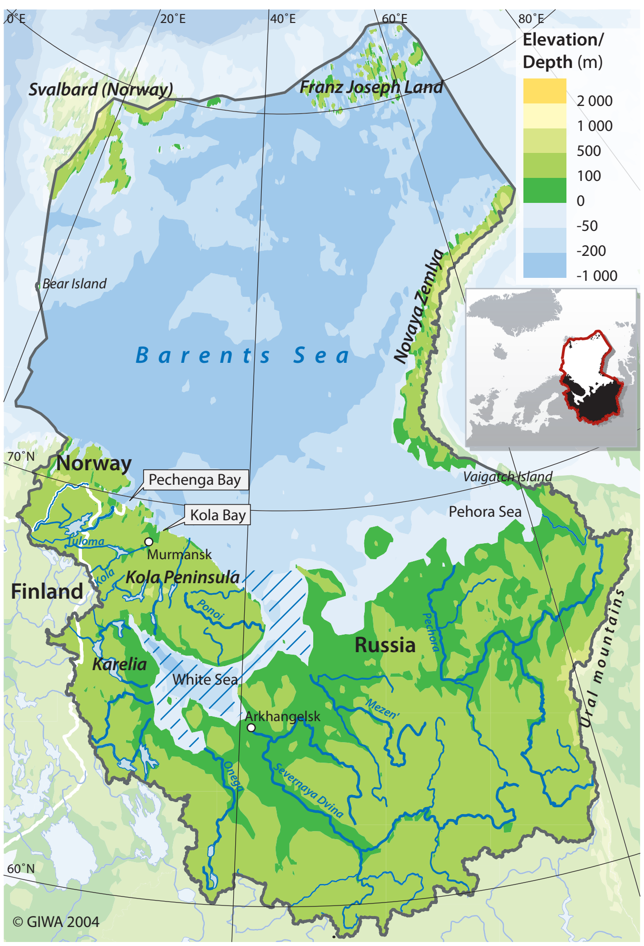


Figure 1 The Barents Sea region.
(Source: elevations based on USGS 2003)

Boundaries of the Barents Sea region

The boundaries of GIWA region 11 follow the traditional geographic boundaries of the Barents Sea and stretches from north to south between the latitudes 82° N and 59° N and from east to west between the longitudes 68° E and 15° E (Figure 1). To ensure the comparison of the Assessment results with other UNEP/GIWA regions, the Barents Sea region was considered as a single system of international waters.

The following systems of the Barents Sea drainage basin were considered in the Assessment:

- The Kola River and the Kola Bay;
- The White Sea and the Severnaya Dvina River;
- The Pechora River and the Pechenga River;
- The Barents Sea.

Physical characteristics

The Barents Sea region is situated in the extreme northeast of Europe (Figure 1). Its open water area is approximately 1.5 million km^2 (Barents Sea: 1 424 000 km^2, White Sea: 90 000 km^2) and the catchment area is 1 386 000 km^2. The White Sea covers approximately 6% of the total open water area and comprises only 2% of the total volume of marine water, but it receives more than half of the river run-off in the region which is of great ecological importance.

The drainage basin lies almost entirely within the boundaries of Russia. In the extreme southwest of the Barents Sea, a small part of the basin belongs to Norway and Finland. However, these territories are sparsely populated and do not impose any considerable ecological burdens on the basin. The White Sea is a semi-enclosed (domestic) sea of Russia. The Barents Sea shelf belongs to Russia and Norway (its National delimitation is presently under discussion).

The Barents and the White Seas are entirely located on the Arctic shelf and thus, the geological structure of the continental and marine parts of the basin is considered as a single unit. The Kola Peninsula and Karelia lie completely within the limits of the Baltic crystalline shield, where bedrocks of Proterozoic and Archean ages predominate at the surface. The remaining terrestrial part of the basin, as well as the marine areas of the Barents and White Seas, lie within the limits of the Russian platform (Richter 1966). The modern terrestrial topography and the marine relief were formed during the Quaternary period under the influence of the continental and shelf glaciation.

The Barents and White Sea shelf is rather deep. In the Barents Sea more than 50% of the area have depths of 200-500 m. The average depth is approximately 200 m and the maximum depth in the Norwegian trench reaches 513 m and in the Franz Josef Land straits it exceeds 600 m. In the White Sea, a considerable part of the shelf consists of shallow bays with an average depth of only 67 m and a maximum of 350 m.

Generally, the terrestrial basin relief is formed by plains and low highlands (up to 450 m), fringed in the east by the meridian Ural Range and its continuation towards the north; the Novaya Zemlya mountains. In the west the Scandinavian mountains and low mountain massifs of the Kola Peninsula (up to 1 200 m) edge the basin, whereas in the southwest and south, the basin is limited by a low watershed.

Figure 2 Average long-term air temperature, January.
(Source: temperature curves redrawn from Terziev et al. 1990, icecover at sea based on NSIDC 2004)

Climate

The main climate-forming factors are latitudinal changes in the incidence of solar radiation and the influence of the warm Atlantic water masses, entering the Barents Sea in the west. In the terrestrial part of the region the climate is transitional from marine to continental, with the continental influence increasing with distance from the coast. The climatic impacts of increasing continental influence are decrease in cyclonic activity, increased range of air temperature, and decrease in number of cloudy days and days with precipitation (Terziev et al. 1990).

The main feature of the winter air temperature distribution (Figure 2) is the so-called warmth pole in the ice-free southwestern Barents Sea, where the average January sea temperature is close to 0°C. In the eastern part of the region, the severity of the winter regime both on land and in the southeastern Barents Sea increases sharply. The absolute air temperature minimum in the Barents Sea region reach 20°C below zero over the ice-free area of the Sea and 30°C below zero in the north and southeastern part. On land, in remote areas far from the Sea, air temperatures reach 50°C below zero.

Summer temperature distribution depends first of all on the solar radiation (Figure 3). Temperature maximum, close to 35°C, are attained in all parts of the land area, including the coastal zone. Corresponding values, calculated for offshore areas, vary from 30°C over the coastal water mass to 24°C at the boundary of Atlantic and Arctic water masses (74° N) (Matishov et al. 1998).

The total annual precipitation decreases northwards within the boundaries of the catchment area from 600 mm in the upper reaches of the Severnaya Dvina to 400 mm at the coast. At the same time, the humidity does not vary much, as evaporation decreases almost in the same proportion (from 250 to 100 mm per year). Over the Barents Sea, the total annual precipitation increases in the ice-free southwestern

Figure 3 Average long-term air temperature, July.
(Source: temperature curves redrawn from Terziev et al. 1990, icecover at sea based on NSIDC 2004)

part to 800-1 000 mm/year. In the north of the Barents Sea and the Arctic archipelagos, annual levels of 300-400 mm are typical.

River basins

The drainage basin of the Barents and White Seas is characterised by numerous middle-sized and small lakes, which are, as a rule, of glacial origin (Richter 1966).

The southern part of the region is noted for a dense river network, abundant river run-off and considerable water resources comprised of numerous lakes and water reservoirs. On the Kola Peninsula and in Karelia the relief and geological structure allow the formation of many river basins, which drain directly into the Sea. Lakes and water reservoirs regulate the run-off of most of the rivers in this part of the region. The characteristics of the largest rivers of the region are presented in Table 1. Among these rivers only the Pasvik River is transboundary.

Table 1 Characteristics of the largest rivers in the Barents Sea region.

River	Location of discharge	Length (km)	Catchment area (km²)	Discharge (m³/s)
Tuloma	Barents Sea	64	22 800	200
Kola	Barents Sea	83	3 800	40
Voronya	Barents Sea	155	9 800	110
Iokan'ga	Barents Sea	197	6 020	60
Ponoi	White Sea	410	15 200	140
Kem'	White Sea	200	28 000	270
Vyg (Belomorsko-Baltiysky canal)	White Sea	308	29 500	290
Onega	White Sea	416	57 600	575
Severnaya Dvina (from the Sukhona entering the Vychegda)	White Sea	730	360 000	3 500
Mezen'	White Sea	910	76 500	840
Pechora	Barents Sea	1 790	327 000	4 100
Pechenga	Barents Sea	~100	1 820	22.2
Pasvik	Barents Sea	143	18 340	201

Note: Among these rivers only the Pasvik River is transboundary. (Source: Richter 1966)

The main source for the rivers is melting waters that comprise 50-55% of the run-off. Strong increases in river flow during the period of snow melt, low run-off during summer and winter, and variable autumn floods, determined by high precipitation levels and decreased evaporation, are typical for the majority of rivers. The rivers of the Kola Peninsula and Karelia are characterised by a more even run-off throughout the year.

Hydrological characteristics

The volume of the Barents Sea is, according to the most recent assessments, 282 000 km³ and that of the White Sea 6 000 km³. The Barents Sea is marginal; its water exchange with the Norwegian Sea and the Arctic basin is free and is part of a circulation involving the waters of the North Atlantic and the Arctic Ocean. The length of the cycle of Barents Sea water renewal is about 6 years (Terziev et al. 1990). For the White Sea water balance, the determining factor is river run-off, which is approximately 230 km³/year or 4% of the volume (Glukhovsky 1991).

The seasonal ice-cover, which is characterised by considerable inter- and intra-annual variability, is formed in the Barents and White Seas. The White Sea is covered by drift ice in November-December, followed by 5-6 winter months when the ice cover is close to 100%. In the Barents Sea, the ice conditions contrast between practically no ice at all in the southwestern part, to ice appearing also in the summer (under certain synoptic conditions), in the northern part. Processes of summer heating and autumn-winter convection determine the changes in water temperatures in both the Barents and the White Seas during the year.

Salinity in the Barents Sea is close to oceanic salinity (approximately 35‰ in the open areas and 34.5‰ in coastal waters). In the White Sea, as a result of intensive mixture of river and marine waters, it decreases to 25-26‰ in summer and 26-27‰ in winter (Matishov et al. 1998, Glukhovsky 1991).

Marine biodiversity

The composition and migratory habits of living organisms in the Barents Sea are determined by the contrast of the environmental conditions between the Atlantic and the local water masses (Matishov 1986a).

Benthos

All types of invertebrates, apart from chaetognaths, which are planktonic organisms, are represented in the Barents and White Seas benthos. At present, no less than 3 245 zoobenthos species have been identified (Sirenko 2001). The majority of species belongs to widely distributed Arctic boreal and Arctic high-boreal biogeographic groups. The taxonomic groups with highest species numbers are Polychaeta, Hydroidea, Mollusca, Crustacea and Bryozoa. Many of the White and Barents Seas invertebrates are commercially exploited e.g. Icelandic scallop (*Chlamys islandica*) and Common mussels (*Mytilus edulis*), or are potentially subject to exploitation e.g. the Northern sea urchin (*Strongylocentrotus droebachiensis*) and the sea cucumber *Cucumaria frondosa*. At present, there is a commercial fishery for the Red king crab (*Paralithodes camtschatica*) which was introduced in the 1960s and has since increased in abundance. This fishery is now under discussion (Kuzmin & Gudimova 2002).

Plankton

The list of Barents Sea phytoplankton includes at present more than 310 reliably distinguished species belonging to the Bacilloriophyta, Dinophyta, Chrysophyta, Chlorophyta, Haptophyta, Prasinophyta, Euglenophyta and Cryptophyta. According to the phytogeographic characteristics, approximately 40% of the Barents Sea phytoplankton species can be characterised as Arctic species, more than 20% as boreal species and the rest as cosmopolitan or with an undesignated geographic distribution (Matishov et al. 2000).

A total of 145 marine species and varieties of phytoplankton are recorded for the White Sea (Semina & Sergeeva 1983). There are fewer diatom species than in the Barents Sea but the number of dinoflagellates species is higher in the White Sea (Makarevich et al. 1991). In the Barents Sea pelagic fauna, more than 200 zooplankton species are represented. The most commonly observed and the most numerous are representatives of the crustacean class, including copepods (Copepoda). By its zoogeographic characteristic, the Barents Sea zooplankton consists of boreal, arctic, and transitional species (Matishov et al. 2000).

Phytobenthos

Algal macrophytes are an important source of raw materials for food and pharmaceutical industries. Fucoids (*Ascophyllum nodosum*, *Fucus distichus*, *F. serratus*, *F. vesiculosus*) and blade kelps (*Laminaria saccharina*, *L. digitata*) belong to the commercial algae of the Barents and White Seas. At present, the stocks of commercial algae in the investigated areas of the Barents Sea are estimated to 350 000-450 000 tonnes. Most of them are concentrated on the Murman coast (Matishov 1998).

Ichthyoplankton

The Atlantic waters, dominating in the west of the Barents Sea, are noted for high productivity and high diversity of commercial fish species (cod, haddock, Atlantic herring, catfish, plaice, halibut etc.). More simple food links are typical of the eastern and northern areas of the Sea where huge concentrations of Arctic cod and capelin, forming the feeding base for the Gadidae family, are recorded (Matishov & Denisov 2000). The most important commercial resource of the freshwater basin is the salmon, which enters the rivers of the Kola Peninsula, the Mezen River, the Pechora River and small rivers of the southeastern Barents Sea and the Norwegian coast.

Birds and mammals

Marine birds and mammals are top consumers in marine ecosystems. Many species are rare and endangered. There are 24 marine bird species in the Barents Sea (Krasnov et al. 1995). The marine ornithofauna in the southern part of the Barents Sea mainly consists of gulls; Herring gull (*Larus argentatus*) and Great black-backed gull (*Larus marinus*). In the northern Barents Sea Glaucous gull (*Larus hyperboreas*) and Fulmars (*Fulmarus glacialis*) dominate. The largest bird colonies of the Barents Sea are located along the western coast of Novaya Zemlya and along the coast of Murman. The most abundant species at these sites are Brunnich's guillemot (*Uria lomvia*) and Kittiwake (*Rissa tridactyla*) (Anker-Nilssen et al. 2000).

Marine mammals, such as polar bears and different whales and pinnipeds, inhabit the Barents Sea region either seasonally or constantly. The majority of the Barents Sea pinnipeds and whales are representatives of rare or protected species included in the Red Books of the IUCN, USSR and RSFSR.

In total, there are 12 whale species in the Barents Sea (Matishov 1999). Among them five can be considered as regular inhabitants: the Arctic right whale (*Balaena mysticetus*), the Narwhal (*Monodon monoceros*), the

White whale (*Delphinapterus leucas*), the Bagridae family (e.g. *Orcinus orca*) and the Little piked whale (*Balaenoptera acutorostrata*). The most abundant species of the Barents and White Seas are white whales and little piked whales, which are the traditional commercial species.

The area of Murman and the Western Arctic is inhabited by seven species of pinnipeds. One of the most numerous species is the Harp seal (*Pagophilus groenlandica*), which is closely associated with cold waters and is of great economic importance in Russia (Isaksen & Wiig 1995).

The Polar bear (*Thalassarctos* (*Ursus*) *maritimus*) is a rare species, until recently listed as an endangered species in the Red Books of the IUCN, USSR, and RSFSR. Its distribution is related to the islands of Frantz Josef Land, Novaya Zemlya, and Svalbard.

Terrestrial ecosystems

Figure 4 shows the landcover in the terrestrial part of the region. More than two thirds of the territory of the basin are under taiga forests (needleleaf forest and broadleaf forest), where coniferous species are dominant. The western part of the region is dominated by Norway spruce, pine, and European larch and in the eastern part Siberian spruce, fir, cedar, and Siberian larch predominate.

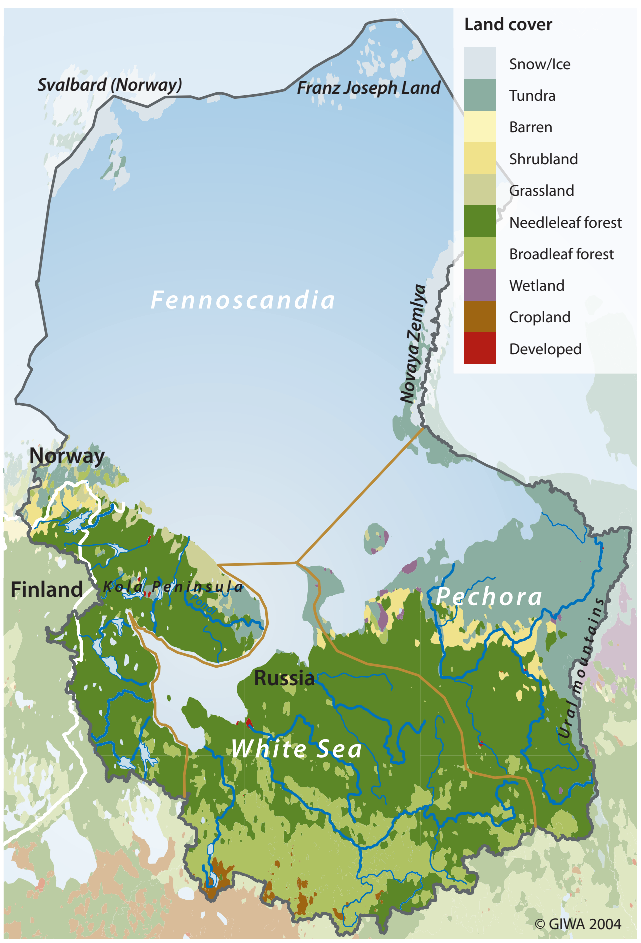


Figure 4 Land cover in the Barents Sea region.
(Source: based on USGS 2002)

The composition of the terrestrial fauna corresponds to two main landscape zones, the tundra and the taiga. The most dominant mammal species of the tundra are lemming and polar fox, among birds polar owl and tundra partridge predominate together with numerous passerines. Reindeer, which in the past were wild and widespread in the tundra and taiga, now survive in the form of domesticated populations and are the basis of economic activity in the Pechora tundra, as well as in the central areas of the Kola Peninsula. Fur-bearing mammals such as Blue hare, marten, squirrel, fox, stoat, etc. as well as moose, wolves, and bears are typical of the taiga zone. Typical bird species are tits and woodpeckers. Species of commercial value are Hazel hen, Black cock, Capercaillie and White grouse. Both landscape zones are characterised by large populations of waterfowl and near-water birds, e.g. woodcocks, teals, geese, ducks and swans.

Among the freshwater fishes, the most valuable are whitefish, burbot, and trout. Perch, ruff and pike are widely spread.

Physical and geographical sectors

For the purpose of this report, three geographic sectors were identified: the White Sea, Pechora and Fennoscandia (the northern and northeastern slopes of the Baltic shield). The boundaries of the sectors are shown in Figure 4.

The river basins of Fennoscandia belong to both the Barents and the White Seas, but in both cases, their influence on the marine waters is comparatively slight. The river run-off does not play a significant role for the western part of the Barents Sea. The state of the aquatic environment is determined by the water exchange with the deepwater oceanic basins, transboundary transfers of contaminants in the ocean and in the atmosphere, and on the discharges of contaminants directly from the coast to the coastal waters.

The main factor influencing the ecology of the White Sea sector is the run-off from the Severnaya Dvina, Mezen and Onega rivers. In total, they transport 80% of the freshwater entering the White Sea, comparable parts of particulate and dissolved run-off and practically the entire load of chemical contaminants. The impacts of these sources on the Barents Sea can be shown only indirectly through their impact on the White Sea water mass (Berger & Dahle 2001).

In the Pechora sector, the formation of water and the chemical balance is in principle determined by the run-off of the Pechora River. Here, unlike the other two marine sectors, seasonal changes in salinity and the chemical composition of marine waters are pronounced since the volume of the river run-off is comparable to the volume of coastal marine waters. The Pechora sector also differs in the character of its anthropogenic impact and its source distribution: there are fewer large industrial centres and the agricultural activity is negligible. However, the terrestrial and marine oil and gas complexes, present in all their aspects including geological and geophysical prospecting, exploratory drilling, and hydrocarbon extraction and transportation, have been developing quickly.

Socio-economic characteristics

Although the Barents Sea region is constituted as one geographic system, there are two separate socio-economic regions, Norway and Russia, which are discussed separately in this section as well as further in the Causal chain analysis.

Protection of the Barents Sea environment is a common responsibility of all border countries. Changes in environmental and social conditions are highly interdependent. Environmental conditions and trends affect human health and quality of life. Social conditions and outcomes need to be reviewed when designing and implementing environmental management activities and policies.

The state of water systems in the Barents Sea region is influenced by the water catchments of:

- Four administrative regions of the Russian Federation located on the coast of the Barents and White Seas: the Murmansk Region, the Arkhangelsk Region, Karelia, and the Nenets Autonomous Region;
- The easternmost county of Norway, Finnmark, located on the westcoast of the region.

In this report, socio-economic factors that can influence the state of aquatic ecosystems with respect to GIWA concerns, such as growth of industrial and agricultural production, fisheries development, population development and social problems, have been considered.

Population

The population density in the four Russian regions considered for the Barents Sea region is 3.5 persons per km^2, which is lower than the average Russian density of 8.5 (Figure 5 and Table 2) (State Statistics Committee 2002a). This is a consequence of the population decrease, including migration from these regions during the last two decades. In Finnmark, Norway, the population size decreased slightly over the same period and was 1.52 persons per km^2 in 2002 (Figure 5 and Table 2). However, the population density in Finnmark has always been significantly below the Norwegian average, which was 14.0 persons per km^2 in 2002 (State Statistics Committee 2002a).

The urban population in the Russian part of the region is rather high (79.9% in 2001) (Table 3) (State Statistics Committee 2002a). In Finnmark, the level of urbanisation is low. The population of the four regional centers Vadsø, Hammerfest, Alta and South-Varanger is about 42 000, compared to a total population of approximately 74 000 for Finnmark as a whole. The population development in the northern regions of Russia, 1990 being the starting point, is negative (Table 4) (State Statistics Committee 2002b).

The main reason for the decrease in population is natural population loss. In the four Russian regions considered for the region the number

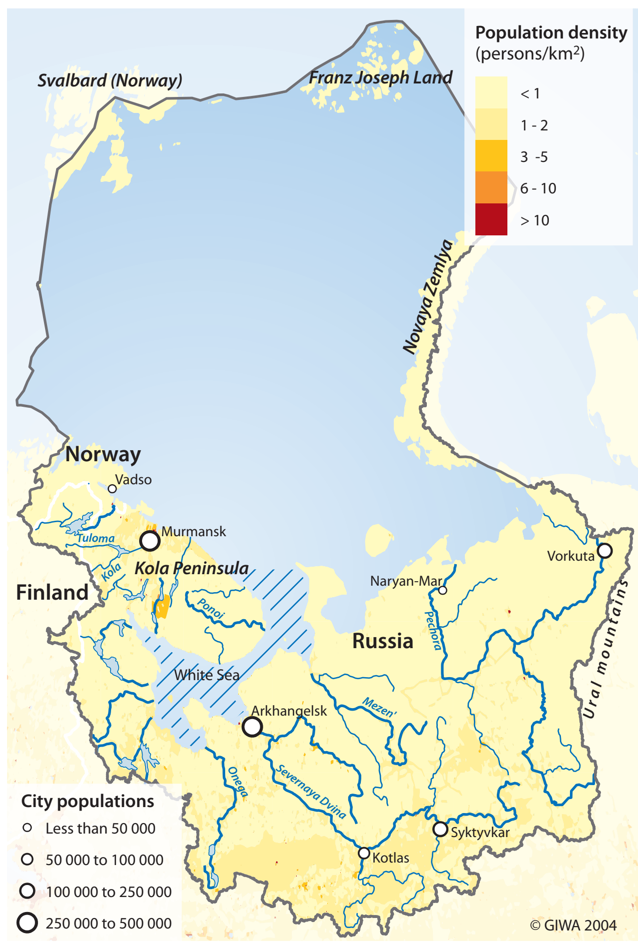


Figure 5 Population density.
(Source: data from ORNL 2003)

of deaths exceeds the number of births. Analysis of the indices of birth and death per 1 000 persons showed that the number of persons born in all the regions of the Northwest Russia, starting since 1985, decreased. The other reason for the negative population development is the number of people migrating from the regions compared to the number of people immigrating, caused by state policy. In coastal settlements, negative tendencies in demographic and migration processes manifest themselves more severely. Life expectancy at birth is the most commonly used statistical value for assessing population health. This characteristic is directly dependent on the socio-economic development of the region. While for all northern Russian regions the life expectancy has decreased, it is increasing in Finnmark County, Norway (Table 5) (State Statistics Committee 2002b).

Economic indicators

The average material welfare can be defined by the Gross Domestic Product (GDP) per capita. Table 6 shows that the growth of GDP was broken by the crisis of 1998. In 2000, GDP per capita was 36.2% lower than in 1997 (State Statistics Committee 2001). The highest average level of the material welfare was in 1997. However, this does not reflect the late 1990s, as it was the time when the USD was very much undervalued in Russia (up to August 1998). Then in 1999 it was substantially overvalued, and the difference was significant (Table 6). At present, the GDP has not yet reached the level of 1997.

Comparable statistical data for Finnmark County are not available. However, the gross income per employee over 17 years of age shows a steady increase, which is not only caused by the inflation rate, but also by increased economic activities in the region. The annual gross income per employee in Finnmark in 1994 was 19 802 USD, then increased in the subsequent years and in 2000 it was 28 512 USD. The index of the growth in USD constituted 144% (Finnmark County statistical data).

The annual gross income per employee in Karelia, Arkhangelsk Region, Nenets Autonomous Region, and Murmansk Region in 2000 constituted 945 USD, 867 USD, 1 305 USD, and 1 444 USD respectively. Thus, the annual gross income per employee in these four Russian regions in 2000 was lower than in Finnmark, Norway, by 97%, 97%, 96%, and 95% respectively (State Statistics Committee 2001).

A stable increase in industrial production and GDP in the four Russian regions considered for Barents Sea region began as late as in 1999 (Tables 7 and 8) (State Statistics Committee 2001). The Russian economy experienced a heavy crisis during the last decade and suffered not only a sharp decrease in production volumes but also an increase in unemployment. Table 9 illustrates not only a considerable reduction in population of the northern regions of Russia, but also an increase in unemployment (State Statistics Committee 2002b).

The population decreased in 2000 and 2001 and continues decreasing. This negative trend will continue if measures to reduce poverty are not taken. At the same time it should be noted that there has been a slight reduction in unemployment since 2002, caused by the growth of industrial production and GDP (State Statistics Committee 2002b).

Table 2 Population density.

	1985 (people/km^2)	1990 (people/km^2)	2002 (people/km^2)
Russia (four regions considered)	3.77	3.93	3.5
Finnmark (Norway)	1.55	1.52	1.52

(Source: State Statistics Committee 2002a)

Table 3 Urban population in the Russian sector of the region.

	1959	1985	1990	1992	1994	1996	1998	1999	2000	2001
Total population	2 486 000	3 463 500	3 549 700	3 495 600	3 417 100	3 336 100	3 267 200	3 225 500	3 191 800	3 162 900
Urban population	1 598 000	2 767 100	2 898 300	2 778 400	2 711 300	2 648 300	2 598 500	2 548 100	2 544 200	2 525 700
Urban population (%)	64.3	79.9	81.6	79.5	79.3	79.4	79.5	79.0	79.7	79.9

(Source: State Statistics Committee 2002a)

Table 4 Changes in population in the Russian sector of the region.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Russia (four regions considered) (per 1 000 persons)	4.1	2.2	-0.9	-4.8	-5.9	-5.7	-4.3	-3.7	-3.3	-5.6	-5.8	-5.6

Note: 1990 being the starting point. (Source: State Statistics Committee 2002b)

Table 5 Life expectancy at birth.

	1999	2000	2001
Russia (four regions considered)	65.1	64.3	64.2
Finnmark	72.0	72.3	72.7

(Source: State Statistics Committee 2002b)

Table 6 Gross Domestic Product per capita in Russia and the Russian sector of the region.

	1994 (USD)	1995 (USD)	1996 (USD)	1997 (USD)	1998 (USD)	1999 (USD)	2000 (USD)	2001 (USD)	2002 (USD)
Russia (four regions considered)	2 288	2 408	2 546	2 551	1 760	1 252	1 627	ND	ND
Russia	ND	2 116	2 593	2 654	1 672	1 134	1 589	1 904	2 515

Note: ND=No Data. (Source: State Statistics Committee 2001, 2003)

Table 7 Indices of industrial production in the Russian sector of the region.

	1994 (%)[1]	1995 (%)[1]	1996 (%)[1]	1997 (%)[1]	1998 (%)[1]	1999 (%)[1]	2000 (%)[1]	2001 (%)[1]
Russia (four region considered)	82	97	90	105	98	117	116	103

Note: [1] % of previous year. (Source: State Statistics Committee 2001)

Table 8 Indices of physical volume of the Gross Domestic Product in the Russian sector of the region.

	1997 (%)[1]	1998 (%)[1]	1999 (%)[1]	2000 (%)[1]
Russia (four regions considered)	98.4	95.0	109.6	109.6

Note: [1] % of previous year. (Source: State Statistics Committee 2001)

According to the data, the number of unemployed in 2001 increased compared to 1992: in Karelia by 157.6%, in the Arkhangelsk Region by 164.4%, and in the Murmansk Region by 208.5%.

The unemployment (the ratio of unemployed compared to the number of the economically active) during these years varied: in Karelia from 5.0% in 1992 to 16.6% in 1998 and 8.7% in 2001, in the Arkhangelsk Region from 4.9% in 1992 to 14.9% in 1999 and 8.8% in 2001, in the Murmansk Region from 5.5% in 1992 to 21.1% in 1998 and 12.8% in 2001.

The economic crisis had an impact on the fishing industry as well, to which the majority of the population was connected and which solved many social problems in the region in the past. In the end of the 1980s approximately 75 000 people were employed in the fisheries sector. During the 1990s, the fishery outside the Barents Sea was stopped and coastal fish processing reduced, which resulted in an employment decrease in the sector of 60%.

The total number of employed in Finnmark County, Norway, increased in 2001, compared to 1994, by 822 persons (2.5%). The number of employed in the fisheries sector and aquaculture was at the same time reduced by 1 069 (22.1%). The unemployment in Norway in total decreased from 5.2% in 1994 to 2.7% in 2001, in Finnmark County the unemployment rate decreased from 5.6% in 1994 to 4.8% in 2001 (Table 10) (Finnmark County Statistical data). It should be noted that the unemployment rate in Finnmark is two times higher than in Norway as a whole, primarily caused by the reduction in the number employed in the fisheries sector.

The crisis in the Russian fisheries sector, together with a reduction in the number of units of the Northern Navy, which was the only support for some coastal settlements, has had the most negative impact on the coastal settlements and villages. Coastal fishery and appropriate social policy could raise the living standard on the coast. However, the coastal fishery declined in the 1960s and 1970s. The fishing kolkhozes (cooperative groups) were mainly occupied in oceanic trawling fishing, though supporting the social sphere of the coastal settlements and villages before the market reforms. During the last decade the quotas for the Barents Sea fisheries decreased, which resulted in the reduction of fishing subsidies. All this dramatically increased social and economic problems on the coast.

Table 11 shows the change of the population number in the coastal settlements and villages of the northern regions of Russia and Finnmark in Norway. In the Murmansk Region, in the fishing kolkhozes and coastal settlements previously occupied by the military, the population decreased from 1989 to 2000 by almost 12 000 persons (33.7%).

Economic sectors

The most important economic sectors in Finnmark County, Norway, are fishery and fish processing, reindeer breeding, the service sector and trade.

Table 9 Population and employees in the Russian sector of the Barent Sea region.

	1985	1990	1995	1999	2000	2001
Population at the end of the year	3 413 500*	3 551 700*	3 369 900*	3 270 700	3 191 800	3 162 900
Average annual number of employees	1 714 300*	1 747 000*	1 479 600*	1 361 600	1 375 100	1 382 400
Ratio of employed to the total population (%)	50.2*	49.1*	43.9*	41.6	43.1	43.7

*Note: *Without the Nenets Autonomous Region. (Source: State Statistics Committee 2002b)*

Table 10 Number of employed persons and the unemployment rate in Finnmark County, Norway.

	1994	1995	1996	1997	1998	1999	2000	2001
Number of employed persons	32 451	33 413	33 548	33 694	33 740	33 474	33 720	33 273
Number of employees in the fisheries sector and aquaculture	4 841	4 881	4 533	4 532	4 248	4 038	3 925	3 772
The unemployment rate, Norway (%)	5.2	4.8	4.2	3.3	2.4	2.6	2.7	2.7
The unemployment rate, Finnmark (%)	5.6	6.1	6.7	5.5	4.5	4.8	4.9	4.8

(Source: Finnmark County Statistical data)

Table 11 Population changes in the coastal villages and settlements of the northern regions of Russia and Finnmark, Norway.

Coastal villages and settlements	Population			
	1950	1970	1989	2000
Karelia	2 073	1 085	795	688
Arkhangelsk Region	ND	9 424	6 985	6 077
Nenets Autonomous Region	ND	4 317	3 412	3 047
Murmansk Region	ND	ND	35 510	23 536
Eastern Finnmark	12 000	12 500	10 100	9 800

Note: ND = No Data. (Source: Russia: Local administrations data, Finnmark: County statistical data)

Table 12 The share of economic sectors in GDP in the Russian sector of the region in 2000.

	Industry (%)	Agriculture (%)	Building (%)	Retail trade (%)
Russia (four regions considered)	65.2	4.4	4.2	26.2

(Source: Batchaev et al. 2002)

The four Russian regions considered for the Barents Sea region are industrially developed regions. Table 12 shows that agriculture constitutes an insignificant part of the total GDP: 4.4% (in Karelia 4.7%, in the Arkhangelsk Region 7.7%, in the Nenets Autonomous Region 0.4%, and in the Murmansk Region 1.5%) (Batchaev et al. 2002).

The determining factors for economic development of the Russian coast of the Barents Sea region are the exploitation of natural resources. The main branches of industry are the following (Figure 6):

- Mining industry and metallurgy (Karelia, Murmansk Region);
- Forestry, wood-processing, and pulp and paper industry (Karelia, Arkhangelsk Region);
- Oil and gas industry (Arkhangelsk Region, Nenets Autonomous Region);
- Fishery and fish-processing industry (Murmansk Region, Arkhangelsk Region, Nenets Autonomous Region);
- Electric power production (Murmansk Region);
- Production of building materials (Karelia, Murmansk Region).

The Murmansk and Arkhangelsk regions house shipbuilding enterprises, including those strategically important for the entire country. The ports of Murmansk and Arkhangelsk are among the largest ports of Russia. One of the main features of the Russian part of the region is insufficient development of the railway and motor transport infrastructure; the density of the road net decreases both from west to east and from south to north.

The following features of the economy of the northern Russian regions should be noted:

- Low economic development, poor infrastructure, dominance of mining and energy industries, insufficient development of energy-preserving and environmentally friendly technologies;
- Increased cost of goods due to increased expenses for the development of production and the social sphere, transport expenses, increase in the share of imported goods, and salary expenses;
- Low competition in many sectors of the economy on the local market;
- Lack of elasticity regarding the size of enterprises. Most of the enterprises are either very large or too small. For instance, in the Arkhangelsk Region there are practically no enterprises with 200 to 2 000 employees. Thus, an issue of great concern is the problem of so-called town-forming enterprises.

The structure of industrial production in the region is presented in Figure 7. The major industrial branches in the Murmansk Region are non-ferrous metallurgy, food industry, chemical industry, and electric power production.

Figure 6 Main economic sectors and industry branches in the region.
(Source: Central Directorate of Geodesy and Cartography 1983))

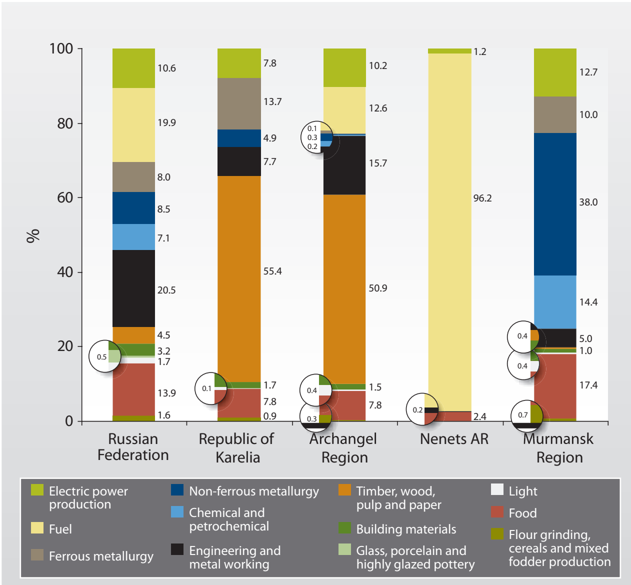


Figure 7 Relative proportion of products comprising industrial output in 2001.
(Source: State Statistics Committee 2002c)

The Murmansk Region provides (State Statistics Committee 2002c):

- 100% of the total Russian production of apatite and nepheline concentrate;
- 8.5% of iron-ore concentrate;
- 17% of copper;
- 45% of nickel;
- 11.5% of fish products;
- 2% of electric power (the share of the branch in the northwest Russia is 20.8%).

The backbone of the Murmansk Region's economy is mining and metallurgy. The leading enterprises in the non-ferrous metallurgy are the Kola Mining Company (which, together with traditional productions like nickel, copper, cobalt, gold and platinum, is developing the production of non-traditional metals) and Kandalaksha Aluminium Plant (one of the two aluminium plants in the Northwest Russia). In the ferrous metallurgy industry, the largest enterprise is the Kovdor Ore Processing Plant producing iron ore concentrate.

The apatite ore processing plant in Apatity is the 12th largest chemical enterprise in Northwest Russia. The Murmansk Shipping Company is the only shipping company in Russia able to work in the Arctic all year round. Possessing a unique fleet of nuclear powered icebreakers, it enables yearly navigation along the Northern Sea Rout. The port of Murmansk takes fourth place among 42 Russian ports and is the largest port in Northwest Russia, able to dock ships with dead-weights up to 250 000 tonnes.

In Karelia, the forestry sector is the most important and constitutes 55.4% of the regional production volume (Figure 7). The forestry sector is also the leading branch for the Arkhangelsk Region. In second place is the electric power production.

The oil industry is the backbone for the Nenets Autonomous Region; 4 million tonnes of oil were extracted in the region in 2000. In general, the Nenets Autonomous Region occupies second place in oil production in Northwest Russia (34.1%). A large volume of construction work in the region is linked to the exploitation of oil deposits.

Table 13 presents the production dynamics in the northern Russian regions. The data show that the production volumes in the region, including the dominant sectors, decreased during the 1990s. This can be explained by the economic crisis caused by the difficulties faced and the mistakes made during the transition period from a planned to a market economy. However, the production decrease is over and, except for food production, a slight increase is observed. Nevertheless, the growth rates are not high and a significant increase compared to the basic period (1985-1990) cannot be expected. In addition, the structure of industrial production has changed during the period analysed. In 1990, the share of the metallurgy complex in the region accounted for approximately 30% of the industrial production and the share of fishery accounted for up to 40%. During recent years, the share of metallurgy has increased while the share of fishery decreased (State Statistics Committee 2002c).

Agriculture

The most important agricultural branches in Northwest Russia are cattle breeding, poultry farming, breeding of animals for furs, reindeer breeding and growing potatoes and vegetables (Table 14) (State Statistics Committee 2002c).

The radical restructuring of the agricultural sector ended in 1995. Nowadays, 86% of agricultural production enterprises are private. About 15% of agricultural holdings have the form of kolkhozes (cooperative groups). Reforms in the agricultural sector caused the disruption of inter-regional and inter-sectorial connections. This has had a negative impact on large agricultural holdings specialising in beef and pork production, poultry, breeding of pedigree cattle, raising seeds of cereals, potato and perennial herbs. However, the past decrease in production in the agricultural sector is over and positive tendencies have been observed over the last few years. The dairy- and meat production slightly increased over the period 1997-2000. However, the agricultural sector in Northwest Russia still faces a number of problems such as:

Table 13 Industrial production in the northern Russian regions.

	1985	1990	1995	1998	1999	2000	2001	Ratio 2001 to 1985
Electric power (TWh)	29.2	31.4	27.1	26.4	25.9	27.4	27.3	93.4
Iron ore (million tonnes)	20.6	41.6	13.1	13.8	14.5	7.1	7.0	34.0
Tractor (pieces)	11 841	10 661	1 419	903	1 409	1 300	700	5.9
Timber (million m^3)	34.1	31.6	13.1	11.2	13.6	14.2	14.4	42.2
Saw-timber (m^3)	2 299 800	2 009 000	875 800	490 500	710 800	890 000	807 100	35.1
Cellulose (tonnes)	787 100	768 200	325 300	223 200	308 500	383 700	410 800	52.2
Paper (tonnes)	1 592 000	1 617 000	843 000	735 000	912 000	1 022 000	1 001 000	62.9
Stock brick (million bricks)	435	462	114.2	34.9	35.4	40.0	40.6	9.3
Bakery (tonnes)	390 500	392 800	281 500	178 700	191 800	176 600	164 300	42.1
Meat (tonnes)	63 500	74 900	24 300	12 600	10 200	13 000	14 200	22.4
Unskimmed milk products (tonnes)	412 000	499 000	110 900	67 800	64 200	79 100	90 700	22.0
Oil and condensate (million tonnes)	0.0	1.2	2.7	3.4	3.8	4.5	4.6	383.3
Wooden slab (million conventional m^3)	20.3	22.4	13.5	12.6	17.5	18.1	18.4	90.6
Pasteboard (tonnes)	602 000	628 000	400 000	460 000	575 000	620 000	627 000	104.2
Cement (tonnes)	1 325 000	1 355 000	335 000	289 000	272 000	225 000	327 000	24.7
Reinforced concrete constructions (m^3)	610 000	720 000	157 000	42 300	36 900	49 800	73 800	12.1
Apatite concentrate (million tonnes)	8.1	8.1	3.3	3.7	4.2	4.2	3.9	48.1
Nepheline concentrate (million tonnes)	1.6	1.6	1.0	0.9	0.9	0.8	1.0	62.5

(Source: State Statistics Committee 2002c)

Table 14 Production of the most important kinds of agricultural products in the northern Russian regions.

	1985	1990	1995	1998	1999	2000	2001	Ratio 2001 to 1985
Grain crops (tonnes)	106 300	100 000	46 000	18 300	12 900	14 700	14 700	13.8
Potatoes (tonnes)	327 300	276 600	610 900	545 300	608 500	591 300	591 800	180.8
Vegetables (tonnes)	65 800	52 000	95 600	102 700	123 500	133 700	132 600	201.5
Livestock and poultry, in slaughter weight (tonnes)	92 700	111 600	56 000	34 200	28 700	31 000	31 300	33.8
Milk (tonnes)	597 900	649 800	350 500	294 700	276 500	274 900	275 400	46.1
Cattle (heads)	509 100	524 800	332 800	217 800	206 600	181 400	180 800	35.5
Pigs (heads)	313 900	419 700	183 400	71 900	72 900	75 900	80 000	25.5

(Source: State Statistics Committee 2002c)

- Insufficient production volumes of some agricultural products for the local market (mainly meat and dairy products);
- Inefficiency and unstable functioning of many agricultural enterprises;
- Under-development, lack of modern equipment and a dramatic decrease in supplies of agricultural machines;
- Social degradation in rural areas, low wages, decrease in living standard in most of the villages;
- Lack of legislative and regulatory initiatives at state- and regional levels;
- Inefficiency and under-development of private farms.

In Finnmark County, Norway, reindeer breeding dominates over agricultural production. However, a slight increase in the farmed areas was observed over the period 1994-2001 (Table 15).

Table 15 Farmed area and number of reindeer units in Finnmark 1994-2001.

		1994	1995	1996	1997	1998	1999	2000	2001
Farmed area (km^2)		95.3	96.0	97.3	98.0	102.1	105.5	107.4	-
Reindeer units	Eastern Finnmark	201	184	168	169	172	179	173	182
	Western Finnmark	274	244	217	215	216	220	227	236

(Source: Finnmark County statistical data)

Forestry

Forestry has a vital role in the economy of the Russian part of the region. First of all this is true for Karelia and the Arkhangelsk Region, where the share of the forestry sector in the total production volume constitutes 55.4% and 50.9% respectively. 60% of the whole export from Karelia comes from the forestry sector. The increase of the share of the forestry sector has been accompanied by an improvement in the structure of the production. The share of the pulp and paper industry has increased while logging has been reduced. This is mainly caused by an increase in recycling. This enables forest resources to be used more effectively and increases local incomes. More than 70% of the potential logging areas in the region are exploited nowadays.

Karelia produces:

- Paper: 22.6% of the total production volume in Russia (first place in the Northwest Russia);
- Timber: 6.1% of the total production volume in Russia;
- Sawn timber: 4.3% of the total production volume in Russia.

The major products of the wood manufacturing industry in the region encompass:

- Sawn timber: 39.2%;
- Timber: 30.8%;
- Paper: 14.9%;
- Plywood: 8.3%.

The Murmansk Region is the northernmost of the four Russian regions considered for the Barents Sea region and its forest reserves are of low productivity. Thus, in spite of 67.5% of the territory being covered with forests, the share of the forestry sector in the economy of the region constitutes no more than 0.6%. However, it is of importance for the employment of the population as it is the only activity in a number of settlements.

After the financial crisis of 1998, the export of timber from the Russian sector of the region and from Russia as a whole was substantially increased. Russian timber companies were able to increase export of wood products significantly after the drop of the Ruble compared to the USD and other major international currencies by several hundred percents. Demand for Russian timber on Western markets increased (though it is still much lower than it used to be in mid-1980s). Demand for sawn timber also increased. Many Russian timber companies were able to build or upgrade their sawmills and obtained drying kilns (mostly from German and Italian producers). Production of timber and sawn timber in Russia went down practically every year since the late 1980s up to 1999. As a result of that, in different regions of Russia production decreased approximately 3-5 times during last 10-12 years of the past century. The wood-processing sector was especially affected and many sawmills were closed. In the meantime, since 1999 the trend has changed, and timber production and production of secondary wood products went up in practically all regions of Russia involved in forest industry and wood processing.

The major factors for the successful work of the forestry sector are favourable conditions for export and demand on the home market. The income from the exports of the wood manufacturing industry increased in 2000 by 19.3%. This was caused by an increase in sale volume (by 18.5%) and the increase in price of cellulose (by 33%). On the home market, there is an increase in demand for furniture and wood building materials.

Further perspectives of development of the forestry sector in Northwest Russia present an optimistic picture. The demand for the products of the wood manufacturing industry will have increased by a factor of 2 by year 2006 (State Statistics Committee 2002c).

However, there are a number of problems to be solved, which are hampered by the lack of funding:

- To increase the marketability and quality of the wood products;
- To increase the share of recycling;
- To increase the introduction of modern, environmentally friendly technologies.

Fishery

The fishing industry constitutes one of the backbones of the coast of northern Norway and is a sector for economic development in Northwest Russia. The commercially most important fisheries of the Barents Sea are for cod (*Cadus morhua morhua* L.), haddock (*Melanogrammus aeglefinus* L.), shrimp, capelin (*Mollotus villosus villosus* Muller) and saithe (*Pollachius virens*).

The economically and politically dominant fishery in the Barents Sea is for Northeast Arctic cod. The haddock fishery can be regarded as supplemental to the cod fishery. The capelin fishery undergoes substantial cyclical variations rendering it unreliable as a resource basis. The Norwegian spring-spawning herring spends part of its lifecycle in the Barents Sea, while mainly being caught in the Norwegian Sea. Saithe is an exclusively Norwegian stock, while shrimp is mainly caught west of Svalbard.

The above-mentioned fisheries constitute 90% of the total catch. Such species as Black halibut (*Reinhardtius hippoglossoides hippoglossoides* Walbaum), Polar cod (*Boreogadus saida* Lepechin), perch (*Sebastes marinus* L.), deep-water prawn (*Pandalus borealis* Kröyer), scallop (*Chlamus islandica* Müller) and others are caught with special gears in insignificant amounts. Plaice (*Pleuronectes platessa* L.), American plaice (*Hippogolossoides platessoides limandoides* L.), catfishes (genus *Anarhichas*), saithe (*Pollachius viren*s L.) and others are mainly caught as by-catch during the cod fishery.

Several of the commercially important Barents Sea fisheries straddle the geographical boundaries of the Barents Sea and the Norwegian Sea. In the period 1992-2001 an average of 36-54% of cod was caught in the Barents Sea[1]. This illustrates that fishing beyond the Barents Sea has a substantial impact on the Barents Sea fisheries and the ecosystem in general. Available statistics from ICES do not overlap with the GIWA definition of the Barents Sea, complicating estimates on the geographical distribution of catches[2] (ICES 2003a).

Figure 8 presents the catch dynamics of the main commercial fisheries in the Barents Sea over the past 50 years (ICES 2003a). The figure shows that from the 1960s, a continuous decrease in catches is observed reflecting the negative trend of the total catch and the spawning fish stocks.

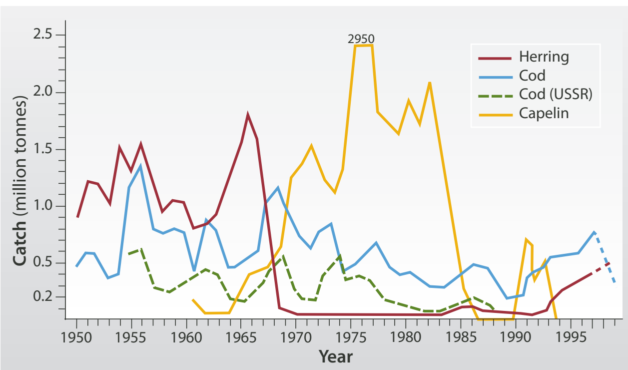


Figure 8 Total catch dynamics of the main commercial fisheries in the Barents and Norwegian Seas.
(Source: ICES 2003a)

There has been an overall decrease in catches both in Finnmark and Northwest Russia. The annual Russian catch by the end of the 1980s was 1.6-1.8 million tonnes including 50-70% outside the Barents Sea in the Northwest and Central Atlantic (Figures 9 and 10). In 2001 the total catch constituted 924 000 tonnes, thus it was reduced over the period considered by a factor of 2.

Reduced catches resulted in decreased importance of the fisheries sector in the economic structure of Northwest Russia, increased unemployment and aggravated social problems. At the end of the 1980s the contribution of fisheries to the GDP of the Murmansk Region was 30%, in the Arkhangelsk Region 8-10%, in Karelia 5-6%. Its present contribution to the GDP has decreased to 14-17% in the Murmansk Region, 4-5% in the Arkhangelsk Region and 3-4% in Karelia. Decreased catches in Russia can be explained by the reduction of fish stocks, the difficult market situation, as well as by political mistakes and miscalculations made during the period (State Statistics Committee 2002b).

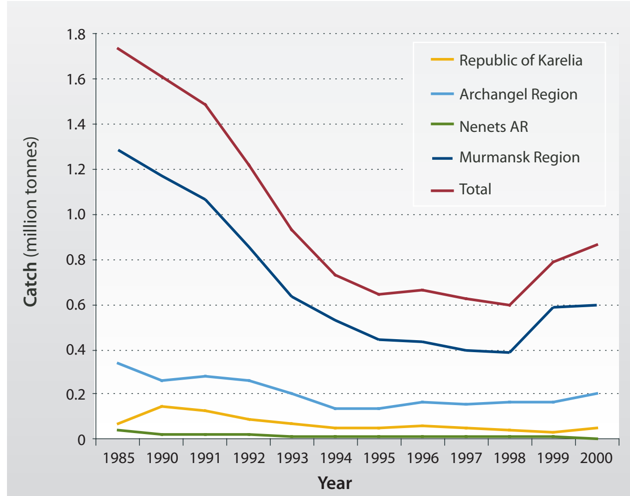


Figure 9 Fish catches in Northwest Russia.
(Source: State Statistics Committee 2000)

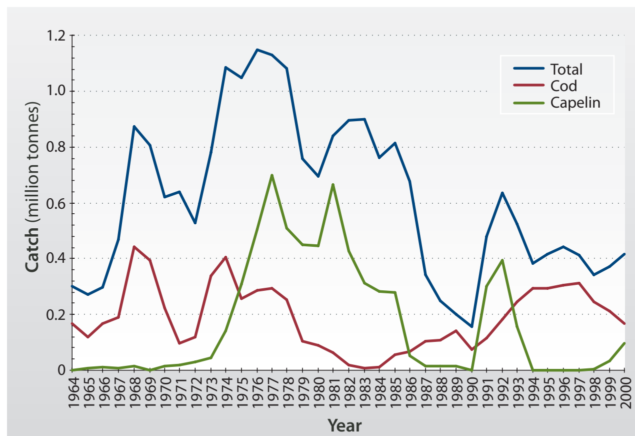


Figure 10 Dynamics of the Russian catches in the Barents Sea.
(Source: State Statistics Committee 2000)

There has been an overall reduction in annual catches for the fishing fleet of Finnmark as for the Norwegian fishing fleet in general, though there are substantial periodic variations. In terms of the landing of catches, the situation in Finnmark has seemingly not been as severe as in Northwest Russia. A main reason has been the Russian landings of catches in Finnmark. These landings constituted more than 50% of the total cod landings in the county and were of great importance to the Norwegian processing industry. However in recent years a substantial quantity of the Russian landings have gone to freezing terminals for further export to the international market, without being processed in Finnmark. As such, Finnmark for a large part functions as a portal for Russian fishing vessels to the international market. Figure 11 therefore presents a distorted picture of the actual situation. In 2003 the fishing industry in Finnmark underwent a serious crisis, with a series of bankruptcies (Norwegian Directorate of Fisheries 2003).

[1] *Pending on whether ICES statistical Area IIb is included or not. Havets Ressurser, 2002:13.*
[2] *CES statistical areas in the region are the Barents Sea (Area I), Bear Island/Spitsbergen (Area IIb) and the Norwegian coast (Area IIa).*

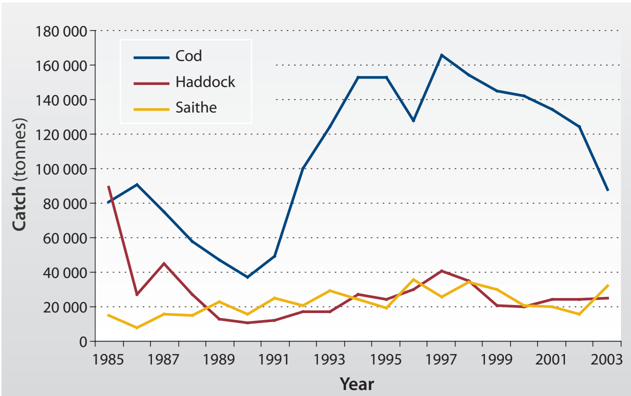


Figure 11 Landings of cod in Finnmark 1985-2003.
Note: Figure includes landings from foreign vessels (Russian).
(Source: Norwegian Directorate of Fisheries 2003)

Aquaculture

The aquaculture industry is expected to grow rapidly both on the Norwegian and Russian side of the Barents Sea. Governments and the industry in both countries show great interest in increasing the production of farmed fish; there is also an excellent scientific potential in the region. Development of aquaculture in the Murmansk region is considered as one of the most important for the nearest 15 years. Aquaculture in Northwest Russia is traditionally developed in the following directions:

- Industrial fishery and fish-breeding in inland water reservoirs based on aquaculture;
- Breeding of commercial fish on natural and artificial food in fish farms;
- Reproduction of fish stocks.

The production of farmed salmon (*Salmo salar*) and Rainbow trout (*Parasalmo mykiss*) in northern Norway has seen a rapid growth in recent years. In Norway, fish farming is an important industry, providing jobs and income in rural Arctic areas. In Finnmark, according to official information from the Norwegian Directorate on Fisheries (2004), the total production of salmon was 20 292 tonnes in 2000, and 32 893 tonnes in 2001; Rainbow trout production was 0 and 282 000 tonnes, respectively. There is still growth potential in this market (LENKA 1990). Marine species such as cod (*Gadus morhua*), halibut (*Hippoglossus hippoglossus*), sea urchin, Red king crab (*Paralithodes camschaticus*), Arctic char (*Salvelinus alpinus*) and wolfish (*Anarhichas* spp.) are also potential for aquaculture in addition to salmonids. Sea-based aquaculture activities are currently small in the Russian part of the region, primarily due to lack of investment funds (Larsen et al. 1994), but are expected to grow in the future in both the Barents and White Seas regions.

Oil and gas

Unique reserves of oil and gas on the Arctic shelf of Russia may constitute the basis for an increased development of Russia in the 21st century. At present, 62.5 trillion m^3 of natural gas and 9 billion tonnes of oil have been discovered in the seas of the Arctic Ocean and 3.5 billion tonnes of oil have been discovered on the coast (Figure 12). This constitutes 25% of the world reserves (Denisov 2002).

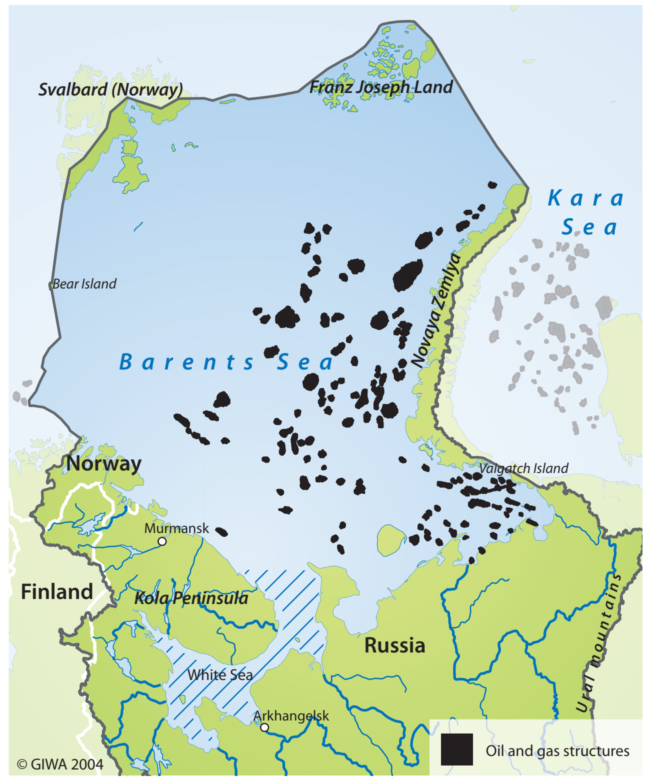


Figure 12 Oil and gas structures of the Barents and Kara Seas.
(Source: Denisov 2002)

If the present average volumes per year of oil and gas extraction remain, these reserves will last for 250 years. The largest oil and gas deposits, the Stockman gas condensate deposit, the Prirazlomnoye oil deposit, and a number of coastal deposits are being exploited already. These deposits will determine the social and economic development of Northwest Russia for the next 25-50 years. The problem of extraction and transport of oil and gas is becoming a strategically important task.

It is planned to transport up to 7 million tonnes of oil each year from the Prirazlomnoye oil deposit in the Pechora Sea, which is now being developed by the Rosshelf and Gazprom companies. Considerable volumes of oil transport are also expected from other deposits located in the Pechora Sea, from the Timano-Pechora oil and gas province bordering the Pechora Sea, from the Ob Bay area, from the area of the Ob and Yenisey rivers, and from other areas. In addition to oil transport, large volumes of gas condensate transport are also expected. There are large reserves of natural gas in the Stockman gas condensate deposit in the Barents Sea, as well as in Rusanovskoye and Leningradskoye deposits in the Kara Sea. Large gas fields have also been discovered in the Laptev and North Siberian Seas.

The development of oil and gas deposits in northern Russia will increase oil transport to 40 million tonnes by the year 2020. This will correspondingly increase the pressure on the Northern Sea Rout by a factor of 6. To develop only the enumerated deposits, 18 ice-resistant platforms, 10-12 ice-breakers, including three to four nuclear powered ice-breakers, about 60 vessels for technical maintenance, and large amounts of tankers with a total deadweight of 4 million tonnes, need to be constructed.

Tourism

The unique geopolitical location of the region and the opening of the Russian borders have contributed to increased cooperation across the borders during recent years, and transboundary tourism plays a significant role in this cooperation. A new project on international tourism within the EU programme MACIS "Development of tourism in the Russian part of the Barents Region" started in the year 2001 with a budget of 1.1 million EUR. This project is of fundamental importance for tourism in the region, especially for outdoor and adventure tourism, the two sectors with the fastest growth. There are seven national and nature parks in the Russian part of the region (one in the Arkhangelsk Region, one in the Nenets Autonomous Region, five in Karelia, and none in the Murmansk Region).

The development of the tourism sector is of great socio-economic importance for the development of the region. It stimulates new investments and leads to increased income for the local communities, creates new jobs, and improves international and inter-regional cultural cooperation. The main task is to include as many new areas as possible into the sector, create a positive tourist image and promote the region on the European market.

The most popular branch of tourism in the northwest, cruise travel, is growing. Western tour operators and ship owners are interested in voyages along the Belomorsko-Baltiysky canal, as well as along the coast of the Barents Sea. The number of cruise tourists can be increased without implementing solid land based investment, but by adopting new laws, which allow foreign vessels in the internal waters of Russia.

Finnmark is also a very attractive tourist destination within the "Arctic triangle" (Sodankylä (Finland) – Alta (Finnmark) – Murmansk). In close cooperation between the authorities from northern Finland and Northwest Russia, Finnmark is a leader of a project to strengthen tourism in the north (the Image Project). The project aims at a joint profile for the area, which will be the basis for future promotion of the "Arctic triangle". The Regional Development Programme funds the initiative.

Three national parks exist in Finnmark and there are plans to extend their areas and increase the number of national parks by another three. Additionally, the landscape structure of many other areas is protected. These are of great potential for outdoor and adventure tourism.

The outdoor and adventure tourism in the Russian sector of the region has gained specific features: from all the branches of tourism offered to foreign tourists, the most profitable one is sport fishing and hunting. The reasons for increased profitability in this sector are that, firstly, most of the clients are foreigners. Secondly, there are no fees for the use of unique recreational resources in the region and the nature protection regulations are less strict compared to European countries. Thirdly, there is availability of a cheap labour force.

Since mid-late 1990s, many western tourists have visited places in the Murmansk Region to practise sport fishing, several Russian and some joint venture companies do business in the area. However, functions of tourist agents and tourist operators are not clearly defined between Russian and foreign firms. There is such a phenomenon as "capture of rent" by foreign firms and loss of income for both private Russian joint stock and for budgets at all levels.

Competition in the market of recreational branches of tourism in the region is hampered by interests of criminal circles in this sphere.

Cooperation on the protection of the environment

Environmental protection is part of the agenda of many of the international and national organisations in the Barents region and the Arctic. The integration of environmental issues into economic activities and the efforts to promote sustainable development have brought environmental challenges to the forefront in the activities of all of the main institutions and organisations in the Barents region. The main international organisations and bodies dealing with environmental issues in the Arctic and Barents region are described in the following.

The Barents Euro-Arctic Council

The Council has established a Task Force on the Environment. The Task Force handles issues concerning e.g. air pollution abatement, environmental technology, the foundation and maintenance of protected areas, radioactive pollution and clean water supply. The

Task Force works in close cooperation with the Barents Council's Economic Working Group and an ad hoc Working Group on Energy. The Environmental Task Force adopted its Environment Action Programme in 1994, and the five main issue areas are prevention of radioactive pollution, environmental capacity building, reduction of pollution from industry, nature conservation and cooperation between regional authorities.

The Task Force has engaged the Nordic Environment Finance Corporation (NEFCO) to identify environmental hot spots in the Barents region and to make feasibility studies on the implementation of pollution reduction projects. Subsequently, the Task Force has followed the progress of these projects. Separately, the Environmental Task Force has, together with the Economic Working Group of the Barents Council, prioritised seven projects of environmental and economic significance in the Barents region. This so-called "Joint List of Environmentally Sustainable Investment Projects", has also been studied by the Task Force. Furthermore, the Task Force has coordinated and promoted projects on biodiversity and forestry issues, as well as environmental capacity building.

The Barents Regional Council

The Regional Council has set up a Regional Environmental Committee, which consists of environmental officials from the administrations of all 10 member-regions. In addition, the Nenets Autonomous Region has its own representative, and the Sami population is also represented. The Committee has drawn up a regional environmental action programme for the Barents region, with priorities on human health, biodiversity and environmental awareness.

The Arctic Council

The work of the Arctic Council (AC) has two main pillars. One is the promotion of sustainable development. The other is to integrate and continue the Arctic Environmental Protection Strategy (the so-called Rovaniemi Process), which started originally in 1989 and officially in 1991, within the framework of the AC. There are five main programmes in the latter process: The Arctic Monitoring and Assessment Programme (AMAP), Conservation of Arctic Flora and Fauna (CAFF), Protection of the Arctic Marine Environment (PAME), Emergency Prevention, Preparedness and Response (EPPR), and Sustainable Development and Utilization (SDU).

The Northern Forum

The Northern Forum (NF) consists of administrative regions from Arctic countries including Japan. The NF concentrates on several issues such as economic development, the utilisation of natural resources, and research cooperation. In addition, the promotion of environmental sustainability is part of the NF's agenda. The cooperation between the NF and the Barents Regional Council is being developed.

Bi-lateral programmes

Finland, Sweden, and Norway all have bi-lateral environmental programmes and projects under way with Russia in the Barents region. The countries in the Barents region are involved in around 150 bi- and multilateral environmental projects. For example, the Research Programme for Environmental Technology (PRIRODA) was started in 1991 between Russia and Norway. Finland has put efforts especially into the handling and storage of radioactive waste in the Murmansk Oblast, as well as water supply and cleaning projects.

The Nordic Council

The Nordic Council has also taken part in Arctic environmental cooperation. In 1993, the parliamentarians of the Nordic Council e.g. established a permanent Arctic committee, which has subsequently participated in the work of the Arctic Environmental Protection Strategy. The Nordic Council's working group on the neighbouring areas has also worked in cooperation with the Barents region organisations.

Non-governmental organisations

Finally, there are many non-governmental organisations (NGOs) involved in environmental cooperation in the Barents region and the Arctic as a whole. Some of the most active are the WWF, the International Arctic Science Committee (IASC), the Sami Council, the Inuit Circumpolar Conference, the International Union for the Conservation of Nature (IUCN), as well as NGOs in the Nordic countries and Northwest Russia.

International programmes and agreements related to water

The water protection activities in the Barents Sea region are regulated by, and carried out through a number of international programmes and agreements.

Rovaniemi Declaration on the Protection of the Arctic Environment

In 1991, the Rovaniemi Declaration on the Protection of the Arctic Environment, was launched by the representatives of the governments of Canada, Denmark, Finland, Iceland, Norway, Sweden, the former Soviet Union and the United States. The Declaration addresses threats to the Arctic environment and the impact of pollution on fragile Arctic ecosystems. Within the framework of the Arctic Council, the Declaration adopted the Arctic Environmental Protection Strategy (AEPS) and elaborated a joint Action Plan for its implementation and further development. The major objectives of the Strategy are: to protect the Arctic ecosystems, including humans; to provide for the protection, enhancement and restoration of environmental quality and sustainable utilisation of natural resources; to review regularly the state of the Arctic environment; and to identify, reduce and, as a final goal, eliminate pollution. At least three of its five programmes deal with the protection of the marine environment: the Protection of the Arctic Marine Environment (PAME) addresses policy and non-emergency response measures related to protection of the marine environment from land and sea-based activities. The second programme, Arctic Monitoring and Assessment Programme (AMAP), deals with the research and control over the state of the Arctic marine environment. It has responsibilities to monitor the levels of, and assess the effect of, anthropogenic pollutants in all compartments of the Arctic environment, including humans. The third programme, Emergency Prevention, Preparedness and Response (EPPR), is responsible for the preparedness in cases of emergency in the Arctic region and is called to provide a framework for future cooperation in responding to the threat of environmental emergencies.

Kirkenes Declaration

In 1993 the Ministers of Foreign Affairs or representatives of Denmark, Finland, Iceland, Norway, the Russian Federation, Sweden and the Commission of the European Communities signed the Kirkenes Declaration at the conference on cooperation in the Barents Euro-Arctic region, which took place in Kirkenes, Norway. The conference was also attended by observers from the United States, Canada, France, Germany, Japan, Poland, and the United Kingdom. The participants expressed their conviction that expanded cooperation in the Barents Euro-Arctic region will substantially contribute to stability and progress in the area and in Europe as a whole, where partnership is now replacing the confrontation and division of the past. The participants felt that such cooperation will contribute to international peace and security. It was decided that regional cooperation in the Barents Euro-Arctic region would comprise the county of Lapland in Finland, the counties of Finnmark, Troms and Nordland in Norway, the counties of Murmansk and Arkhangelsk in Russia, and the county of Norrbotten in Sweden. It was also noted that the region might be extended to include other counties in the future. The participants recalled the Joint Declaration from the meeting of the Ministers of Environment of the Nordic countries and the Russian Federation in Kirkenes on 3 September, 1993, and the Convention for the Protection of the Marine Environment of the Northeast Atlantic signed on 22 September, 1992, and underlined the importance of strengthening bi-lateral and multilateral cooperation to protect the vulnerable environment of the region. The participants also re-affirmed their commitment to the Strategy for Protection of the Arctic Environment, adopted at the Ministerial Meeting in Rovaniemi in 1991, and to the ongoing work in implementing that strategy, especially within the Arctic Monitoring and Assessment Programme (AMAP). The conference also raised the questions of radioactive pollution. The importance of international cooperation was noted in the following areas: expanded monitoring of ecology and radioactivity in the region; enhanced work on the operational safety of nuclear facilities; and rehabilitation of areas that have been polluted as a result of the operation of nuclear facilities.

Fisheries management cooperation

Most major fish stocks are shared with other countries, as is the case of the Barents Sea fisheries, with the exception of saithe. This means that key regulatory decisions are taken in bi- and multilateral arrangements. The Total Allowable Catch (TAC) is therefore a given factor that the national regulatory regime has to deal with.

Norway and Russia manage their shared fish stocks in the Barents Sea (cod, haddock and capelin) through the Joint Norwegian-Russian Fisheries Commission, established in 1975. The Commission sets TACs for the shared fish stocks, throughout their migratory routes across borders of jurisdiction in the Barents Sea. The TACs are based on scientific advice from the International Council for the Exploration of the Sea (ICES) and national research institutions (see Figure 13). The parties also allot a quota for third-countries with "historical rights" to the fisheries (e.g. EU and Iceland). The parties also exchange fishing quotas according to established fishing patterns and provide mutual access to fish in each other's national Exclusive Economic Zones (EEZ). During the 1990s cooperation in control and enforcement and marine research has been strengthened (Hoel 1994).

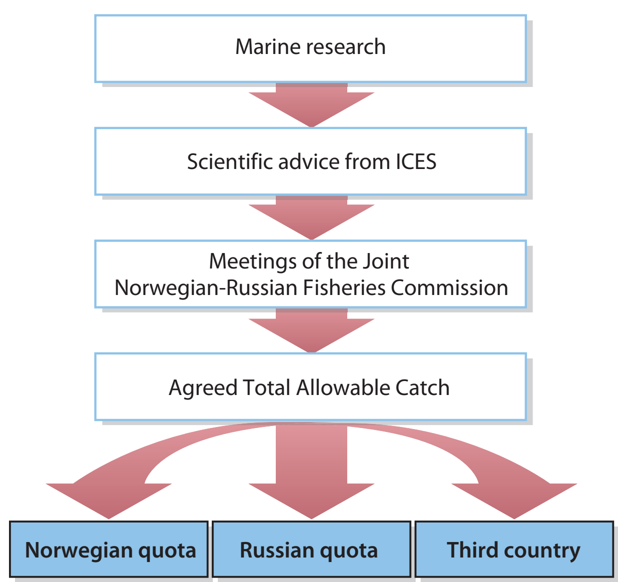


Figure 13 The scheme of setting of TACs for the shared stocks of the Barents Sea.

There is a border dispute between Russia and Norway in the Barents Sea. Norway and Russia (then the Soviet Union) established their EEZ in 1976, following the developments at the third United Nations Conference on the Law of the Sea (1973-1982). Due to disputes regarding the delimitation of the bordering EEZs, agreement was reached in 1977 on a temporary Grey Zone where both Norway and Russia regulate and control their own fishers. The Grey Zone agreement has been renewed annually by the parties. Another area of contention is the Fishery Protection Zone around Svalbard, established by Norway in 1977. The management of these waters is subject to the Svalbard Treaty of 1920. The Norwegian claims to sovereign rights over the Protection Zone have not been supported by the other signatories of the Svalbard Treaty. In practice, the regulations in the Protection Zone are similar to those of the Norwegian EEZ. However, fleets with fishing rights in the Barents Sea are not sanctioned. In the northeast of the Barents Sea there is an area of high seas beyond the jurisdiction of coastal states, the so-called loophole (Churchill & Ulfstein 1992).

Cooperation on radiological protection

The Barents Sea region is somewhat a unique world region in terms of nuclear energy. No other place in the world houses so many sources of potential radiological threats like the Murmansk Region of the Russian Federation, one of the four Russian regions considered for the Barents Sea region.

Major problems of radiological protection and safety in the Russian sector of the region that need active international cooperation and financial and technical support from foreign partners are the following:

- Safety of spent nuclear fuel and radioactive waste management;
- Complex dismantlement and remediation of decommissioned nuclear powered submarines and civilian vessels, nuclear support and service vessels and nuclear storage vessels, remediation of radioactively dangerous sites;
- Construction of storages for spent nuclear fuel and radioactive waste;
- Improvement and upgrading of systems for monitoring, control, prevention and response to emergencies, and protection against radiological terrorism;
- Improvement of safety systems for the transportation of radioactive material.

The radiological protection activities in the region are regulated by a number of national and international conventions and agreements:

Convention on Nuclear Safety

Russia is a signatory-state of the Convention on Nuclear Safety, provided for the re-enforcing of national measures and international cooperation in the field of safe exploitation of nuclear power plants, prevention of accidents and mitigation of their consequences.

Convention on Early Notification of a Nuclear accident

To develop the Convention on Early Notification of a Nuclear Accident (1986), bilateral agreements were reached, which exceed the limits of the Convention. The agreements are provided for mutual exchange of information on the status and exploitation of nuclear power plants located in the mutually agreed border areas of the corresponding states. Such agreements were reached with Great Britain, Germany, Norway, Poland, Finland, and Sweden. Nowadays negotiations are being carried out to reach such agreements with other countries.

Convention on the Physical Protection of Nuclear Material

Russia also ratified the Convention on the Physical Protection of Nuclear Material, which obliges contracting States to ensure during international nuclear transport the protection of nuclear material within their territory or on board their ships or aircrafts.

Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency

Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency sets out an international framework for cooperation among parties and with the International Atomic Energy Agency (IAEA) to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies.

Joint projects between Russia and other countries

In June 2003, Russia signed the frame agreement on the multilateral nuclear ecological programme in the Russian Federation. The list of participants, in addition to the Russian Federation, includes Belgium, Great Britain, Germany, Denmark, Netherlands, Norway, the United States, Finland, France, Sweden, and EU. The Agreement provides for the cooperation in the field of safe handling of spent nuclear fuel and radioactive waste, dismantlement of decommissioned nuclear powered submarines and icebreakers in Northwest Russia. There is also a special fund managed by the European Bank for the Reconstruction and Development for these purposes.

In addition to the international projects, programmes and conventions functioning in the territory of the Russian Federation, there are special projects for Kola Peninsula. Germany assigned 300 million EUR for projects on dismantlement of Russian nuclear powered submarines including 25 million EUR for 2003. The Agreement between the Ministry of Atomic Energy of the Russian Federation and the German Ministry of Economy has been signed to construct a complex for the long-term storage of piles from dismantled nuclear powered submarines in the Saida Bay (Murmansk Region).

Agreements on the dismantlement of two multipurpose nuclear powered submarines have been reached with Norway. A number of joint projects between Russia, Norway, Great Britain and the U.S. are carried out to increase the capacity of storages and treatment plants for spent nuclear fuel and radioactive waste.

The EU has contributed to radiological protection projects in the Barents region. One of the most important projects the EU has been involved in concerns the removal of radioactive waste from a decommissioned carrier vessel, the Lepse, which is lying in the Kola Fjord near the city of Murmansk. The TACIS programme between Russia and EU aims at improving nuclear safety of nuclear power plants in the territory of Russia. The programme also includes the construction of a regional storage for radioactive waste and spent nuclear fuel in Northwest Russia.

Arctic Military Environmental Cooperation

Trilateral Norwegian-U.S.-Russian military environmental cooperation began in 1996. The aim of the cooperation is to clean polluted military areas in Northwest Russia, including radioactive pollution sites. It consists of several projects, part of them aimed at ensuring the appropriate security for military radioactive waste. One of the most promising projects in the framework of this programme is the elaboration and testing of a ferro-concrete container for the storage and transportation of spent nuclear fuel from out-of-duty nuclear powered submarines.

Nuclear safety has also been a priority of the Barents Council since its foundation. Several projects are under way. For example, Finnish and Norwegian authorities have cooperated with Russian experts to upgrade the safety of the Kola Nuclear Power Plant in Polyarnye Zori. A Finnish energy company, IVO Power Engineering, has also completed work on purifying and concentrating liquid radioactive waste generated by the ATOMFLOT's nuclear-powered icebreakers.

Assessment

This section presents the results of the assessment of the impacts of each of the five predefined GIWA concerns i.e. Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, Global change, and their constituent issues and the priorities identified during this process. The evaluation of severity of each issue adheres to a set of predefined criteria as provided in the chapter describing the GIWA methodology. In this section, the scoring of GIWA concerns and issues is presented in Table 16.

Table 16 Scoring table for the Barents Sea region.

Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter).

IMPACT 0 No known impact; IMPACT 1 Slight impact; IMPACT 2 Moderate impact; IMPACT 3 Severe impact

The arrow indicates the likely direction of future changes.

↗ Increased impact; → No changes; ↘ Decreased impact

Barents Sea	Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***
Freshwater shortage	1* →	1 →	1 →	0 →	1	4
Modification of stream flow	0					
Pollution of existing supplies	2					
Changes in the water table	0					
Pollution	1* ↗	2 →	1 ↗	0 →	2	2
Microbiological pollution	0					
Eutrophication	0					
Chemical	1					
Suspended solids	0					
Solid waste	1					
Thermal	0					
Radionuclide	1					
Spills	1					
Habitat and community modification	1* ↗	1 ↗	0 →	1 ↘	1	3
Loss of ecosystems	1					
Modification of ecosystems	1					
Unsustainable exploitation of fish	2* →	2 →	1 ↘	2 ↘	2	1
Overexploitation of fish	3					
Excessive by-catch and discards	1					
Destructive fishing practices	1					
Decreased viability of stock	0					
Impact on biological and genetic diversity	2					
Global change	0* ↗	0 →	0 →	0 →	0	5
Changes in hydrological cycle	0					
Sea level change	0					
Increased UV-B radiation	0					
Changes in ocean CO_2 source/sink function	0					

* This value represents an average weighted score of the environmental issues associated to the concern. For further details see Detailed scoring tables (Annex II).

** This value represents the overall score including environmental, socio-economic and likely future impacts. For further details see Detailed scoring tables (Annex II).

*** Priority refers to the ranking of GIWA concerns.

Freshwater shortage

The Barents Sea region is notable for its abundant water reserves. The total annual precipitation decreases from south to north within the boundaries of the drainage basin: from 600 mm in the upper reaches of the Severnaya Dvina River to 400 mm on the coast. At the same time, the humidity does not vary much since the evaporation decreases nearly in the same proportion (from 250 to 100 mm per year). This results in a dense river and lake network; there are more than 160 000 lakes in the Russian part of the region. Marshes represent a considerable part of water reserves due to the low permeability of crystalline rocks and frozen ground, and low evaporation.

As a result of these hydrological features, the freshwater supply in the region is high (more than 50 000 m^3 per year and person). The total water consumption in 1999 in the Russian sector of the region was 4.25 million m^3. During the past several years, an insignificant increase in water consumption has been noticed. In Finnmark there are no industries with high freshwater consumption, the population is low and there are great volumes of freshwater resources. Freshwater shortage in the region is therefore not expected and the two issues modification of stream flow and changes in the water table was considered as irrelevant for the region. They were assessed as having no known impact and are therefore not further discussed. However, there is evidence of local pollution of the surface waters in the region and the issue pollution of existing supplies was assessed as moderate. It should be noted though that the impact of river water on the quality of international waters is insignificant because of the Barents Sea openness, giving free water exchange with the Atlantic and Arctic Oceans, and the relatively low river run-off (AWI 1994),

Pollution of existing supplies

Large smelter complexes, mining and metallurgy, ore processing and pulp and paper industries have a pronounced and increasing negative impact on rivers and lakes located in the vicinity of the enterprises. The poor coverage by sewage treatment plants, as well as ineffective treatment in the existing plants, have led to pollution of freshwater resources. Polluted water from municipal services, poultry farms and cellulose and pulp industries is discharged into the Severnaya Dvina, Pechenga and Kola rivers.

Severnaya Dvina River

The water and bottom sediments of the Severnaya Dvina are contaminated mainly due to pulp and paper industries and timber rafting. Contamination by easily oxidising organic substances, phenols, oil products, and compounds of copper and iron is typical of the river water. Contamination with methanol, formaldehyde and lignin is typical of the estuary which is characterised by dissolved oxygen deficiency in the spring-winter period.

Analysis of data presented in the Arkhangelsk Region Environment Status reports for the period 1995-2000, shows that at the Severnaya Dvina River mouth, in the area of sewage discharge from theArkhangelsk Pulp and Paper Enterprise (APPE), a steady increase of water contamination was observed. The annual average concentration of lignosulfonates, a pollutant specific for the Arkhangelsk Pulp and Paper Enterprise, ranged from 2.5 to 5 times the Maximum Allowable Concentration (MAC - the standard set by Russian regulations), and the concentrations of aluminium compounds up to 2 MAC (Table 17). Occasional cases of ammonia, methanol and formaldehyde contamination (up to 2 MAC) were also registered. High levels of bacteria in a addition to a high content of poorly oxidised organic compounds create problems with providing drinking water to the population in the Arkhangelsk industrial corridor (the cities of Arkhangelsk, Severodvinsk and Novodvinsk) (Arkhangelsk Region Administration 2003).

According to data from Arkhangelsk Region Directorate of Natural Resources and Environmental Protection (2002) the levels of heavy metals in the estuarine water can vary within a wide range, averaging 3 MAC for copper and 1-2 MAC for zinc (Table 17). Concentrations of trace elements in bottom sediments of the same area vary for copper in the range 13-22 mg/g, for zinc 40-159 mg/g, lead 7-30 mg/g, cadmium 0.1-0.4 mg/g, cobalt 18-21 mg/g and nickel 34-49 mg/g (Aibulatov 2001).

Table 17 Russian water quality guidelines (Maximim Allowable Concentration - MAC) for the protection of aquatic life, based on toxilogical criteria.

Contaminant	Freshwater (mg/l)	Seawater (mg/l)	Fish (mg/kg ww)	Mollusc & crustaceans (mg/kg ww)	Marine algae (mg/kg ww)
Oil hydrocarbons	0.05	0.05	-	-	-
Aluminum (Al)	0.04	0.04	-	-	-
Iron (total) (Fe)	0.1	0.05	-	-	-
Copper (Cu)	0.001	0.005	10.0	30.0	-
Cadmium (Cd)	0.005	0.01	0.2	2.0	-
Chromium (Cr)	0.02	0.02	-	-	-
Cobalt (Co)	0.01	0.005	-	-	-
Arsenic (As)	0.05	0.01	5.0	5.0	-
Nickel (Ni)	0.01	0.01	-	-	-
Lead (Pb)	0.01	0.1	1.0	10.0	0.5
Mercury (Hg)	0.00001	0.00001	0.5	0.2	0.1
Zinc (Zn)	0.01	0.05	40.0	200.0	-
DDT (Technical)	0.00001	0.00001	0.2	-	-
HCH	0.00001	0.00001	0.2	-	-
PCB	-	-	2.0	-	-

Note: ww=wet weight. (Source: VNIRO 1999, State Committee for sanitary and Epidemiological Control of the Russian Federation 1997)

The levels of organochlorine pesticides were detected in traceable amounts, up to 0.006 mg/l in 2001-2002 (Arkhangelsk Region Directorate of Natural Resources and Environmental Protection 2002). Oil products were detected in concentrations close to 1 MAC.

Pechora River

Pollution of the Pechora River is mainly caused by the activity of the Timano-Pechora oil and gas province (Bryzgalo & Ivanov 1999a, Bryzgalo et al. 1999). The levels of oil products in the water therefore require special attention. Paraffin concentrations in the river mouth varied from 0.003 to 0.036 mg/l in year 2000, which is lower than maximum allowable concentration. According to Sevgidromet (1994, 1995, 1996) and the Research Institute of the Atmospheric Air Protection (1998), the situation in this region has not changed significantly during recent years and the concentration of oil hydrocarbons remains approximately at the same levels.

Concentrations of heavy metals in the Pechora River water are lower than MAC and organochlorine pesticides are detected in insignificant amounts (up to 0.005 mg/l) (Arkhangelsk Region Directorate of Natural Resources and Environmental Protection 2002).

Kola River

The Kola River and its tributaries are affected by: sewage and filtration waters from the areas of manure repositories and liquid manure collectors of the sovkhozes (state farms) of Murmansk, Prigorodny and Kolsky; the experimental industrial farm Voskhod; the integrated poultry farms Murmanskaya and Snezhnaya; and industrial and municipal sewage and stormwaters from industrial enterprises and settlements situated on the Kola river banks.

Maximum concentrations of copper and manganese were registered in 1993-1995 (Sevgidromet 1994, 1995, 1996). At the same time, other toxic metals such as mercury, chrome, nickel, cadmium and lead exceeded MAC considerably. In 1995-2000 the situation at the river mouth improved somewhat, but by the year 2000 the concentration of copper (5 MAC), nickel (3 MAC) and manganese (6 MAC) remained at high levels (Sevgidromet 1994, 1995, 1996, State Environmental Committee of the Murmansk Region 1999, 2001).

Pollution by oil products were less than 0.02 mg/l up to the year 1998 (State Environmental Committee of the Murmansk Region 1999). However, the concentrations abruptly increased to 0.1 mg/l in 1998 and 0.08 mg/l in 2002. According to Sevgidromet (1995) the average annual input of oil products in 1993 and 1994 was 17 and 10 tonnes respectively but at present, the values are somewhat higher.

Pechenga River

In 1994 and 1995, extremely high concentrations of heavy metals were observed in the River caused by accidental wastewater discharges from the Pechenganikel smelter. For example, copper concentrations reached 6.6 mg/l and 10.3 mg/l respectively and extremely high contamination by zinc, nickel, manganese, and high contamination with chrome, cadmium and cobalt was also registered. By now, the situation has normalised but some contamination of the Pechenga River is still prevalent; in year 2000 the concentration of copper, nickel and manganese exceeded the MAC with 4, 3 and 2 times respectively (Murmansk Region Directorate of Natural Resources and Environmental Protection 2001).

Up to 1998, the concentration of oil products remained within the background range of 10-20 mg/l (Bryzgalo & Ivanov 1999b). However, in 1998 and 2000, an increase in concentration up to 70-80 mg/l was observed (Murmansk Region Directorate of Natural Resources and Environmental Protection 2001).

Pasvik River

Smelting of copper-nickel ore in the cities of Nikel and Zapolyarnyy on the Kola Peninsula is the main air pollution source in the border areas. The emissions peaked at approximately 380 000 tonnes SO_2 per year in 1979 (Henriksen et al. 1997). The emissions have later been reduced to approximately 150 000 tonnes per year due to lower production in the early 1990s and later due to cessation in the use of Norilsk ore (SFT 2002). The air emissions also include metals, particularly nickel (maximum emissions approximately 500 tonnes per year), copper (maximum 300 tonnes per year), and other environmental contaminants (SFT 2002). In addition to the air pollution, the mining activity in Nikel discharges approximately 50 tonnes nickel per year directly to the Kolosjohki River of which 40 tonnes reach the transboundary Pasvik River (Arnesen et al. 1996). The impacts of the emissions on the environment are largest on the Russian side of the border closest to the pollution sources but the easternmost parts of Norway are also affected. The emissions have led to acidification of soils and surface waters, direct effects of SO_2 on vegetation, and higher concentrations of some metals in terrestrial and aquatic ecosystems.

During the previous decade, the environmental situation within the border area has been investigated as part of Norwegian, Finnish and Russian national monitoring programmes as well as part of the Joint Norwegian-Russian Commission on Environmental Cooperation, Finnish-Russian Environmental Cooperation and during implementation of research projects carried out by various scientific institutes. Long-term monitoring of water chemistry in lakes and rivers shows that extensive acidification of surface water has taken place, particularly on the Norwegian side of the border (Amundsen et al. 1993, 1997, Kashulin et al. 1997, 1999, 2003, Skjelkvåle et al. 2001, Traaen et al. 1991 etc.). Critical loads are exceeded in large areas of South-Varanger municipality, especially in the Jarfjord area, and in areas situated around Nikel and Zapolyarny.

Economic impacts

Economic impacts were assessed as having a slight impact. Polluted water from municipal services, poultry farms, and pulp and paper industries is discharged into the Severnaya Dvina, Pechenga, and Kola river basins, which are the sources of drinking water for the people living in the area. In periods of increased discharges and during intense snow melting, the population is affected by shortage of freshwater. As a result, a more active use of the less polluted groundwaters is required in the region. However, an existing programme to increase the use of groundwater makes only slow progress because of the financial situation and the potential groundwater resources are currently poorly explored.

Health impacts

Health impacts were assessed as having no known impact. There are no statistical data on diseases caused by freshwater pollution, but there are single records of diseases related to the quality of freshwater e.g. dysentery and hepatitis. This is in agreement with results from the joint Russian-Norwegian studies carried out by the Institute of Community Medicine (ISM) in the Barents region which are based on an initiative by the Ministry of Environment in both countries to explore the possible effects of air pollution coming from the nickel industry on the Russian side of the border. The Health Group of Norwegian and Russian scientists, headed by the ISM, was founded in 1991. The group decided to carry out a health study in the Norwegian-Russian border area to map human exposure and to investigate possible health effects of local air pollution. Human urinary nickel levels were substantially higher on the Russian side, and highest in the vicinity to the nickel smelters. Despite that, the Russian women had lower prevalence of nickel allergy compared to the Norwegian. Airway symptoms were frequently reported in Russia, but lung function was better than predicted on both sides. No associations between sulphur dioxide concentrations in air and lung function could be verified. The study revealed no major health effects from the nickel on either side of the border (AMAP 1998, 2002, Dotterud et al. 2000 2001, Odland et al. 1999, Odland 2000, Smith-Sivertsen et al. 2001 etc.).

Other social and community impacts

There are no records of other social and community impacts (e.g. increased damage to water-related equipment, and damage to infrastructure).

Conclusions and future outlook

Freshwater shortage is not relevant for the Barents Sea region and the transboundary aspect is largely missing. Therefore, a slight impact was assigned to the present conditions. The freshwater shortage is predicted to be reduced or at least stay at the same level of impact by 2020. According to predictions, the major production of the Kola Mining and Metallurgy Company, which is one of the major polluters of air and the aquatic environment, will decrease by 50% and thus, pollution of the water resources will decrease as well.

Efforts aimed at technical re-equipment of industries will facilitate a reduction of pollution. For example, pollution of water resources in the Arkhangelsk Region and Karelia from enterprises of the pulp and paper and mining and processing industries is not predicted to increase since despite a slight growth of the production volumes, measures will be taken to decrease the inputs of contaminants into the air, as well as pollution of water (Batchaev et al. 2002, Murmansk Region Administration 2001, 2002).

Pollution

Various pollutants enter the Barents Sea via two main and complicated pathways: external advection (marine and atmospheric) which dominates, and local economic activities (effluents from land, transport activities etc.).

Atmospheric pollution over the Barents Sea water area is conditioned by the global processes of dissipation and transport of anthropogenic pollutants from sources located in medium and high latitudes of Asia, Europe, and North America. However, local sources influence as well and one of the features of the region is the presence of large mining, metallurgy, ore processing and pulp and paper industries. Analysis of the infrastructure of anthropogenic polluters in the Russian sector of the Barents Sea drainage basin (in the interconnection with their annual power) has shown that the main sources of emission of toxic substances are concentrated in the northern part of the drainage basin, and closest to the coast. This results in increased atmospheric contamination over the Barents Sea open water area with substances such as trace elements, including heavy metals, polycyclic aromatic hydrocarbons, persistent organic pollutants, and sulphur compounds.

Water and ice exchange with adjacent areas has a significant role in the pollution of the Barents Sea. The Barents Sea is the unloading zone of the Atlantic water currents, thus, it is important to take into consideration the possibility of advection of the pollutants with the outside sea currents. Water exchange with the White Sea has also some impact.

The issues of microbiological pollution, eutrophication, suspended solids, and thermal pollution were considered as irrelevant and were assessed as having no known impacts. Microbiological pollution is caused by municipal sewage discharged into the freshwater resources, e.g. Kola and Northern Dvina rivers. The impact is local and not relevant for the region in general. There are hotspots of eutrophication in the estuarine zone of the Kola River, but no records of eutrophication of the Barents Sea. As for suspended solids, no significant increased turbidity of waters within the region has been observed. Thermal pollution is localised and mainly observed in the area of the Kola Nuclear Power Station.

Chemical

The coastal areas of the Barents Sea are most exposed to anthropogenic activities. However, even in coastal areas, the levels of chemical pollutants are generally lower than the Russian water quality guidelines (Maximum Allowable Concentration, MAC) and the Norwegian Pollution Control Authority (SFT) environmental quality assessment criteria (Molvaer et al. 1997) and lower than in other parts of Russia or European seas. The Kola Bay, with its high contamination load, is an exception and annual studies of its waters and bottom sediments reveal high levels of pollutants. The Kola Bay ecosystem has not experienced any considerable changes recently, and in some areas the situation is close to critical. The southern and to a lesser degree the central parts of the bay are the most polluted. Pollutants entering the Barents Sea with river run-off only have a slight impact on the ecosystem since the river run-off is low.

The data available on pollution levels in the abiotic and biotic components of the White Sea ecosystem show a moderate level of contamination. Increased levels of some chlorine organic compounds are found in different abiotic and biotic components. In general however, the anthropogenic impact on the ecosystems of the White Sea is comparatively low as well. The only exceptions are the areas of Kandalaksha and Dvina bays. They are heavily polluted by untreated sewage from a number of rivers, especially from the Severnaya Dvina, delivering about 90% of all the pollutants entering the White Sea.

Atmospheric pollution

Measurements of contaminants over the Barents Sea open water area are few. Murmansk Marine Biological Institute (MMBI) carried out measurements of heavy metals in 2001 (see Table 18). The levels are the same as for the West European sector of the Arctic and one order lower than in background areas (areas located significantly far from emission sources) in the European part of Russia.

Persistent organic pollutants (POPs), including organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs) and polycyclic aromatic pollutants (PAHs), are present in concentrations typical of background areas in northern and western Europe. Average concentrations are estimated at 0.060 ng/m^3 for OCPs, 0.037 ng/m^3 for ΣPCB, and 0.002 g/m^3 for benzo(a)pyrene, being an indicator-substance for PAH.

Due to low levels of contaminants in the atmosphere, their contribution to the Barents Sea pollution is low.

Barents Sea open waters

According to the MMBI data from the open part of the Barents Sea, the levels of trace elements, including heavy metals in water, are low (Table 18). As a whole, their concentrations are less than the maximum allowable concentration (Table 17) and the concentration is also low in bottom sediments. The levels of trace elements in the area considered, probably depend on atmospheric precipitation and advection with Atlantic waters.

According to Sevgidromet (1992), average concentrations of α-HCH and γ-HCH in 1991 were 0.0004 µg/l and 0.002 µg/l respectively in the open part of the Barents Sea (Table 19). During subsequent years, HCH concentrations in the Barents Sea waters were significantly lower.

ΣDDT concentrations in the central Barents Sea bottom sediments are shown in Table 19. The maximum concentration has been registered in the area of the Stockman gas-condensate deposit (Matishov & Nikitin 1997).

ΣHCH concentrations in the bottom sediments of the central area are not high (Table 19) and the maximum concentrations are mainly found in shallow water areas. The HCH isomer lindane is found in many areas and constitutes 49% or more of the sum of three HCH isomers (Matishov & Nikitin 1997).

PCB levels in bottom sediments of the Barents Sea central area are less than 0.0005 µg/g (Matishov & Nikitin 1997, Loring et al. 1995, Klungsøyr et al. 1995). Thus, the levels of chlorinated hydrocarbons in the water and the surface layer of bottom sediments in the Barents Sea central part can be characterised as background values.

On average, the level of oil contamination in seawater is not high and does not exceed MAC (0.05 mg/l). In the western areas the average long-term concentration of oil products is somewhat higher (0.030 mg/l) than in the eastern areas (0.026 mg/l). PAH levels in the Barents Sea bottom sediments are relatively low and average 0.11 mg/g (Matishov & Nikitin 1997, Loring et al. 1995, Klungsøyr et al. 1995).

Kola Bay

In the Kola Bay the concentration of most trace elements in the water are low (Table 18) and less than MAC (Illin & Dahle 1997). The only exception is copper and mercury. Maximum mercury levels, 2 orders higher than MAC, has been registered in the central part of the bay (42 µg/l). However, in the southern and northern parts of the bay mercury concentrations are significantly lower (down to 0.026 µg/l). In the same investigation, copper levels were found to vary within the range 0.4-25 µg/l, exceeding MAC on occasion. In the Kola Bay waters the levels of α-HCH and γ-HCH varied from 0.0013-0.0017 µg/l in the 1990s and from 0-0.0012 µg/l in 1991 (Aibulatov 2001), which is less than MAC.

Table 18 Concentration of heavy metals in the Barents Sea region.

	Cadmium	Copper	Nickel	Lead	Zinc	Cobalt	Chromium	Mercury	Arsenic
Barents Sea, atmospheric pollution over open water (ng/m^3)	0.022	4.0	0.28	0.15	2.3	0.16	0.34	0.67	ND
Barents Sea, open water (µg/l)	0.03	0.66	0.83	0.51	ND	0.1	ND	ND	ND
Kola Bay, bottom sediments (µg/l dw)	0.1-0.2	4.2-5.9	5.1-12.4	16.5-20.5	ND	ND	ND	ND	ND
Kola Bay, coastal waters (µg/l)	0.01-0.06	0.4-25	0.3-1.6	0.65-1.1	ND	ND	13-59	0.026-42	ND
Kola Bay, ports of Murmansk and Severomorsk (µg/g dw)	0.06-0.2	9.5-26.2	3.15-23	5.5-45.0	ND	ND	20.8-64.9	ND	ND
Kola Peninsula, near-shore bottom sediments (µg/g dw)	0.04-0.05	2.3-3.1	3-3.4	8.3-10.2	ND	ND	3-3.4	0.007	ND
Pechora Sea, open water (mg/g dw)	0.0-0.2	1.1-7.3	3.6-13.7	1.2-3.7	ND	ND	20.0-93.6	0.0-0.08	ND
White Sea, bottom sediment (mg/l)	ND	0.5-15.9	1.6-34.1	1.9-63	ND	0.7-19.9	1.2-17.1	0.04-0.1	ND
Kola Peninsula, sea algae (mg/kg dw)	ND	32-36	ND	ND	ND	ND	ND	0.3-0.4	7-8
Kola Peninsula, benthos invertebrates (mg/kg dw)	24	66	ND	ND	ND	ND	ND	ND	ND

Note: dw = dry weight, ND = No Data.

(Source: APN 2003, Sevigdromet 1992, 1996, Aibulator 2001, Matishov & Nikitin 1997, Loring et al. 1995, Klunsøyr et al. 1995, Illin & Dahle 1997, measurements by the Murmansk Marine Biological Institute 2001)

Table 19 Concentration of organic pollutants in the Barents Sea region.

	α-HCH	γ-HCH	ΣHCH	ΣDDT	ΣPCB	PAH	DDE	DDD
Barents Sea, open water (µg/l)	0.0004	0.002	ND	ND	ND	ND	ND	ND
Barents Sea, bottom sediments (µg/g)	ND	ND	0.003	0.0032	0.0005	110	ND	ND
Kola Bay, bottom sediments (µg/g dw)	0.12-0.52	0.43-0.92	ND	1.9-9.1	1.02-15.7	ND	ND	ND
Kola Peninsula, near-shore waters (µg/l)	0.3-0.5	0.2-0.4	ND	0.001	0.02-0.05	ND	ND	ND
Pechenga Bay, bottom sediments (mg/g dw)	ND	ND	0.05-0.68	0.27-36.7	1.11-37.9	ND	ND	ND
Pechora Sea, open water (µg/l)	0.6-2.2	0.6-2.0	ND	0.11-0.54	ND	ND	0.03-0.032	0.05-0.39
Pechora Sea, bottom sediments (µg/g)	0.58	0.00028	ND	ND	ND	ND	ND	ND
White Sea (Aibulatov 2001) (µg/l)	0.5-10	0.3-12	ND	3	ND	ND	ND	ND
Kola Peninsula, red king crab muscle (ng/g ww)	ND	ND	0.6-3.2	0.06-0.25	0.6-32.2	ND	ND	ND

Note: dw = dry weight, ww = wet weight, ND = No Data.

(Source: APN 2003, Sevigdromet 1992, 1996, Aibulator 2001, Matishov & Nikitin 1997, Loring et al. 1995, Klunsøyr et al. 1995, Illin & Dahle 1997, measurements by the Murmansk Marine Biological Institute 2001)

The distribution of trace metals in bottom sediments is characterised by a marked tendency towards decreased concentrations in the direction from south to north. The water areas adjacent to the port of Murmansk and the port centre of Severomorsk are the territories of extremely high accumulation levels of practically all metals (Table 18).

Investigations of POPs in the Kola Bay bottom sediments were carried out in 1999 (Table 19). The highest ΣPCB levels were observed in the area of the town of Zapolyarny; 1.65-8.7 µg/g dw (dry weight). At present, the bottom sediments themselves are likely a source of water pollution. The levels of oil hydrocarbons in bottom sediments vary within the range of 80 mg/g dw (the northern part of the Kola Bay) to 1 280 mg/g dw (the southern part of the Kola Bay) (Sevgidromet 1992).

PAH concentrations in sediments also decrease from south to north, reaching the highest values in the area of the city of Murmansk (9 µg/g) and in the Severomorsk area (10.8 µg/g) (APN 2003). Only limited information exists on so-called "new" POP compounds in bottom sediments, however there is an indication on elevated toxaphene and brominated flame retardant levels in some areas of the Kola Bay (Savinova et al. 2000). More detailed studies are needed on sources and levels of these contaminants within the study area.

Kola Peninsula near-shore area (Fennoscandia)

Concentrations of trace metals in bottom sediments along the coast are of uniform character (Table 18), and are considerably lower than the values for the Kola Bay. There are practically no data on POP levels in the Kola Peninsula near-shore waters. According to APN (2003) all levels of α-HCH and γ-HCH, ΣDDT and ΣPCB were 1-2 orders lower than MAC (Table 19).

According to Aibulatov (2001), water pollution with organochlorine pesticides in the Motovsky and Teribersky bays was as a whole insignificant during the past five years. In the bottom sediments of the above-mentioned areas, α-HCH and γ-HCH levels in 1992-1993 were 0.3-0.4 mg/g dw. POP levels in the Pechenga Bay bottom sediments in 1997 is shown in Table 19.

The concentration of oil hydrocarbons in the Kola Bay coastal waters is low (0.05-0.06 mg/l). The highest level of pollution for the waters of Motovsky and Teribersky bays was observed in the 1980s reaching 0.61 mg/l (Aibulatov 2001).

PAH concentrations in the Guba Pechenga surface sediments vary in the range 428-3 257 ng/g dw, which is considerably higher than in the adjacent areas Guba Bol'shaya Volokovaya, Guba Malaya Volokovaya, and Varangerfjord, where PAH levels vary between 151-442 ng/g dw (Savinov et al. 2003a).

The Pechora Sea

The Pechora Sea water masses are characterised by pollutant concentrations that are one order lower than MAC, except for copper (3.9 mg/l). Concentrations of trace elements in bottom sediments are also lower than the values characteristic of the Kola Bay (Table 18). POP levels in the Pechora Sea in 1995 is shown in Table 19 (Sevgidromet 1996).

ΣDDT concentrations in bottom sediments is also shown in Table 19. The highest concentrations of this pollutant (0.0019 and 0.001 mg/g) have been registered in the shallow water areas between the Island of Vaigach and the Island of Dolgy, and in the central Pechora Sea (0.001 mg/g). The total HCH levels in bottom sediments vary within the range 0.08-0.84, averaging 0.28 ng/g, which is one order lower than the values for the Barents Sea central part (1.53-5.18 ng/g).

Chlorinated hydrocarbons in the Pechora Sea bottom sediments is low even compared with relatively clean bottom sediments of the Barents Sea. The most contaminated area is to the southwest of the Island of Vaigach (silty-sandy character of the sediments) and the central Pechora Sea (grey clay, silt).

In 1999, according to the hydrometeorology data service, the average oil hydrocarbon level in the Pechora Sea surface waters was 0.04 mg/l. In the Pechora Bay the concentration of oil hydrocarbons increased up to 0.66 mg/l while in bottom sediments the level was on average 23.7 mg/g dw.

The White Sea

The analysis of the heavy metal content in bottom sediments carried out by Aibulatov (2001) suggests low levels of contaminants in the White Sea (Table 18).

Most of the organochlorine pesticides enter the White Sea with river run-off, the rest from the atmosphere. The highest α-HCH and γ-HCH levels are observed in the Dvina Bay (Table 19) but are still less than MAC. The concentrations of DDT and its metabolites are also observed in low levels (Table 19) (Aibulatov 2001). In bottom sediments, organochlorine pesticides of the DDT family prevail due to their greater persistence (Aibulatov 2001).

In the central part of the Sea, in Onega and Mezen bays, the levels of oil hydrocarbons in seawater are on average lower than or equal the MAC level (0.01-0.05 mg/l). In areas adjacent to the Kandalaksha Bay and Mezen Bay, the concentration of oil hydrocarbons are higher and may reach 1.5-5 MAC. In the water area of the port of Kandalaksha, oil hydrocarbon concentrations are observed at levels of 0.1-0.26 mg/l. Dvina Bay is the most polluted; the levels here may reach 0.3 mg/l (Aibulatov 2001). The highest concentrations of oil hydrocarbons are observed in bottom sediments of the Dvina and Kandalaksha bays (0.20-0.29 and 0.15-0.17 mg/g dw, respectively) (Sapozhnikov & Sokolova 1994). PAH concentrations in the White Sea bottom sediments are 2-3 times lower compared to the northwestern and southeastern parts of the Barents Sea, but are comparable to the levels reported for sediments from the Pechora Sea (Savinov et al. 2000).

Finnmark

Levels of PAHs and trace elements in bottom harbour sediments collected in 1994 in Finnmark show, according to the Norwegian Pollution Control Authority (SFT) classification (Table 20) (Molvaer et al. 1997), "background" and "moderate" contamination, except at Vardø, where "strong" contamination was found (Konieczny 1996).

POP and trace element levels in bottom sediments from Finnmark have been studied in Varangerfjord during the Joint Assessment and Monitoring Program (JAMP) (Green 1997, 1999). A comparative study was conducted on POP levels in sediments from harbours in northern Norway and Northwest Russia (Dahle et al. 2000). The highest concentrations of ΣPCB were found in the harbours of Harstad, Hammerfest and near Severomorsk. All those harbours had elevated ΣDDT and ΣPCB levels, and, according to SFT classification (Table 20) were classified as "marked". In contrast, PCB levels in Finnmark show mainly background levels (Green 1997, 1999).

Levels of POPs in blue mussels and fish from the Varangerfjord area studied in the frame of JAMP were low and a tendency for decreasing levels of ΣDDT and ΣPCB was observed. The results confirmed that POP and trace element levels in commercial fish from the coastal areas of northern Norway were below the safety threshold levels for human consumption (Table 21).

Table 20 The Norwegian Pollution Control Authority (SFT) classification of environmental quality: contaminants in marine bottom sediments.

Contaminant	**Marine bottom sediments** (upper limit for classes I-V)				
	I: Background	II: Moderate	III: Marked	IV: Strong	V: Very strong
Arsenic (As) (mg/kg dw)	<20	20-80	80-400	400-1 000	>1 000
Lead (Pb) (mg/kg dw)	<30	30-120	120-600	600-1 500	>1 500
Cadmium (Cd) (mg/kg dw)	<0.25	0.25-1	1-5	5-10	>10
Copper (Cu) (mg/kg dw)	<35	35-150	150-700	700-1 500	>1 500
Chromium (Cr) (mg/kg dw)	<70	70-300	300-1 500	1 500-5 000	>5 000
Mercury (Hg) (mg/kg dw)	<0.15	0.15-0.6	0.6-3	3-5	>5
Nickel (Ni) (mg/kg dw)	<30	30-130	130-600	600-1 500	>1 500
Zinc (Zn) (mg/kg dw)	<150	150-700	700-3 000	3 000-10 000	>10 000
TBT (µg/kg dw)	<1	1-5	5-20	20-100	>100
ΣPAH (µg/kg ww)	<300	300-2 000	2 000-6 000	6 000-20 000	>20 000
B(a)P (µg/kg ww)	<10	10-50	50-200	200-500	>500
ΣPCB-7 (µg/kg ww)	<5	5-25	25-100	100-300	>300
HCB (µg/kg ww)	<0.5	0.5-2.5	2.5-10	10-50	>50
ΣDDT (µg/kg ww)	<0.5	0.5-2.5	2.5-10	10-50	>50
$TE_{PCDF/D}$ (ng/kg ww)	<0.01	0.01-0.03	0.03-0.10	0.10-0.5	>0.5

(Source: Molvaer et al. 1997)

Table 21 The Norwegian Pollution Control Authority (SFT) classification of environmental quality: contaminants in blue mussels.

Contaminant	**Blue mussels** (upper limit for classes I-V)				
	I: Background	II: Moderately	III: Markedly	IV: Strongly	V: Very strongly
Arsenic (As) (mg/kg dw)	<10	10-30	300-100	100-200	>200
Lead (Pb, mg/kg dw)	<3	3-15	15-40	40-100	>100
Cadmium (Cd) (mg/kg dw)	<2	2-5	5-20	20-40	>40
Copper (Cu) (mg/kg dw)	<10	10-30	30-100	100-200	>200
Chromium (Cr) (mg/kg dw)	<3	3-10	10-30	30-60	>60
Mercury (Hg) (mg/kg dw)	<0.2	0.2-0.5	0.5-1.5	1.5-4	>4
Nickel (Ni) (mg/kg dw)	<5	5-20	20-50	50-100	>100
Zinc (Zn) (mg/kg dw)	<200	200-400	400-1 000	1 000-2 500	>2 500
ΣPAH (µg/kg ww)	<50	50-200	200-2 000	2 000-5 000	>5 000
B(a)P (µg/kg ww)	<1	1-3	3-10	10-30	>30
ΣDDT (µg/kg ww)	<2	2-5	5-10	10-30	>30
HCB (µg/kg ww)	<0.1	0.1-0.3	0.3-1	1-5	>5
ΣHCH (µg/kg ww)	<1	1-3	3-10	10-30	>30
ΣPCB-7 (µg/kg ww)	<4	4-15	15-40	40-100	>100
$TE_{PCDF/D}$ (ng/kg ww)	<0.2	0.2-0.5	0.5-1.5	1.5-3	>3

(Source: Molvaer et al. 1997)

Biota contamination

Levels of trace elements in the sea algae *Laminaria saccharina, Ascophyllum nodosum* and *Fucus vesiculosus* in the Kola Peninsula near-shore zone are less than MAC (Table 18). The highest concentrations are observed for mercury, arsenic and copper.

Concentrations of microelements in benthic invertebrates (*Gammarus oceanicus, Littorina rudis, Nucella lapillus, Mytilus edulis, Arenicola marina)* from the Kola Peninsula near-shore areas are considerably lower than MAC for lead and zinc, but close to the MAC level and higher for copper and cadmium. The concentrations of the latter might reach 66 and 24 mg/kg dw respectively. The levels of accumulation of heavy metals in the Red king crab muscles from the Kola and Motovsky bays have low values as well, about one order lower than MAC.

The data on the levels of trace elements in muscles of fish species are presented in Table 22. The highest concentrations are registered for zinc. Nickel, cobalt and chromium levels are lower than the detection limit of the applied analysis techniques. Lead, cadmium and mercury levels varied within a very narrow range and correspond to a greater degree to the natural background level.

According to the MMBI and APN (2003), ΣDDT, ΣHCH and ΣPCB levels in Red king crab muscles from the Kola Peninsula near-shore areas vary within the following ranges: 0.06-0.25 ng/g ww, 0.6-3.2 ng/g ww, 0.6-32.2 ng/g ww respectively.

Table 22 Average annual concentrations of trace elements in the tissues of the most important commercial fish species of the Barents Sea in 2000.

Species	Lead (mg/g dw)	Copper (mg/g dw)	Cadmiumn (mg/g dw)	Mercury (mg/g dw)	Zinc (mg/g dw)	Arsenic (mg/g dw)
Cod	0.2±0.01	0.72±0.05	0.03±0.003	0.03±0.002	3.7±0.2	0.2±0.03
Haddock	0.2±0.02	0.8±0.1	0.02±0.002	0.03±0.004	4.1±0.3	0.3±0.05
American plaice	0.2±0.03	0.7±0.03	0.02±0.002	0.02±0.002	3.5±0.2	0.2±0.01
Plaice	0.2±0.03	0.8±0.05	0.02±0.004	0.02±0.1	4.5±0.6	0.2±0.1
Perch	0.2±0.01	1.0±0.06	0.02±0.001	0.03±0.002	3.9±0.2	0.2±0.03
Herring	0.2±0.01	1.0±0.03	0.02±0.002	0.03±0.002	5.2±0.2	0.4±0.02
Coalfish	0.9±0.09	0.2±0.03	0.02±0.006	0.03±0.005	3.9±0.4	0.4±0.02
Halibut	0.2±0.02	0.9±0.2	0.02±0.02	0.04±0.1	3.0±0.3	0.3±0.02
Capelin	0.1±0.2	0.8±0.1	0.02±0.003	0.03±0.004	5.4±0.5	0.3±0.04
Mackerel	0.1±0.02	0.9±0.06	0.02±0.002	0.03±0.002	5.2±0.3	0.3±0.03
Spiny skate	0.3±0.06	1.02±0.09	0.02±0.007	0.13±0.04	0.5±0.3	ND

Note: ND = No Data. (Source: SRW/MMBI 2000)

In 2000, the total content of hexachlorcyclohexan isomers in muscles of commercial fish species varied from 0.1 to 0.68 ng/g fresh weight; DDT and its metabolites from 0.3 to 5.86 ng/g fresh weight; polychlorinated biphenyls from 0.3 to 5.7 ng/g fresh weight and did not exceed the allowable levels for unprocessed and processed food products (SRW/MMBI 2000). Spiny skate was characterised by relatively high OCPs (organochlorine pesticides) and PCB contents (36.7±5.4 and 98±39 ng/g respectively).

Higher levels of contaminants were detected in higher trophic levels such as seabirds, marine mammals and polar bears, since pollutants accumulate via food-web transport (Muir et al. 2003, Savinov et al. 2003).

Solid waste

Observations of the Barents Sea show that the areas of South-Svalbard and Sørkapp Currents, the northern branch of the Nordkapp Current, the Bear, and the southern branch of the Nordkapp Currents are the most polluted areas in the northwest. Due to the fact that the polar front in these areas is distinctly expressed in the surface layers, pollutants concentrate along the frontal zone, forming long drawn-out plait stripes, which at times are traced by clots of foam. They are mainly composed of timber and ligneous wastes as well as municipal waste of various origin.

In the central Barents Sea, the zone of intensive pollution is also conditioned by the character of circulation and is located in the frontal zone between the central branch of Nordkapp Current and the Central Current. Here, like in the northwest, the waste is mainly composed of timber and municipal waste. The southwestern part is also polluted by timber and other waste.

Radionuclide

The main sources of artificial radionuclides into the Barents Sea are atmospheric fallout, river transport, discharges from West European nuclear reprocessing plants entering the region with the Gulf Stream, discharges of liquid radioactive waste from sources located on the Kola Peninsula, as well as accidents causing the release of artificial radionuclides.

Among the radionuclides entering the atmosphere as a result of nuclear and thermonuclear explosions, plutonium-239, strontium-90, cesium-137, iodine-131, cobalt-60 and carbon-14 are particularly dangerous (Matishov et al. 1994). The majority of these radionuclides are transported into the oceans via complex physical, chemical and biological pathways.

The condition in Kola Bay has attracted increased attention as a possible source of chemical and radioactive pollution of the Barents Sea. Therefore, an assessment of the ecological state of the region should be carried out in this coastal area.

Global atmospheric fallout

The main source of artificial radionuclides into the atmosphere was nuclear weapons tests in the 1950s and 1960s at three polygons of the Novaya Zemlya: Chernaya and Sul'meneva bays and Matochkin Shar Strait, and later the Chernobyl accident in Ukraine. To assess the levels of artificial radionuclide fallout on the Barents Sea surface, the Roshydromet data has been used (Sevgidromet 1996, Murmansk Region Directorate of Natural Resources and Environmental Protection 2001, Makhon'ko 1987-1995). The values of atmospheric fallout in the Roshydromet's Annual-books are presented as the average over the Russian Polar North i.e. Murmansk, Norilsk, Nar'yan-Mar, Dixon, Khanty-Mansijsk, Turukhansk, Amderma, Salekhard, and Kandalaksha.

A temporal analysis of the atmospheric fallout of artificial radionuclides shows that maximum atmospheric fallout of radionuclides was observed in 1986 connected with the Chernobyl accident (Table 23) (Namyatov 1998). In 1987 atmospheric fallout of artificial radionuclides abruptly decreased compared to the previous year. Since 1987 a stable decrease has been observed, both in the region in general and onto the Kola Bay surface in particular (Namyatov 1998).

Table 23 Artificial radionuclide fallout over the Russian Polar North and on the Kola Bay surface.

Nuclide	1986	1987	1988	1990	1991	1992	1993
Russian Polar North (10^7 Bq/km^2/year)							
^{137}Cs	15.355	0.407	0.268	0.246	0.150	0.228	0.208
^{90}Sr	1.306	0.814	0.692	0.029	0.0376	0.0786	0.0702
^{239,240}Pu	ND	ND	0.0070	0.006	0.0039	0.0059	0.0054
^{134}Cs	7.692	0.141	0.085	ND	ND	ND	ND
^{144}Ce	0.851	0.248	0.013	ND	ND	ND	ND
^{106}Ru	7.015	0.127	0.100	ND	ND	ND	ND
Tritium	256.0	247.9	333.0	115.81	164.4	200.4	178.3
Kola Bay surface (10^9 Bq/year)							
^{137}Cs	32.921	0.872	0.575	0.527	0.322	0.489	0.446
^{90}Sr	2.800	1.745	1.484	0.062	0.081	0.169	0.151
^{239,240}Pu	ND	ND	0.015	0.014	0.008	0.013	0.012
^{134}Cs	16.492	0.302	0.182	ND	ND	ND	ND
^{144}Ce	1.825	0.532	0.028	ND	ND	ND	ND
^{106}Ru	15.040	0.272	0.214	ND	ND	ND	ND

Notes: ND = No data. The Russian Polar North: Murmansk, Norilsk, Nar'yan-Mar, Dixon, Khanty-Mansijsk, Turukhansk, Amderma, Salekhard, and Kandalaksha. (Source: compiled by Namyatov 1998)

River run-off

The Kola Bay water catchment area is 27 720 km^2. Unfortunately, there are no studies devoted to investigations of radioactive contamination of the rivers on the Kola Peninsula. Therefore, data presenting the average content of cesium-137, strontium-90 and tritium in the Nordic rivers is used (the Onega, the Severnaya Dvina, and the Pechora) (Makhon'ko 1987-1995, Cheluykanov & Savel'ev 1992) (Tables 24 and 25). It is assumed that the contamination level of these rivers is comparable to that of

Table 24 Strontium and cesium in the Onega, Severnaya Dvina, and Pechora rivers.

River	1961	1962	1963	1964	1965	1966	1967-1985	1986	1987-1989
^{90}Sr (Bq/m^3)									
Onega	ND	29.6	118.4	125.8	114.7	81.4	22.2-55.5	14.8	11.1-14.8
Severnaya Dvina	11.1	29.6	ND	103.6	44.4	40.7	18.5-48.1	18.5	18.8
Pechora	22.2	25.9	62.9	37.0	44.4	51.8	62.9	7.4	11.1
Average	16.7	28.4	90.6	88.8	67.8	58.0	34.5	13.6	14.0
^{137}Cs (Bq/m^3)									
Average	ND	ND	ND	ND	31.2	26.7	10.4	2.7	2.8

ND = No Data. (Source: compiled by Namyatov 1998)

Table 25 Tritium in the Severnaya Dvina and Pechora rivers.

River	1981-1985	1986	1987	1989	1990	1991	1992	1993
Tritium (Bq/m^3)								
Severnaya Dvina	5 809	4 958	5 106	3 182	3 922	3 200	3 500	2 600
Pechora	7 918	4 477	5 328	4 338	2 960	4 500	4 300	3 600
Average	6 864	4 718	5 217	3 760	3 441	3 850	3 900	3 100

ND = No Data. (Source: compiled by Namyatov 1998)

the rivers of Kola Peninsula. Such an assumption is justified by the absence of any publications showing abnormal contents of artificial radionuclides in the soils of the water catchment area of these rivers or in the soils of the Kola Peninsula river catchment areas.

The data on the ^{90}Sr concentrations are taken from Cheluykanov and Savel'ev (1992). Measurements of ^{137}Cs in rivers were found to be very rare (Bochkov et al. 1983, Makhon'ko et al. 1977, Kolvulehto et al. 1980, Salo & Voipio 1972); a summary of available results was presented in Bochkov et al. (1983). Based on these values, the ^{137}Cs and ^{90}Sr transport into the Kola Bay with the river run-off from the catchment area was calculated as 2.6×10^{10} and 1.3×10^{11} Bq/year respectively.

Discharge of liquid radioactive waste from sources located on the Kola Peninsula

The main potential sources of radioactive pollution in the region are:

- Nuclear submarine bases;
- Ship-repairing yards for nuclear submarines;
- Civil enterprises, where civil vessels with nuclear energy installations are based, repaired and maintained;
- Sites for temporary storage of radioactive waste and spent nuclear fuel.

In total, there are 10 sites with radioactively dangerous objects in the water and at the coast of the Kola and Motovsky bays. These are the towns of Murmansk, Severomorsk, Polyarny, and Gadjievo, as well as Sayda, Olenya, Pala, Zapadnaya Litsa, Ura and Ara bays (Figure 14).

Before 1986, all liquid radioactive waste (LRW) from the Northern Navy and the Repairing Technological Enterprise (RTE) ATOMFLOT[1] was transported to the Barents Sea and discharged there. Reprocessing (purification) of liquid radioactive waste at ATOMFLOT has been carried out since 1989. The purification of liquid radioactive waste is intended for reprocessing waste from the Civil Atomic Fleet[2] vessels and the sites of special production at ATOMFLOT. Waste with a total specific beta activity of not more than 11.1×10^5 Bq/l to the level of 37 Bq/l is reprocessed by the sorption method, with subsequent dilution into the system of industrial and municipal sewage to the level of 3.7-11 Bq/l before discharge. Nowadays, all liquid radioactive waste coming from atomic icebreakers and some supporting vessels of the Northern Navy ships, is processed at the ATOMFLOT installation. Table 26 presents data on the input of artificial radionuclides after the liquid radioactive waste purification facility was put into operation.

A major source of pollution by ^{137}Cs and ^{90}Sr in the Kola Bay is discharges from the RTE ATOMFLOT. During 1992, the annual discharge of these nuclides was the greatest; 2.1×10^8 and 2.6×10^7 Bq/year, respectively. During the period 1989-1994, the average annual discharges were 1.6×10^7 and 7.6×10^7 Bq/year respectively (see Table 26).

Table 26 Total input of artificial radionuclides since the installation of the LRW purification facility at RTE ATOMFLOT.

Nuclide (10^6 Bq/year)	Year						Total (1989-1994)	Average	Nuclide/^{137}Cs
	1989	1990	1991	1992	1993	1994			
^{90}Sr	7.4	5.6	2.5	26.3	15.5	37.0	94.0	15.7	0.21
^{137}Cs	20.7	31.1	5.56	208.7	94.0	97.3	457.0	76.2	1
^{134}Cs	6.3	9.2	3.3	62.8	31.5	27.0	139.1	23.2	0.30
^{125}Sb	28.1	39.2	26.6	185.0	92.1	40.7	411.8	68.6	0.90
^{60}Co	31.8	44.4	10.0	130.2	72.2	81.0	369.6	61.6	0.81
^{154}Eu	47.0	65.1	40.0	160.6	139.5	84.4	536.9	89.5	1.18
^{152}Eu	20.0	27.8	18.1	105.0	79.2	50.3	299.3	50.0	0.65
^{95}Zr	10.7	12.6	5.2	35.5	51.4	30.3	147.6	24.6	0.32
^{95}Nb	9.2	12.5	5.2	30.3	22.6	17.0	96.9	16.2	0.21
^{54}Mn	10.4	14.1	10.4	34.4	25.5	22.9	117.7	19.2	0.26
^{144}Ce	25.9	29.6	35.9	159.8	130.9	81.0	463.2	77.2	1.01
^{58}Co	9.6	13.3	8.1	32.6	27.8	16.3	107.7	18.0	0.24
^{106}Ru	81.4	111.0	46.6	270.8	199.4	115.8	825.1	137.5	1.82
^{103}Ru	6.3	8.5	5.2	20.4	22.9	12.6	77.7	13.0	0.17

(Source: Matishov 1997)

[1] The Repairing and Technological Enterprise ATOMFLOT is a treatment facility for radioactive waste as well as a permanent base for the nuclear-powered ships of the Civilian Atomic Fleet.
[2] The Civilian Atomic Fleet is controlled by the Ministry of Transport of the Russian Federation and the ships of the Fleet are federal property. The ships are exploited by the Murmansk Shipping Company on a treaty between the Company and the Murmansk Region Committee for the Control of the State Property.

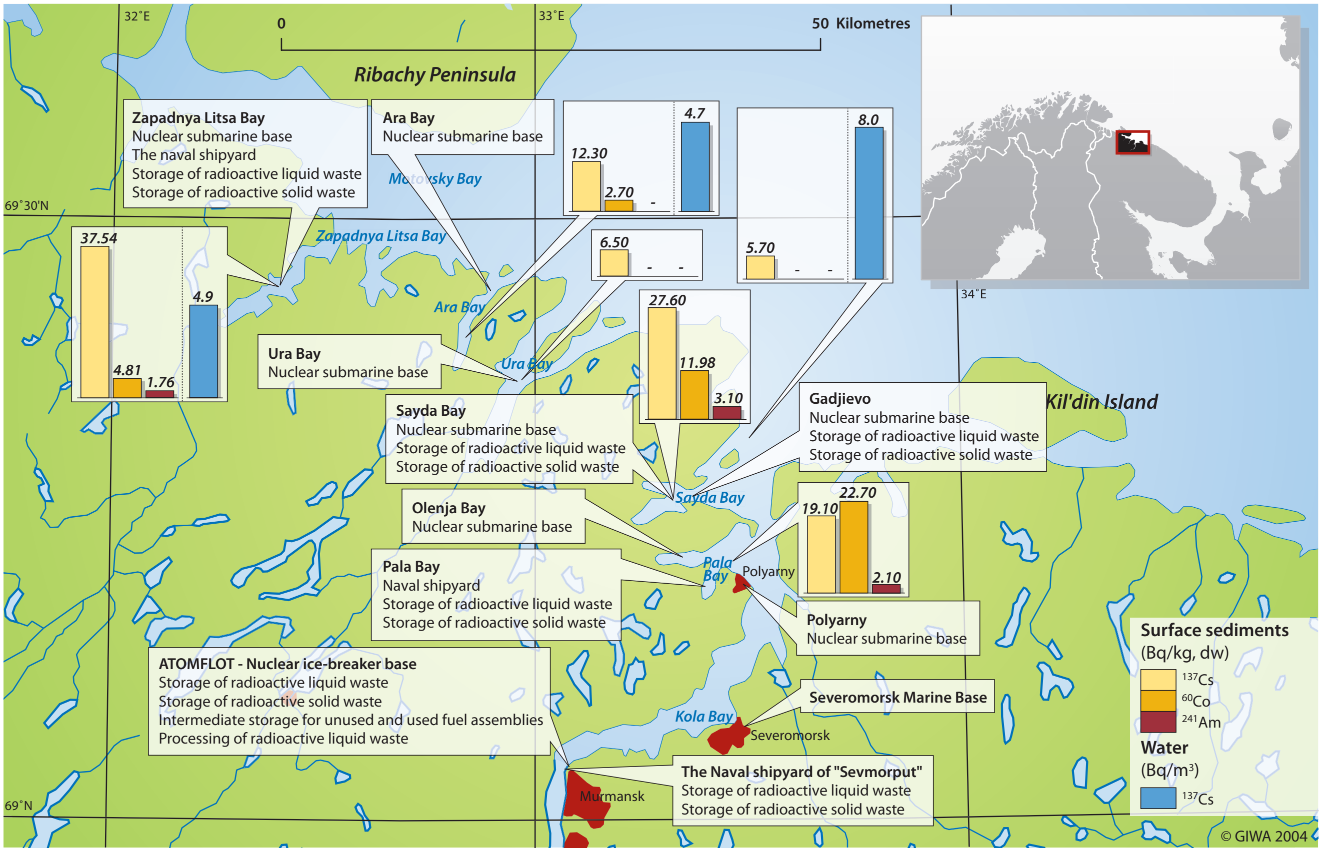


Figure 14 Location of the sources of radioactive contamination on the coast of Kola and Motovsky bays.
(Source: MMBI expedition data in May-June 1996)

Input from Western European reprocessing facilities via the Gulf Stream

Data shows that artificial radionuclide discharges into the marine environment from the enterprises located in Western Europe, such as Sellafield in the UK and La Hague in France, are transported northeastwards with warm Atlantic waters and reach the Barents, White and Kara seas. Sellafield has been a major source of artificial radionuclides into the Irish Sea during the past years and consequently into the entire basin of the Arctic Ocean (Joint Norwegian-Russian Expert Group 1992, Vakulovsky et al. 1993, Vakulovsky et al. 1985). However, for the Barents Sea the input from Sellafield is much lower.

Radioactive contamination of the Barents Sea

The most well known investigations of artificial radionuclides in seawater in the immediate vicinity of the Kola Bay were carried out in 1982 by the specialists working at the SPA Typhoon (Vakulovsky et al. 1985) and in 1992 within the framework of the Russian-Norwegian joint expedition (Joint Norwegian-Russian Expert Group 1992). The measured concentrations in seawater during these expeditions at the station located closest to the Kola Bay are presented in Table 27.

Table 27 Artificial radionuclide concentrations measured in the Kola Bay.

Nuclide	Depth					Average	
	0 m		100 m		280 m		
	1982	1992	1982	1992	1982	1982	1992
^{137}Cs (Bq/m^3)	33	5.1	28	4.4	22	27	4.8
^{90}Sr (Bq/m^3)	10	4.2	10	3.6	6	8.6	3.9
^{99}Tc (10^{-3} Bq/m^3)	ND	144	ND	ND	ND	ND	144
^{238}Pu (10^{-3} Bq/m^3)	ND	0.2	ND	ND	ND	ND	0.2
$^{239/240}$Pu (10^{-3} Bq/m^3)	ND	7.5	ND	11.5	ND	ND	9.5
^{241}Am (10^{-3} Bq/m^3)	ND	0.7	ND	0.2	ND	ND	0.45
^{134}Cs (Bq/m^3)	0.7	ND	0.6	ND	0.5	0.6	ND

Note: ND = No Data. (Source: Namyatov 1998)

The data presented show that between 1982 and 1992, artificial radionuclide inputs into the Barents Sea waters decreased almost 6-fold. This is explained first of all by the fact that the discharges of liquid radioactive waste at the enterprises in Sellafield and La Hague decreased (Commission of the European Community 1990). Besides the above nuclides, the seawater contains tritium. Unfortunately, there are very few publications devoted to tritium in the Barents Sea.

In the 1990s concentrations of artificial nuclides in seawater were relatively low. The levels of ^{137}Cs varied within the range 2-15 Bq/m^3, ^{90}Sr 1-7 Bq/m^3 and $^{239.240}Pu$ 4-8 Bq/m^3, which is consistent with the global radioactive background (Matishov & Matishov 2001). In general, ^{137}Cs levels in surface waters have decreased by more than 1 order of magnitude. A significant exception is the Chernaya Bay ecosystem in the south of the Novaya Zemlya. In the 1990s, ^{137}Cs concentrations in the waters of the bay were 14-190 Bq/m^3. Such contamination levels remain as a result of the atomic explosions in the area of the bay.

Artificial radionuclides in bottom sediments

The available data on radionuclides indicate low ^{137}Cs and ^{90}Sr levels in the bottom sediments of the central Barents Sea. Minimum (1.6 Bq/kg dry sediment) and maximum (8.4 Bq/kg) ^{137}Cs values represent a small range (Matishov & Matishov 2001). However, the near-shore ecosystem acts as an efficient marginal filter and accumulator of artificial radionuclides. ^{137}Cs, ^{90}Sr and $^{239.240}Pu$ levels in bottom sediments from bays and fjords are 1-2 orders higher than in shelf troughs. The closer to the nuclear testing areas of the Novaya Zemlya the higher are the levels of these radionuclides in bottom sediments (up to 30-45, 4-6, 5-15 Bq/kg respectively) (Matishov & Matishov 2001). The same tendency has been observed for the bottom fauna.

Radioactive contamination of biota

In a study conducted in 2001 the radioactive contamination of biota in the Barents Sea was investigated (Matishov & Matishov 2001). The macrophyte belt on the Barents Sea littoral and sub-littoral was shown to have a great accumulative function. Levels for ^{137}Cs, ^{90}Sr and $^{239.240}Pu$ in the Barents Sea algae varied between 0.5-9, 0.4-3 and 0.02-0.3 Bq/kg respectively. Local emissions from nuclear bases and dumping sites result in ^{60}Co and ^{137}Cs accumulation in macrophytes and sediments (1-20 Bq/kg and 40-260 Bq/kg respectively) (Matishov & Matishov 2001).

^{137}Cs, ^{90}Sr and $^{239.240}Pu$ concentrations in zoobenthos (0.1-3.0, 0.01-0.4 and 0.01-0.05 Bq/kg respectively (Matishov & Matishov 2001)) reflect the dynamics of global fallout. Radioactive uptake by benthic organisms is a function of the type and assortment of the diet. An example of this is the phenomenon of relatively high ^{137}Cs accumulation in silt-feeding worms. ^{137}Cs, ^{90}Sr and $^{239.240}Pu$ levels in the Barents Sea fish varied within the ranges 0.4-2.0, 0.3-1.0, 0.001-0.005 Bq/kg respectively (Matishov & Matishov 2001). The level of artificial radionuclides accumulation in fish is at present not high and remains within the established limits (State Committee for Sanitary and Epidemiological Control 1997).

The level of ^{137}Cs accumulation in species of Barents Sea birds can be placed in the following sequence: Goosander (0.2 Bq/kg); Black guillemot (0.43 Bq/kg); Little auk (0.4-1.1 Bq/kg); Black-headed gull (about 1 Bq/kg); Eider (0.1-3.3 Bq/kg); Kittiwake (0.5-3.3 Bq/kg); Glaucous gull (2.4-5.6 Bq/kg); and Great skua (3-4 Bq/kg) (Matishov & Matishov 2001). Such regularity is conditioned by both the composition of the birds' diet and the place of feeding. There is a tendency towards a decrease in the radioactivity levels in birds feeding on marine crustaceans and other representatives of zooplankton and benthos.

Spills

At present, spills of crude oil in the Barents Sea are scarce. Single small oil spills have been recorded in the Kola Bay, in the Pechora River and in the White Sea. In the period 1990-2000, discharge of petroleum products into the Kola Bay varied in the range 55-70 tonnes per year (Murmansk Region Directorate of Natural Resources and Environmental Protection 2001). In the vicinity of Kolguev Island, where oil is currently extracted, an oil film covering the entire southeastern part of the Barents Sea has been recorded (Ivanov 2002). The Barents Sea is covered with numerous navigation routes, including the Northern Sea Route. Thousands of large vessels, fishing boats, merchant vessels and tankers navigate the Barents Sea throughout the year. This increases the Barents Sea pollution by oil hydrocarbons. Pollution of the Barents Sea will increase further with the development of new oil deposits and increased oil transport by tankers. In winter two thirds of the Barents Sea water area is covered with drifting and packed ice. As ice accumulates pollutants, oil spills represent an increasing threat in the Barents Sea region. During spring ice melting, concentrated oil products and other toxicants enter the marine environment.

At present, the issue was assessed as having a slight impact but the impact will very likely increase in the future due to the rapid development of the Arctic shelf. Oil spills therefore represent a potential future threat for the environment and is one of the issue chosen for the Causal chain analysis.

Economic impacts

Pollution was considered to have moderate economic impacts in the region. Economic impacts relate to the lack of funding needed to reconstruct and modernise water treatment plants, to decrease the pollution of the Kola and Severnaya Dvina rivers and the Kola Bay. An issue of particular concern is radiological protection activities as this implies high levels of expenditure.

Health impacts

Within the Barents Sea region there are large metallurgy, pulp and paper, mining, and chemical enterprises, which are the main sources of contaminants, potentially affecting the health of people living in the neighbouring territories. An increased negative impact of air pollutants, especially of SO_2, on human health in the Russian Euro-Arctic region has been observed. The analysis based on evaluation of long-term exposure effects, shows a close association between mean monthly SO_2 rates and the corresponding mean monthly variations in mortality rate in the area of Nikel and Zapolyarny. Excess mortality is evident at mean monthly SO_2 concentrations exceeding 100 µg/m³. Males seem to have an increased mortality risk when SO_2 levels in the air exceed the mean monthly indices. However, increased mortality within the adult population can be a result of short-term episodic discharges with SO_2 concentrations varying from 10 to 50 µg/m³ (36 µg/m³ on the average) as well. Highest mortality can be observed during the next couple of days after an episodic discharge. The above-mentioned data are from accidental discharges and related mainly to atmospheric air contamination (Tchachtchine & Talykova 1997).

Overall, health impacts were assessed as having a slight impact as there are no statistical evidences of diseases directly caused by pollution of marine and freshwaters, but the risk of diseases related to sewage discharges still exists (dysentery, hepatitis).

Other social and community impacts

There is a lack of data on any other social and community impact. No evidences have been registered for loss of tourism and recreational values of water objects. The same applies to the loss of wildlife sanctuaries and protected areas (as a result of pollution), increased costs of animal protection, damage to equipment, loss of property values, costs of insurance, litigations, unforeseen changes and elimination of public anxiety. Other social and community impacts were therefore assessed as having no known impact.

Conclusions and future outlook

Overall, the impact of Pollution under present conditions was assessed as slight. The most relevant issues for the Barents Sea were identified as: oil spills, chemical and radioactive pollution. At present the Barents Sea ecosystem is in a quite satisfactory condition except for the area of the Kola Bay. However, due to the rapid development of oil and gas deposits on the Arctic shelf and the increased volume of oil and gas transport through the Barents Sea, the situation may change and oil spills are considered a future threat.

Radionuclides has little effect on the environment of the region at present but may increase dramatically in the future. To prevent this, regional authorities should be increasingly focused on radiological protection activities and be prepared for any eventualities to ensure the accident-free exploitation of nuclear reactors, storages of radioactive waste and spent nuclear fuel.

For these reasons the concern Pollution was assessed as having an overall moderate impact; and two issues (oil-spills and radionuclides) were chosen for the Causal chain analysis.

IMPACT Habitat and community modification

Clear changes in the species composition in some regions of the Barents Sea have been recorded, mainly changes caused by intentional introduction of new species. The most important species are Humpback salmon, Red king crab, and Snow crab. The expected changes in the future caused by intentional and unintentional introduction of alien species cause a great potential risk for the region.

Loss of ecosystems or ecotones

There are no records of serious loss of habitats in the region, but evidence of slight degradation of some habitats. The issue was therefore considered as having a slight impact in the region.

Modification of ecosystem or ecotones

Changes in faunal composition have been observed after the intentional introduction of new species, especially the Red king crab (*Paralithodes camtschatichus*). A shortage of food has been noted, both for the crab and for competing species, together with an increase in diseases and the spread of fish parasites through the crab as an interim host. The issue was considered as having a slight impact in the region at present.

Humpback salmon (*Oncorhynchus gorbuscha*)

Soviet scientists conducted the first experiments on the introduction of the Far East species Humpback salmon (*Oncorhynchus gorbuscha)* to rivers of the Kola region in the 1930s. As these experiments were unsuccessful, a bigger introduction programme started in 1956, which continued at least until 1978. Eggs at the eye stage were delivered by aeroplanes mainly from Sakhalin Island to fish farms in the Murmansk Region. For several years, these farms released 6-36 million specimens of outgrown juveniles but the return was very low. A mass return of fishes released from the fish farms in the White Sea Basin was registered during some years, but this phenomenon remained unexplained. Humpback salmon introduced along the Russian coast have been caught long distances from the area of release for example in rivers of Finnmark, the coasts of Scotland, West-Spitsbergen and Iceland. In the eastern direction, Humpback salmon has been registered in the Ob and Yenisey rivers and in the Kara Sea. According to scientists from the Polar Scientific Research Institute of Fisheries and Oceanography (PINRO), release of

Humpback salmon has not been conducted since 1989, and the regular catches of Humpback salmon in Norwegian rivers are an indication for successful establishment at Kola. However, there is no evidence of self-reproducing populations in Norwegian rivers yet.

Many investigations have been conducted on the biology of Humpback salmon but there is still a lack of data on the sea-life period of the species after acclimatisation. Investigations on competitive behaviour of Atlantic salmon and Humpback salmon have been conducted, but this literature is still not translated from Russian to English, and is therefore not available for scientists in other countries. The same applies to research on diet of juveniles and any other investigations on negative interactions between the two species, as well as for general monitoring data from Russian territories.

Snow crab (*Chionoecetes opilio*)

Until recently, the Snow crab (*Chinoecetes opilio*) inhabited the northern seas of the Pacific Ocean and the northwest Atlantic. In 1996, this species was recorded for the first time in the Barents Sea (Kuzmin et al. 1998, 1999). It is assumed that the Snow crab arrived to the Barents Sea through ballast water discharged by ships returning from the northwest Atlantic. Repeated catches of the crab over several years, including catches of females with external eggs, proved its establishment in the southern part of the Barents Sea (Kuzmin 2000, 2001).

Snow crab has been recorded in trawl catches from 100-324 m depth in the central Barents Sea, mainly from the Geese fishing area and further to the west to 30°E. An increase in the number of male individuals has been recorded from the Geese fishing ground towards west and south. In Finnmark, the first individual was observed in April 2003 and some months later a Norwegian research vessel observed the crab in northern Barents Sea.

It is likely that the Snow crab will be able to form a significant population in the Barents Sea in the future. However, the reproduction and other biological features seem to be significantly different from those of the Red king crab and competition between these two species is not expected.

Red king crab (*Paralithodes camtschaticus*)

The greatest intended large-scale change in the Barents Sea coastal ecosystem was the introduction of another Far East species, the Red king crab (*Paralithodes camtschatichus)* by Soviet scientists during the 1960s (Figure 15).

Figure 15 Red king crab.
(Photo: Corbis)

The crabs were transported by aeroplane to the Barents Sea. The majority were caught in the Peter the Great Bay, only one batch in 1965 (31 specimens) was from the Ozernovsky Fish Enterprise (West Kamchatka). The crabs were released into small inlets adjacent to the Kola Bay. During the period 1961-1969, 1.5 million larvae, 10 000 juveniles and more than 3 000 adult crabs were released into the Barents Sea (Orlov 1965, 1977).

The first specimen (a female with eggs) was caught in 1974 (Orlov 1978). From this time the number of crabs caught, both adult and juvenile individuals, increased steadily, indicating that a reproductive population had established in the Barents Sea. After a significant increase in abundance, an analysis of the possibilities of commercial exploitation of Red king crab was carried out. Results of investigations carried out in the Barents Sea show that the acclimatisation of the Red king crab follows the classic steps for the introduction of new species (intended or unintended introduction). From the 1970s to the mid-1990s the acclimatisation process underwent the two first stages: survival of the resettled specimens (phase one), and reproduction and growth of the population (phase two). In the second half of the 1990s, the population growth and the growth of commercial crab fisheries were exponential. Now, the population is in its third stage of the acclimatisation process; the abundance burst. In the fourth stage, an increased conflict between the introduced species and the surrounding biota can be expected. A decrease in individual fecundity might be evidence that the crab abundance in the Murmansk area already has reached its limit, and natural mechanisms restricting population growth have started acting.

In Finnmark, however, a reduction in fecundity has not been observed yet, and further growth of the population and expansion to the west is expected.

The introduction of the Red king crab, which is a large mobile predator and polyphage, influences the existing community. Through rapid population growth, food access was limited for the king crab as well as for other benthic organisms including fish fry. Furthermore the king crab is an intermediate host for a parasite on cod fry and an increased infection rate is expected in the coming years, including a potential decrease in cod abundance.

A number of investigations during recent years show changes in the benthic community structure along the Finnmark and Murmansk coast, including Kola and Motovsky bays. In Zelenetskaya Bay (Dal'niye Zelentsy settlement area), for example, a decrease in sea-urchin biomass by a factor of 5 compared to the period before the Red king crab introduction has been recorded. These might be natural changes in abundances, but similar changes in a number of areas might be evidence for the impact of the crab on benthic communities.

Distribution of the Red king crab along the warm Atlantic water masses and expansion into new warm water habitats have been observed. In the east it has likely already reached its distribution limits. In the north, it has been recorded by fishermen at the west coast of Spitsbergen (these records have not been proved by scientists yet) (Kirkeng-Andersen 2003). In the west, it will continue its expansion along the Norwegian coast. The central area of distribution is the coastal zone of the Kola Peninsula from Cape Teriberka to Varanger Bay.

The Red king crab has not changed its typical behavioural characteristics in the Barents Sea, despite the change in abiotic conditions. As in its original area, it migrates depending on age and season. Hatching, spawning and mating takes place during spring in shallow waters (10-30 m) and both sexes appear together. A female crab may spawn from 25 000-400 000 eggs, depending on body size. The larvae live in the pelagic for 1-2 months before they metamorphose in shallow waters. During their first years, they stay in shallow waters and move to deeper waters at a size of 50-70 mm carapace length.

The crabs have a social behaviour, and usually appear in aggregated groups of the same sex and size. Reproduction and availability of food are considered the most important factors governing the migration patterns of the crab throughout the year. The successful reproduction and high abundance of the crab in the Barents Sea show its ability to adjust to the environmental conditions of the region, such as polar day and night and the seasonal characteristics of biological processes typical for high latitudes.

As the algal genus that serves as a habitat in the Pacific (*Ahnfeltia*) does not have any significant abundance in the Barents Sea, the Red king crab have changed the habitat for the early larval stages, and uses the genera *Laminaria* and *Desmarestia* instead. Most of the year, the crab is found in soft bottom habitats. Investigations of its diet performed by Fiskeriforskning (now Norwegian Institute of Marine Research) show that it eats whatever is available of bottom living organisms. Small mussels, bristle worms (particularly *Pectinaria* spp.) and echinoderms are the main prey items, but also dead fish and algae are eaten by the crab. The latest analyses have documented that the crab also eats fish eggs. An ongoing research programme is now being carried out to investigate the intensity of foraging on capelin eggs and the potential effect on the capelin population. The adult crab has no natural predators, but bottom-dwelling fish, such as catfish, cod and several flatfishes, eat juvenile crabs.

New commensal relations are formed with species of the local fauna, as for example with the fish leech *Johanssonia arctica*. The leech is connected with the crab in the Pacific, but has not yet been recorded in the Barents Sea. However, it is expected that the Barents Sea species will migrate westwards together with the Red king crab and expand its previous range (Sundet 2003).

Economic impacts

In Russia, traditional salmon rivers have lost economic, recreational and aesthetic value because of the introduction of the Humpback salmon, which is less valuable than the Atlantic salmon with regard to sport- and commercial fisheries. There are increased costs for the state authorities caused by the number of intentionally introduced species that have to be managed, especially the Red king crab. Monitoring programmes, research and international agreements on management and quotas have to be funded.

The number of employees in the king crab processing industry has increased in Norway, but over the past years the number of people employed in the traditional fish processing industry has declined. It is too early to give any information on the development of the region with regard to the introduction of the Red king crab.

The development of the Russian Arctic shelf during recent years has lead to increased oil transport through the Barents Sea. This represents a serious threat of introduction of alien species with ballast water.

About 45 alien marine species are already established in Norwegian waters, the potential socio-economic damage of expected introductions can be estimated by calculating the damage caused by already introduced species. The examples are taken from southern Norwegian areas where the amount of ballast water discharge is the highest and where negative effects of alien species have already been recorded. The potentially most damaging alien species in Norway are toxic phytoplankton such as *Chattonella* causing loss to the aquaculture industry of approximately 25 million NOK in 2001 (Botnen & Jelmert 2002) and parasites and pathogens as furunculosis and *Gyrodactylus salaris*, which have caused at least 4 billion NOK of damage to farmed and wild Atlantic salmon in Norway over the past 15 years (Hopkins 2000). Phytoplankton, parasites and pathogens are generally small-sized, very difficult to detect, cause serious impacts and are hard to control. As the export volume (especially of petroleum products) from the Barents Sea increases dramatically, similar situations can be expected. Fisheries and aquaculture are two of the main industries in Norway and in 1999 they had an export volume of 8.7% of all exports from Norway (30 billion NOK). A substantial proportion of this originates from northern Norwegian waters, including coastal areas and the Barents Sea (Hopkins 2001). Alien species therefore pose a serious threat to the economy of northern Norway as well as for coastal communities in Russia. Due to the ecological and socio-economic value of the living marine resources in the Barents Sea and their sensitivity to the threats associated with human development, a potential risk from the introduction of alien species has to be taken very seriously. Otherwise the ecological and economic impacts can potentially be enormous (Barbier 2001).

Health impacts

Spreading of human pathogens or parasites by the Red king crab has not yet been recorded, with the exception of one *Anisakis* sp. observed in a stomach sample. Further sampling to confirm this is necessary. Thus, the indicator was assessed as having no known impact in the region at present.

Other social and community impacts

The populations of the coastal regions, both in Norway and Russia are increasingly focused on introduced species in general, and especially the Red king crab. The increased abundance of the Red king crab has a strong impact on the traditional fishery both along the coast of the Kola Peninsula and in northern Norway, especially because of the constant by-catches of Red king crab during the coastal spring and summer fishery (cod, lump sucker etc.). The autumn fishery, however, seems to have increased, which extends the season by several months, and potentially helps to establish new jobs in the regions. As with the Atlantic salmon, the Red king crab represents an important marine product, which can open up new international markets as well as attract tourists. The indicator was assessed as having a slight impact in the region.

Conclusions and future outlook

At present, Habitat and community modification was assessed as having a slight impact. The most important issue is modification of ecosystems, caused by the introduction into the Barents Sea of Humpback salmon, Snow crab and Red king crab. These species that have acclimatised in the Barents Sea have an impact on the ecosystem resulting in changes in the structure of benthic communities and reduction of food reserves for fish.

In Russia, the rate of increase in the Red king crab population has slowed down, and conflicts between the introduced and native species will most probably lead to a decrease in abundance of the Red king crab. The king crab might be subject to both intra-specific and inter-specific competition, and preliminary observations seem to prove it. The conflicts are caused by overpopulation of the habitats with maximum exploitation and a depletion of the food resources as a consequence, as well as by impacts from predators, parasites, and pathogens. The food shortage may lead to an increased mortality in the Red king crab population, as well as migration into other areas. The consequences can be an increased ecosystem disturbance in adjacent areas, as well as an improvement of the present situation by recovery of disturbed habitats.

Along the Norwegian coast, the situation is different as a rapid growth in abundance is still taking place. As mentioned above, the crab eats fish eggs, and may therefore have a potential effect on abundance and distribution of fish stocks, including the commercial species. It spends most of its lifetime on soft bottoms and it may have severe effects on these communities, both through physical disturbance of the habitat and through disturbance related to grazing on soft bottom fauna. These disturbances may lead to reduced biomass and benthic biodiversity, predominance of opportunistic species and reduced sediment stability. The crab may also compete with commercial and non-commercial species of fish and other crabs for food resources, which can delimit stocks significantly.

The spectrum of possible scenarios ranges from no effects to severe effects. Potentially the king crab has no serious long-term effects on the ecosystem of the Barents Sea, and a sustainable exploitation of the king crab is possible. This will improve the economic situation of the coastal areas both in Russia and in Norway. However, as the Red king crab eats fish eggs and is a host for a cod parasite its proliferation can lead to severe impacts on the wild fish stocks including reduction of the harvestable stocks, which will have consequences for the economy and the coastal population (Costanza et al. 1997). In addition, competition with fish fry and benthic fauna for food resources can lead to a stock reduction with consequences for the fisheries (Seterås 2001).

Another issue of concern is the rapid development of the Arctic shelf and increased oil transport through the Barents Sea increasing the risk of unintentional introduction of alien species into the Barents Sea with ballast water from tankers.

Thus, based on the data presented, the GIWA Task team came to the conclusion that the impacts of Habitat and community modification will increase in the future. Overall the concern was therefore assessed as increasing from slight impact at present to moderate impact in the future and the issue modification of habitats was chosen for Casual chain analysis.

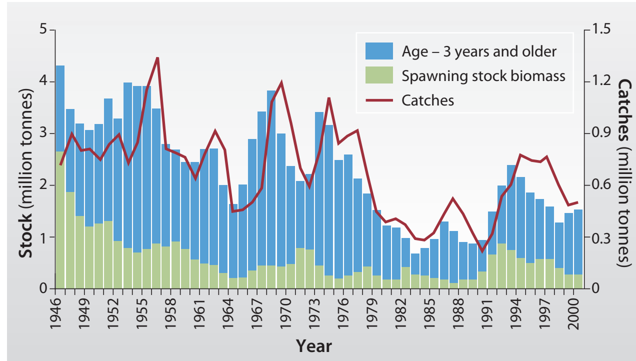


Figure 16 Total biomass of the Northeast Arctic cod 1946-1999.
(Source: Toresen 2000)

IMPACT Unsustainable exploitation of fish and other living resources

For Norway, the assessment of the concern is based on the fisheries within the geographical boundaries of the GIWA Barents Sea region. However, it should be noted that several comercially important fish stocks straddle beyond the boundaries of the Barents Sea and into the Norwegian Sea, and fishing operations for the Barents Sea fisheries are conducted as far south as 62° N in the Norwegian Sea. In addition, the assessment is focused (implicitly) on wild fisheries conducted outside the coastline of Finnmark (cod, haddock, capelin and saithe) while aquaculture has been left out as well as anadromous fisheries (salmon).

Decreased viability of stock through pollution and disease was assessed as irrelevant for the region. Increased reports of parasite infections within some fisheries were noted, but without severe impacts on the main stock.

Overexploitation of fish

Overexploitation of fish was assessed as severe since the major commercial fisheries (cod and haddock) in the Barents Sea are exploited beyond safe biological limits.

Figure 16 shows an obvious decrease in the cod stock and catches during the second half of the 20th century: the stock and catches become lower and the periods of stock crises more prolonged requiring more time for the stock to rebuild (Toresen 2000). The most serious decrease in the cod stock was in 1989-1990, which resulted from a number of factors: abiotic factors (cooling), overexploitation, and a dramatic reduction of food reserves caused by the collapse of the capelin stock (destruction of the trophic web of the ecosystem).

In the 1960s, the main fishing pressure in the cod fishery was on immature fish. In the 1970s, there was an increase of fishing effort (2 times higher than in the 1950s and 1.6 times higher compared to the 1960s). Catches of cod exceeded safe biological limits by a factor of 2 or even 3, which led to overexploitation. At the end of the 1970s to the early 1980s, the cod stock decreased to a minimum of 760 000 tonnes (in 1984), i.e. 30% of the average value for 1950-1980 (2.8 million tonnes) (Matishov 1986).

Since 1996, a steady decrease in the stocks of commercial and spawning cod has taken place. At the beginning of 2000, the commercial stock was 1.5 million tonnes, and the spawning stock 300 000 tonnes, which is significantly lower than average long-term values (2.5 million and 600 000 tonnes, respectively) (Borovkov et al. 2001). To a certain degree, the Total Allowable Catch (TAC) established at the annual meetings of the Joint Russian-Norwegian Fisheries Commission (Figure 17),

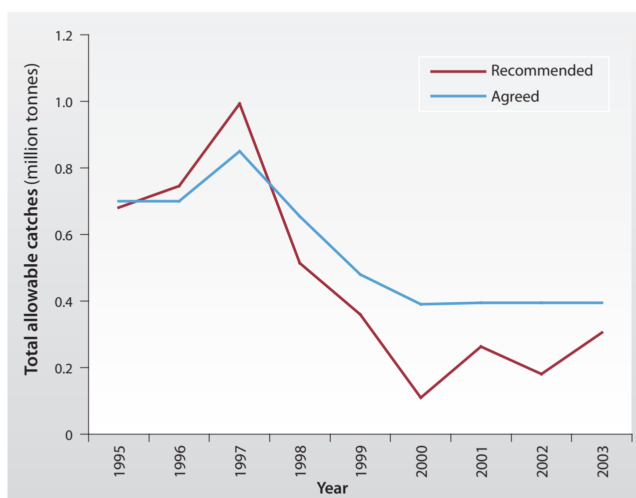


Figure 17 Scientific recommendations and TACs for the Northeast arctic cod 1995-2003.
(Source: Norwegian Institute of Marine Research 2003)

reflects the negative trend. In the period 1997-2002, TAC was reduced by 50%. The past three years, the TACs have been stable at the level of 453 000 tonnes set according to economical and political rather than scientific considerations (Mukhin & Solodovnikov 2002). This has particularly been the case for Northeast Arctic cod and haddock, which at present both are fished outside safe biological limits. According to the unofficial opinions of marine experts (especially in Norway), the TACs of the past years (beginning from 1999) have been set 50-100% too high (435 000 tonnes instead of scientifically justified 110 000-260 000 tonnes). An issue of great concern is the small size of the spawning stock, which has decreased during several years from 800 000 tonnes to 275 000-300 000 tonnes (Shevelev & Yaragina 1998). Based on the data presented it might be concluded that overexploitation exists in the Barents Sea.

In the mid-1980s, there was a serious cod crisis and a collapse in the capelin stock. Capelin, a major prey for cod, was subjected to intensive exploitation during 10 years (1975-1985), which resulted in the reduction of its commercial stock from 7 million tonnes to almost zero. After that, the capelin fishery was banned. Both anthropogenic factors and natural variations are believed to contribute to the dramatic changes in the capelin stock (Skjoldal 2000).

There have been disagreements within the Joint Norwegian-Russian Fisheries Commission regarding the appropriate annual TACs, in certain cases threatening the ability of the parties to reach agreement. The tension within the Commission seems to have increased in later years, as the stock-levels have decreased.

Another factor affecting the unsustainable exploitation of fish is unregistered catches or poaching that leads to overexploitation. This illegal fishery amounts to 20% of cod in the Barents Sea (Mukhin & Solodovnikov 2002). Scientists consider over-quota fishery especially dangerous since it simultaneously generates all types of overexploitation.

Excessive by-catch and discards

In the Barents Sea, by-catch is mainly a side result of the cod fishery. In 1996, by-catch of small-size cod was 15 000 tonnes (VNIERH 1997). In addition, 7-8% of unregistered by-catch is used on board the Russian vessels for the private consumption of the crew. In total, the non-accounted part of discard of the target object (cod) in the Barents Sea might constitute 10-15%, and has a tendency to increase. Based on Murmansk Marine Biological Institute (MMBI) investigations and unofficial assessments, discards of small-size fish reach 30%. In addition to cod, other fish species are also discarded.

The lack of reliable data on discards of under-sized fish leads to uncertainty in the evaluation of the stock size and fishery conditions (PINRO 2000). According to the regulations, all by-catches are to be landed but is generally believed that discards occur. However, there is uncertainty as to the extent of such practices, due to problems of monitoring and control. In view of this, slight impact was regarded as the most appropriate estimate.

Destructive fishing practices

In the Barents Sea, cod and other bottom fish species (catfish, perch, plaice, Greenland halibut, American plaice), which have relatively small stocks, are negatively impacted by the trawl fishery as it destroys the bottom biocenoses. It also results in by-catch of non-target resources, which are not registered in the fishery statistics. It is believed that trawling has had a slight impact on habitats.

Impact on biological and genetic diversity

Measurable impact on biological and genetic diversity was noted in regional hot spots where the introduction of Red king crabs has led to changes in the community structure. The issue was assessed as having a moderate impact. However, it is believed that the issue should be analysed in the framework of Habitat and community modification.

Economic impacts

Fisheries and related (public and private) economic activities, constitute the backbone of most coastal communities in eastern Finnmark and on the Russian coast of the Barents Sea. Overexploitation of fish and reduced catches, have severe economic consequences, in terms of employment, income, investment activity and population rate. There is re-allocation of resources in Russia and loss of food sources (e.g. sources of protein) for human or animal consumption.

As noted in the Regional definition, reduced cod catches by a factor of 2 over the past 10 years have had a negative impact on the economy of the Norwegian and Russian coasts of the Barents Sea. The globalisation of the market for fish products has also had a substantial impact on the economic situation of the fishing industry in the Barents region, resulting in even fewer catches being landed for processing and/or consumption in the region.

Health impacts

It is difficult to find evidence of any direct relation between the exploitation-level of the Barents Sea fish stocks and the health of the population. Therefore the indicator was assessed as having slight impacts in the region.

Other social and community impacts

Other social and community impacts were linked to unemployment, reduced fish consumption by the population, increase in poaching, conflicts for the access to bio-resources and corruption. The fishing industry is important for the social structure of coastal communities. Unemployment and reduced income due to crises in the fisheries, combined with a lack of alternative job opportunities, have led to unemployment and a decrease in the population both in Finnmark, and in Russia. The social impacts largely derive from the economic impacts noted above.

The number of fishermen in Finnmark was reduced in the period 1992-2002 from 1 903 persons to 1 291 (see Table 29). The number of fish processing enterprises was halved (from 88 to 41) in the period 1985-2002. This was also the case for the number of people employed at fish processing enterprises, which decreased from 3 383 to 1 656 persons (see Table 28).

Reduced fish catches have had a particularly severe impact on the living standard of the Russian population, where the problem of overexploitation was aggravated by the difficulties of the transition period. At the end of the 1980s in Northwest Russia 75 000 people were employed in the fisheries sector, among them 30 000 fishermen. By the end of the 1990s the number of employed in the fisheries sector was reduced by a factor of 2.5, and the number of fishermen by a factor of 1.4. In addition, for the past 10 years the employment of fishermen at fisheries operations was reduced from 6-12 months to 2-6 months per year. This means that the earnings of fishermen abruptly decreased and the unemployment increased by a factor of 2. In addition to the increased unemployment, fish consumption in the north of Russia was reduced by 50% in 2001 compared to 1990.

Table 28 Fishprocessing in Finnmark.

Year	Fish-processing companies	Employment
1985	88	3 383
1986	80	3 352
1987	75	3 219
1988	60	2 884
1989	54	2 437
1990	43	2 003
1991	42	1 921
1992	42	2 037
1993	40	2 281
1994	41	2 478
1995	38	2 388
1996	38	2 181
1997	41	2 180
1998	43	2 033
1999	41	1 723
2000	33	1 703
2001	40	1 656
2002	41	ND

Note: ND = No Data.

(Source: Norwegian Institute of fisheries and Aquaculture Ltd.)

The crisis in the fisheries sector of Russia particularly increased the socio-economic problems in coastal settlements and villages, for which fishery was the main activity. At the beginning of the 1990s the quotas and subsidies for the coastal fishery in the Barents and White Seas were dramatically reduced. Due to the increased competition for the resources there has been an increase in the number of illegal transactions, conflicts between groups of fishers and corruption. Other social and community impacts were therefore scored moderate.

Conclusions and future outlook

Overexploitation and discards in the Barents Sea will likely remain in the coming years. However the frequency and duration of the crises in the fisheries are commonly medium-term, allowing for stocks to rebuild.

In spite of the difficult economic situation, the Government of Russia is believed to take measures to stabilise the economy in the nearest five years, which will somewhat mitigate the severity of the situation in the fisheries sector. The regional dependency on the fishing industry in northern Russia and Norway will likely be reduced in the coming decades, partly due to developments in other marine sectors. This, most probably, will reduce the economic and social impacts of future crises in the fishing industry. However, such predictions are hampered by a high degree of uncertainty.

It is assumed that the situation will improve as environmental principles and standards pertaining to fisheries management, over time will be implemented for the Barents Sea fisheries through the Joint Norwegian-Russian Fishery Commission. This is to a large extent driven by the parties' commitments to international agreements pertaining to the conservation and management of the marine environment and living marine resources, as for example the Convention on Biodiversity, the UN Fish Stocks Agreement and the World Summit on Sustainable Development. Thus, a reduction in overexploitation is expected. However, the same score was given for environmental and economic impacts under future conditions as for present conditions.

Table 29 Registered fishermen in Finnmark 1992-2002.

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Finnmark	1 903	1 867	1 564	1 649	1 647	1 568	1 403	1 477	1 361	1 288	1 291
Total	19 779	19 072	16 442	17 160	17 087	16 661	15 141	15 328	14 270	13 700	13 913

(Source: Norwegian Directorate of Fisheries 2002)

Global change

The overall score no known impact was assigned to the concern. In the opinion of the GIWA Task team, there is at present no known negative impacts of the four environmental issues related to Global change on the Barents Sea drainage basin.

Priority concerns

In the course of several workshops, the priority of the concerns considered for region 11 Barents Sea were discussed according to the GIWA methodology. Table 30 presents the results of the assessment.

The GIWA concerns were prioritised as follows:

1. Unsustainable exploitation of fish and other living resources
2. Pollution
3. Habitat and community modification
4. Freshwater shortage
5. Global change

The most alarming problem for the region at present is the Unsustainable exploitation of fish and other living resources and in particular the issue overexploitation of fish. The analysis carried out for the region suggests that fish in the Barents Sea continue to be overfished despite measures of regulation and control. This problem is believed to remain in the coming years. However, it is expected that increased activities in other sectors in the Barents Sea (e.g. aquaculture and drilling for gas) may mitigate the socio-economic impacts of reduced fishing opportunities. However, the predictions are hampered by a certain degree of uncertainty.

The conditions of the Barents Sea ecosystem, judging from the major pollutants, is satisfactory at present. The levels of pollutants suggests that the Barents Sea is much cleaner than other European seas and does not constitute any threat to human health. However, two issues of the Pollution concern were chosen for further analysis since their impacts may increase significantly in the future: oil spills and radionuclides.

Table 30 Severity analysis of the concerns for the present and 2020.

Major concern	Present score	Future score (2020)
Freshwater shortage	1	1
Pollution	1	2
Habitat and community modification	1	2
Unsustainable exploitation of fish and other living resources	2	2
Global change	0	1

Note: Scoring criteria as in Table 16.

There are many concerns over the increased exploitation of and prospecting for oil and gas reserves in the Barents Sea, as well as increased volumes of oil and gas transport through the Barents Sea. That is why the issue of oil spills requires increased attention and has been chosen for further causal chain analysis.

At present, radioactive pollution has an insignificant impact on the Barents Sea ecosystems. However, the potential threat of radioactive pollution in the region is very high. That is the reason for considering radioactive pollution as a factor of priority for the Barents Sea region. The significance of this factor may increase dramatically in the future. To prevent this, regional authorities should be increasingly focused on radiological protection activities to ensure the accident-free exploitation of nuclear reactors, storages of radioactive waste and spent nuclear fuel and should therefore be prepared for any eventualities.

Another serious problem that may increase considerably in the future, is modification of ecosystems. Oil and gas transport through the Barents Sea has increased dramatically over recent years and is going to increase further. All this causes large volumes of ballast water to be discharged into the Barents Sea. The unintended introduction of alien marine species into the Barents Sea via ballast water can have severe effects on marine diversity and ecosystems.

Another issue of concern is the intentional introduction of alien species, mainly the Red king crab, which nowadays represents both a resource and a potential threat for fish stocks and local fauna. In Russia, the growth of the Red king crab population has slowed down, and conflicts between the crab and native speices will most probably lead to a decrease in abundance of the Red king crab. The king crab might be subject to both intra-specific and inter-specific competition. The conflicts may be caused by overpopulation of the habitats with depletion of the food resources as a consequence, as well as by impacts from predators, parasites, and pathogens.

The crab eats fish eggs, and may therefore have a potential effect on abundance and distribution of fish stocks, including the commercial species. It spends most of its lifetime on soft bottoms and it may have severe effects on these communities, both through physical disturbance of the habitat and through disturbance related to grazing on soft bottom fauna. These disturbances may lead to reduced biomass and benthic biodiversity, predominance of opportunistic species and reduced sediment stability. The crab may also compete with commercial and non-commercial species of fish and other crabs for food resources, which can delimit stocks significantly. For the above-mentioned reasons the issue modification of ecosystems has been chosen for Causal chain analysis.

Causal chain analysis

This section aims to identify the root causes of the environmental and socio-economic impacts resulting from those issues and concerns that were prioritised during the assessment, so that appropriate policy interventions can be developed and focused where they will yield the greatest benefits for the region. In order to achieve this aim, the analysis involves a step-by-step process that identifies the most important causal links between the environmental and socio-economic impacts, their immediate causes, the human activities and economic sectors responsible and, finally, the root causes that determine the behaviour of those sectors. The GIWA Causal chain analysis also recognises that, within each region, there is often enormous variation in capacity and great social, cultural, political and environmental diversity. In order to ensure that the final outcomes of the GIWA are viable options for future remediation, the Causal chain analyses of the GIWA adopt relatively simple and practical analytical models and focus on specific sites within the region. For further details on the methodology, please refer to the GIWA methodology chapter.

As a result of the Scaling and scoping analysis, the following issues were identified as issues of highest priority for the Barents Sea region:

- Overexploitation of fish;
- Modification of ecosystems;
- Radionuclide pollution;
- Potential oil spills.

All these issues are further assessed in this section.

Overexploitation of fish

Environmental and socio-economic impacts

The environmental impacts of overfishing manifest themselves in the reduction of commercial fish stocks during the past several decades. This is particularly the case for the cod, as the spawning stock has been reduced over the past few years by a factor of 3. Overexploitation of commercial species, especially of those with short life cycles (e.g. capelin), have caused changes in food web structure and decreased the stability of the Barents Sea ecosystem.

Overexploitation of fish and reduced catches have severe economical consequences in terms of employment, income, investment activity and population rate both in Northwest Russia and in Finnmark. At the beginning of the 1990s, the consumption of fish by the population in Russia was reduced by a factor of 2. Due to increased competition for the resources, there has been an increase in the number of illegal transactions, conflicts between groups of fishers and corruption.

Immediate causes

Overexploitation in the Barents Sea is, first of all, a result of fisheries pressure, which has increased during the past 20 to 25 years. The growth of fisheries pressure is characteristic both of Norwegian and Russian fisheries. Increased fishing effort has resulted in fish catches exceeding scientific recommendations by a factor of 2 or even 3, which has led to overfishing (Matishov 1986).

In the Barents Sea fisheries, there has been a clear tendency that the annual Total Allowable Catch (TAC) have been set beyond scientific recommendations in years when these have recommended low TACs. This has particularly been the case for Northeast Arctic cod and haddock, which at present both are fished outside safe biological limits (see Assessment, Unsustainable exploitation of fish and other living resources, Overexploitation and Figure 12).

At present, the total capacity of fishing vessels in the Russian fisheries exceeds TACs for cod, haddock and halibut by a factor of 3-4. Middle-sized vessels with an annual capacity of more than 2 000 tonnes operate in the cod fishery. For the past 10 years, quotas for these vessels have been 2-5 times lower than their nominal capacity.

Table 31 shows that for the period 1993-1998, the total Russian quota and the vessel-quota grew in the Barents Sea. The growth of the vessel-quota exceeded the growth of the total Russian quota because the number of vessels decreased during this period by a factor of 1.2. By the year 2002, compared to 1998, the total cod quota was reduced by a factor of 1.6, while the vessel-quota was reduced almost by a factor of 2 (from 977 to 511 tonnes per year). At the same time the number of fishing vessels increased by a factor of 1.2.

The comparison of the vessels' nominal capacity, quotas and time at sea, suggests that a large part of all catches are not registered when landed, which leads to overfishing. To reduce the negative effect of overfishing, the time at sea for vessels was limited in 2002 and a vessel-monitoring system was introduced. However, these measures, that already have been introduced in Iceland and other EU countries, are of low effect as they reduce but do not eliminate overfishing.

In Norway and Finnmark there has been a slight reduction in the total number of fishing vessels in the period 1992-2002 (Tables 33 and 34) while the total engine power for the same period increased by a factor of 1.2 and 1.3 (Table 32). In Finnmark, the number of small- and middle-sized vessels decreased while the number of large-size vessels (more than 40 m long) increased slightly (Table 34).

Root causes

In the course of the causal chain analysis, the root causes, which together have led to overexploitation of fish stocks, have been defined. These root causes can be divided into the following categories: Economic, Technological, Governance, Legal, Knowledge, and Political.

Economic

Economic root causes encompass negative effects of fishing subsidies, taxes, fish prices, payments for the access to fishing resources and prices of vessels' quota-rights, failures of economic reforms and market failures.

Fishing subsidies

Fishing subsidies are recognised by many as one of the major root causes of overcapacity and overinvestment in the world's fishing fleet. At the same time, fishing subsidies are the immediate cause for overfishing (FAO 1993, Iudicello et al. 1999, Porter 1997, Titova 2003). This is also the case for the Norwegian fishing industry. The Norwegian fishing industry has traditionally received substantial State support by way of subsidies, loans and direct investments. This has also been the

Table 31 Cod quota and the number of middle-sized vessels in the Russian cod fishery 1993-2002.

	1993	1995	1998	2000	2002
Number of middle-sized vessels	341	314	288	341	342
Total cod quota (tonnes)	225 900	252 000	281 300	155 500	174 700
Vessel-quota (tonnes)	663	802	977	456	511

(Source: State Statistics Committee 2002b)

Table 32 Norwegian fishing fleet's total engine power 1992-2002.

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Finnmark (HP)	157 095	160 247	154 349	164 508	164 713	162 342	171 403	184 765	189 327	191 523	210 364
Total (HP)	1 522 969	1 529 434	1 527 734	1 564 738	1 595 224	1 635 561	1 683 681	1 749 217	1 796 957	1 854 856	1 837 394

(Source: Norwegian Directorate of Fisheries 2002)

Table 33 Fishing vessels participating in the cod fishery, Norwegian coastal fleet 1990-2002.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Cod Gr I	3 468	2 330	3 617	3 627	3 579	3 400	3 202	2 978	2 858	2 683	2 607	2 502	2 583
Cod Gr II	4 001	5 264	4 428	4 357	3 944	3 720	3 347	2 937	3 100	3 420	3 552	3 573	3 342

Notes: Gr I = coastal vessels with full quota rights, Gr II = coastal vessels with limited quota rights. (Source: Norwegian Ministry of Fisheries 2002-2003)

Table 34 Fishing vessels by length in Finnmark 1990-2000.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0 to 39.9 m	1 861	1 981	1 934	1 964	1 776	1 669	1 670	1 667	1 677	1 642	1 660
More than 40 m	22	19	22	23	21	23	23	22	21	25	26

(Source: Norwegian Directorate of Fisheries 2001)

case for Finnmark, recognised as the most fisheries-dependent region of the country. A common criticism of previous and present State involvement in the fishing industry has been that it has contributed to maintain an overcapacity both in the fish-processing industry and in the fishing fleet. The end to direct price-subsidies in Norway (following the European Free Trade Agreement in 1990) has put the fleet in the Barents Sea under increased economic pressure.

The fishing fleet has not been subsidised in Russia. The major root cause in Russia is mistakes and difficulties in introducing market reforms.

Failures of economic reforms in Russia in implementation for the fisheries sector

The rapid transition from the centralised planned economy to the free market system in Russia did not allow market structures and an adequate system of auctions in the fisheries sector to be created. Due to imperfections in privatisation rules, most of the enterprises in Russia suffered quick disruption of economic links within the infrastructure of the fishing industry, first of all between fishery and fish-processing plants. Emerging stock companies and small enterprises have had much more difficulties in solving both financial and productive problems (FAO 1997).

Failures of privatisation were aggravated by the fact that foreign trade liberalisation had led to the sharp growth of interest rates and prices for fuel and materials. However in the difficult transitional period in Russia, the fishing industry did not receive sufficient State support (subsidies as in EU). New vessel owners lack the financial resources to be invested into the modernisation of the fleet and fishing equipment, resources needed to make them meet the requirements of sustainable fishing. Decrease in profitability of fishing has led to the growth of poaching and increases in unregistered landings to avoid taxation. Ship-owners obtain a small fish quota that clearly does not allow them to pay for the vessels' maintenance. However, the weak enforcement and control enable them to catch much more fish than the quota allows.

Payments for the access to bioresources, prices of the vessels, quota-right, taxes and fish prices

High taxes in the fisheries sector in Russia, and the non-conformity of the tax system to the specific character of the fishery, leads many fishers to overfish the quota to compensate for tax expenses. The introduced fishing auctions with prices for quota-rights have only increased overfishing (Titova 2001).

Following the introduction of access and quota regulation in the Norwegian fisheries in the Barents Sea, the second-hand price of vessels with limited quota-rights (coastal fleet) and licenses (trawlers), have risen dramatically. This has mainly been due to the price of the vessels' quota-rights. This implies that vessel-owners are dependent on a higher economic return from the fisheries to cover their investments. This is perceived by many as a root-cause for the increased fishing effort in the Norwegian Barents Sea fishery (Holm et al. 2002).

A difference in prices between small-size and large-size fish in Norway and on the international market causes discards of small-size cod and other by-catch species. The prices for cod 56-70 cm and 71-100 cm long at present are 2.0 and 2.7 times higher than for cod 35-45 cm long. The Russian fishery faced the problem of discards with the beginning of market reforms. Before 1990, under the conditions of State control over the purchase prices, all fish caught of any size, including by-catch, were kept and reprocessed independent of market price and the expenses of fishing. Thus, discards of by-catches and small-size fish was limited.

Market failures

One of the clear causes of overfishing is the continuously growing imbalance between the fishing effort and the potential biological production. According to Iudicello et al. (1999) and Voitolovsky et al. (2003) the balance can be achieved by a reduction in the available fishing capacity, that is, by decreasing the number of vessels. This process cannot be left to market forces alone, as the relevant fish stocks may be depleted before an equilibrium has been reached. It should be supported by a comprehensive approach combining decommissioning schemes and regulatory measures, which reduce the fishing effort on the stocks (Iudicello et al. 1999, Voitolovsky et al. 2003). Such regulations to reduce the overcapacity are being implemented for the Norwegian fishing fleet.

Technological

By-catch and discards in the Barents Sea are often side effects of the fishery for cod. According to expert estimates, the total excessive by-catch and discards amount to 30% of the total catch. The main causes of discards are: imperfections in the selectivity of the fishing gear, use of inappropriate or illegal fishing gear, and fishing in areas limited or banned for fishery. Trawling also has a negative impact on the fisheries (cod, catfish, perch, plaice, Black halibut, American plaice), by way of destruction of bottom habitats (Denisov 2002).

Governance

Causes related to Governance encompass imperfection of the system of fishery control, gaps in fishery statistics, non-compliance of fishers to regulations and imperfection of the system of fisheries management.

Fishery control

Overexploitation can be proved indirectly by the fact that vessel owners usually get a quota that is not enough to cover exploitation costs. The fact that fishing vessels continue operations for several years may indicate that: (i) fishermen catch more resources ("industrial" poaching) than the quota allows; and (ii) that the existing system of the fisheries control and management is unable to enforce regulations effectively. The Norwegian control of the Barents Sea fisheries is conducted on land and at sea by the Directorate of Fisheries, The Norwegian Coast Guard and the mandated sales organisations. Per date, the frequency of controls in the Norwegian Exclusive Economic Zone represents merely 0.5% of the 400 000 annual landings of fish. In general, the inspection frequency increases with the size of vessels. However, this seems to be well below sufficient. The low inspection frequency represents a substantial uncertainty regarding the compliance of fishers to established regulations, and as such, to the actual annual catches in the Barents Sea. Based on experiences, the Norwegian Directorate of Fisheries has estimated that non-compliance of Norwegian fishers represent 0-20% catch beyond the annual Norwegian TACs (Norwegian Directorate of Fisheries 2002). An estimate of Russian catches in the Barents Sea conducted in 1992 by Norwegian fishery authorities indicated overfishing of the Russian TAC by 25% (Hønneland 2000). There are no reasons to believe that these figures have been reduced.

Fishery statistics

Many catches in Russia are misreported (both not reported and misreported by area). An increase in a number of different ownership forms has had a negative effect on the collection of catch statistics (MegaPesca 1999, Iudicello et al. 1999, Titova 2003). According to Norwegian regulations, all catches of commercial stocks are to be reported when landed. This also includes the landing of Russian catches in the Norwegian zone. However, fisheries authorities assume that misreporting and discards are relatively common. This is to avoid being caught overfishing the vessels' individual quotas for specific fisheries (e.g. cod), and the infringements this leads to.

Compliance

One of the main challenges of fisheries management is ensuring the compliance of fishers to regulations. The sustainability of fish stocks may be seriously threatened through by-catch, unregistered landings, discards and catch of undersized fish. Secondly, non-compliance leads to a high degree of uncertainty in the catch- and stock data which provide a basis for the scientific models applied to estimate stock sizes, biomass, which in turn are the scientific bases for setting annual TACs (ICES 2003).

Legal

One of the main reasons for the unsustainable fishery in Russia is the absence of a Fishery Law, which would reflect the current market situation in Russia and contain the main principles of a sustainable fishery.

Knowledge

A high degree of scientific uncertainty and lack of catch- and stock data hamper scientific recommendations and predictions. The Barents Sea is characterised by clearly marked annual fluctuations of abiotic factors resulting in fluctuations of stock sizes. These fluctuations are generally not reflected in scientific predictions (Alekseev & Ponomarenko 1998, Objectives and uncertainties in fisheries management 1997). Changing natural conditions such as water temperature, cannibalism, predation, and anthropogenic factors such as by-catch, discards and unregistered landings, all impose uncertainty on the scientific recommendations. Therefore the scientific recommendations and predictions from ICES have varied greatly and been subject to severe uncertainties. Retrospective estimates of scientific predictions for the period 1984-1994 showed an overestimation of stock-levels by 25% (Nakken 1998). While researchers are aware of the uncertainties related to their scientific recommendations, politicians and the industry to a lesser degree take scientific uncertainty into consideration.

Political

The tendency that the annual TACs have been set beyond scientific recommendations in years when low TACs have been recommended, is a witness to that TACs in some cases have been set according to political and economical, rather than scientific and biological considerations. There have also been disagreements within the Joint Norwegian-Russian Fisheries Commission regarding the appropriate annual TACs, in certain cases threatening the ability of the parties to reach agreement. The issue of contention between Norway and Russia, to a large extent, refers to the size of the annual TAC. Though the negotiations are close to the public, there is a general understanding that Russia, in years with low scientific recommendations, wants to set higher TACs than Norway. However, the Norwegian delegation does not always follow the scientific advice of ICES either. The tension within the Commission seems to have increase over later years, as the stock-levels have decreased[1]. One of the disagreements is that in the Barents Sea fisheries, Norway and Russia apply different approaches as to mesh size of trawl nets (125 mm mesh size of the trawl nets in Russia and 135 mm in Norway).

Another issue of concern is that the negotiations of the Joint Norwegian-Russian Fisheries Commission are not open to the public. The national delegations are composed of officials from the relevant

[1] *The Norwegian Ministry of Fisheries annually publishes a white paper for the Parliament regarding Norwegian fisheries cooperation with other states (for 2000-2001 see: http://odin.dep.no./fid/norsk/publ/stmeld/008001-040006/index-dok000-b-n-a.html). There are also annual protocols of the meetings of the Joint Norwegian-Russian Fisheries Commission. Both are available at: http://odin.dep.no./fid/).*

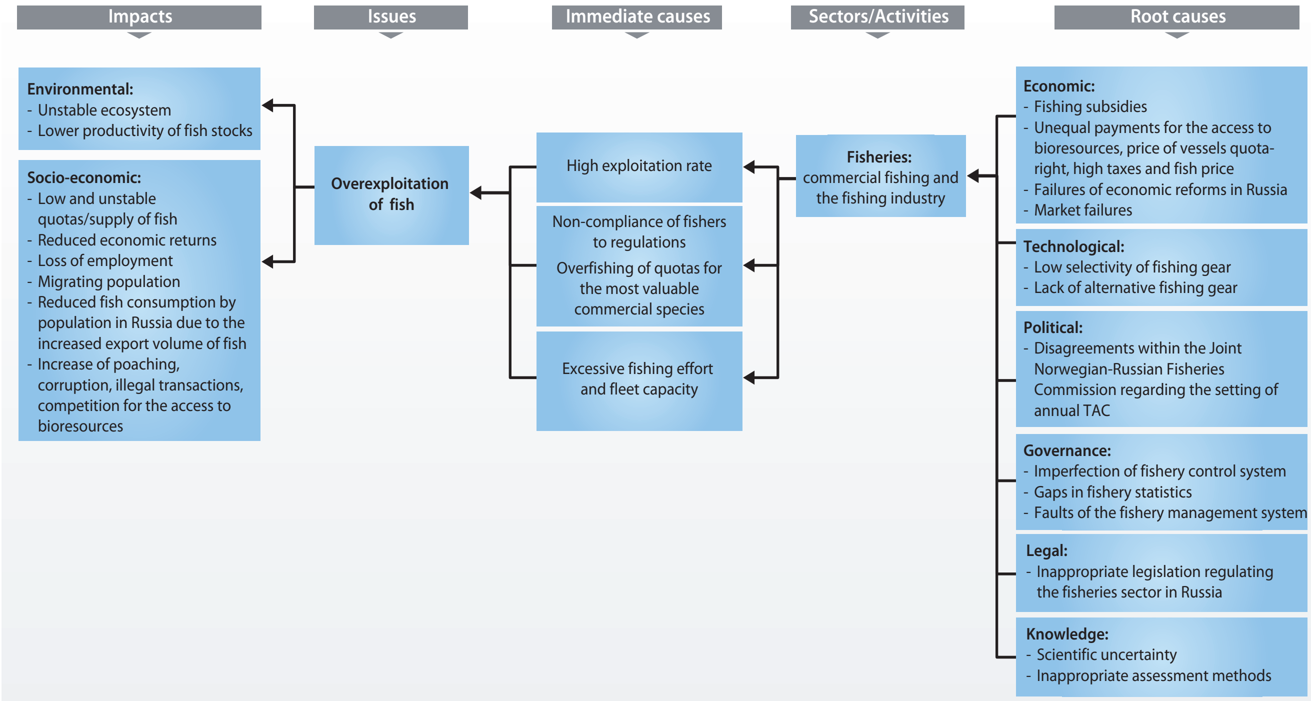


Figure 18 Causal chain diagram illustrating the causal links for overexploitation of fish.

national authorities, scientific experts and representatives from the most important industrial non-governmental organisations (NGOs)[2]. The lack of transparency has raised questions regarding the influence of the industrial NGOs on the setting of annual TACs. At present non-industrial NGOs have no influence on the conservation of biologic diversity of the sea, while the influence of NGOs on the conservation of biologic diversity of land animals has increased.

Conclusions

The following root causes have lead to the overexploitation of fish:

- Economic: fishing subsidies, unequal payments for the access to marine bioresources, price of vessels' quota-rights, taxes and fish prices, and economic reform failures and market failures;
- Technological: low selectivity and lack of alternative fishing gear;
- Governance: imperfections of the fishery control system, gaps in fishery statistics, non-compliance of fishers to regulations, and faults in the system of coordination of fisheries management;
- Legal: inappropriate legislation regulating the fisheries sector in Russia;
- Knowledge: inappropriate assessment methods;
- Political: disagreements withing the Joint Norweigan-Russian Fisheries Commission regarding the setting of annual TAC.

Numerous scientific assessments show that all above-mentioned causes act in one direction at present; in the direction of deterioration in the Barents Sea fisheries (Matishov & Rodin 1996, Kotenev 2000, Shevchenko et al. 2001, Denisov 2002). The Causal chain analysis shows that there are clear linkages between environmental and socio-economic impacts, immediate causes and root causes of overexploitation of fish in the Barents Sea. These linkages are presented in Figure 18.

Modification of ecosystems

Environmental impacts

The introduction of alien species into new ecosystems always has impacts on the latter. The intended introduction of the Red king crab (*Paralithodes camtschatica*) into the Barents Sea has lead to the spread of this species over a large territory and an increase of its population (Figure 19). This resulted in an increased conflict between the introduced species and the surrounding biota. Through the rapid population growth, food access was limited for the king crab as well as for other benthic organisms including fish fry. Furthermore, the king crab is a potential threat for cod abundance as it is an intermediate host for a parasite on cod fry.

Investigations of the Red king crab's diet performed by Fiskeriforskning (now Norwegian Institute of Marine Research) show that the crab eats

[2]The Norwegian Ministry of Fisheries has separate meetings with environmental NGOs and the three northern counties (Nordland, Troms and Finnmark), prior to the meetings of the Joint Norwegian Russian Fisheries Commission.

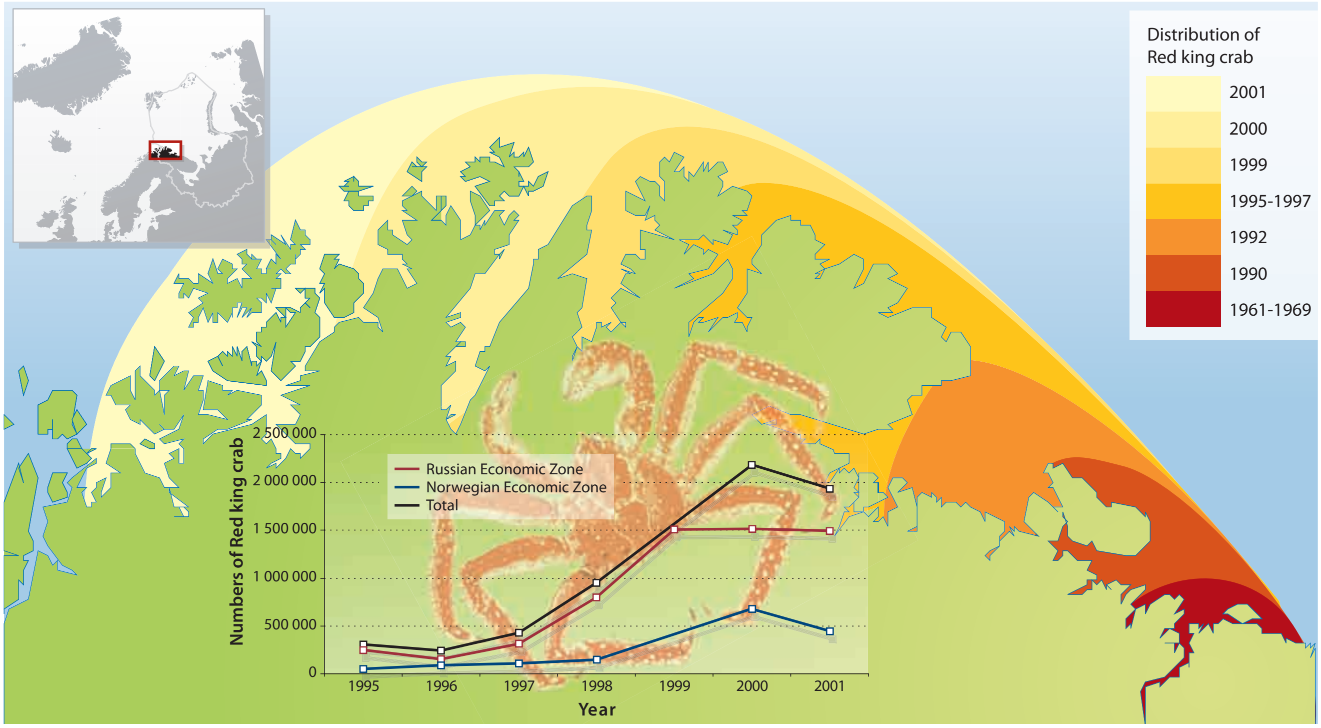


Figure 19 Red king crab in the Barents Sea.
(Source: Matishov & Denisov 2000)

whatever is available of bottom living organisms. Small mussels, bristle worms (particularly *Pectinaria* spp.) and echinoderms are the main prey items, but the crab eats also dead fish and algae. The latest analyses have documented that the crab also eats fish eggs. A research programme is now carried out to investigate the intensity of foraging on capelin eggs and the potential effect on the capelin population. The adult crab has no predators, but bottom-dwelling fish, such as catfish, cod and several flatfishes eat juvenile crabs.

In other areas, the Red king crab has formed new commensal relations with species of the local fauna, for example with the fish leech *Johanssonia arctica*, inhabiting the Pacific. The leech has not been recorded in the Barents Sea yet but it is expected that some Barents Sea species will migrate westwards together with the king crab and expand their previous range.

The impact of another introduced species, the Humpback salmon (*Oncorhynchus gorbuscha*), on the ecosystems of the Barents Sea is poorly investigated. There is still a lack of data on negative interactions between Humpback salmon and Atlantic salmon, a native species for the Barents Sea.

As for the Snow crab (*Chionoecetes opilio*), it is likely that this species will be able to form a significant population in the Barents Sea in the future. However, the reproduction and other biological features seem to be significantly different from those of the Red king crab and competition between these two species is not expected.

Socio-economic impacts

There are increased costs for the state authorities caused by the number of intentionally introduced species that have to be managed, especially the Red king crab. Monitoring programmes, research and international agreements on management and quotas have to be funded. The crab represents both a resource and a potential threat for fisheries. The threat arises through the crab's direct or indirect effects on the stock of other commercial species, and through demolition of fishing equipment.

By-catch of king crab in gill-nets and longline fishery has been a major economic problem in Finnmark and Russia and fishermen and scientists put great efforts into solving this problem. Fishing equipment has been modified and developed and modifications of the traditional equipments are now used commonly. Even though it is more time-consuming to use the new equipment, the fishermen are expected to benefit from it. In 2001, the by-catches of Red king crab were reduced compared to earlier years. It is forbidden to keep by-catches of the crab, but most of the crabs die from the injuries in such catches. By-catches have therefore represented an important contributor to the mortality rate in the king crab population.

Norwegian and Russian authorities cooperate through the Joint Russian-Norwegian Fisheries Commission (established in 1977) in the management of the joint fisheries resources of the Barents Sea, including management of the Red king crab as a resource for fisheries. This commission decides the size of the catch quotas for the two countries and has agreed to catch 20% of the legal-sized stock.

In 1992, the Joint Russian-Norwegian Fisheries Commission decided to start joint investigations of the Red king crab in the Barents Sea and, for both countries, the expenses for the joint work increased. In 1994 Norwegian research fishing of the Red king crab started. The aim was to obtain information on the crab's biology and population. The commercial fishing started in 2002. Fishing takes place from the middle of October to the end of December, and it is only allowed to sell male crabs over a defined size. The fishermen who are most affected by by-catch of Red king crab, mainly in eastern Finnmark, have first priority for commercial fishing quotas. In 2002 the total Norwegian quota was 100 000 crabs and for 2003 the quota has been doubled to 200 000 crabs. With the commercial exploitation of the Red king crab resources, a highly valuable species on the world market, a new fishing industry has been established in Russia and Norway. The number of employees in the king crab processing industry has increased in Norway, but in recent years, the number of people employed in the traditional fish processing industry declined. It is too early to give any information on the development of the region with regard to the introduction of the Red king crab.

Impacts on human health can be caused by transfer of pathogens via ballast water, but are under the prevailing climatic conditions not very likely. The populations of the coastal regions, both in Norway and Russia, are increasingly focused on introduced species in general, and especially the Red king crab. The increased abundance of the Red king crab has a strong impact on the traditional fishery both along the coast of the Kola Peninsula and in northern Norway, especially because of the constant by-catches of Red king crab during the coastal spring and summer fishery (cod, lump-sucker etc.).

Autumn fishery, however, seems to be increasing, which extends the season by several months, and potentially helps to establish new jobs in the regions. As with the Atlantic salmon, the Red king crab represents an important sea product, which can open for new international markets as well as attract tourists. These impacts depend on the type of species introduced in the future and cannot be assessed today. But definitely, further research, monitoring and management of Red king crab and Humpback salmon will require financial support from the public.

Immediate causes

The immediate causes of modification of ecosystems are the intentional or unintentional introductions of non-indigenous species and further growth of their population (abundance burst). Non-indigenous species (invasive, alien species etc.) are species, which have extended their habitat over their natural geographical range (Carlton & Geller 1993, Sandlund et al. 1996, Weidema 2000). They are considered as a major threat for ecosystems worldwide (ICES 1995, 2000) and several international agreements and instruments deal with this threat (e.g. IMO 1997).

Alien species can have severe effects on marine diversity and ecosystems no matter if they are introduced intentionally or unintentionally (Gollasch & Leppäkoski 1999, Weidema 2000, Leppäkoski et al. 2003). Two species have been introduced intentionally into the Barents Sea; the Humpback salmon and the Red king crab. An increasing threat to the ecosystem of the Barents Sea is the unintentional introduction of alien species.

Of all vectors for alien marine species, shipping is considered as one of the most important (Gollasch & Leppäkoski, 1999). Unintended introductions and transfers caused by shipping mainly occur by transport and discharge of ballast water and to a lesser degree by transport of fouling organisms on hulls. An additional risk, that follows the introduction of an alien species, is the transfer of species associated with the original alien species. Examples of such associated species are spores of macrophytes or phytoplankton found on or in benthic organisms as well as parasites and pathogens. Once an alien species is introduced into an area, natural transfer processes cause further spreading (ocean and coastal currents).

Russia has increased the export volume of oil dramatically during the past years and is going to increase these activites further. Great volumes of ballast water are already discharged into the Barents Sea and these volumes will increase. Within the year 2010 the yearly export of oil from Russia shipped through the Barents Sea will be 150 million tonnes and the amount of discharged ballast water calculated conservatively will be at least 50 million tonnes per year. Introductions of additional alien species (as already has happened with the Snow crab) are likely and can have severe consequences for the Barents Sea ecosystem in the future, including a potential collapse of fishery resources.

Root causes

An issue of concern is the lack of knowledge and investigations of alien species' biology and lack of funding to prevent negative effects of the introduction of alien species. The former Soviet Union carried out large-

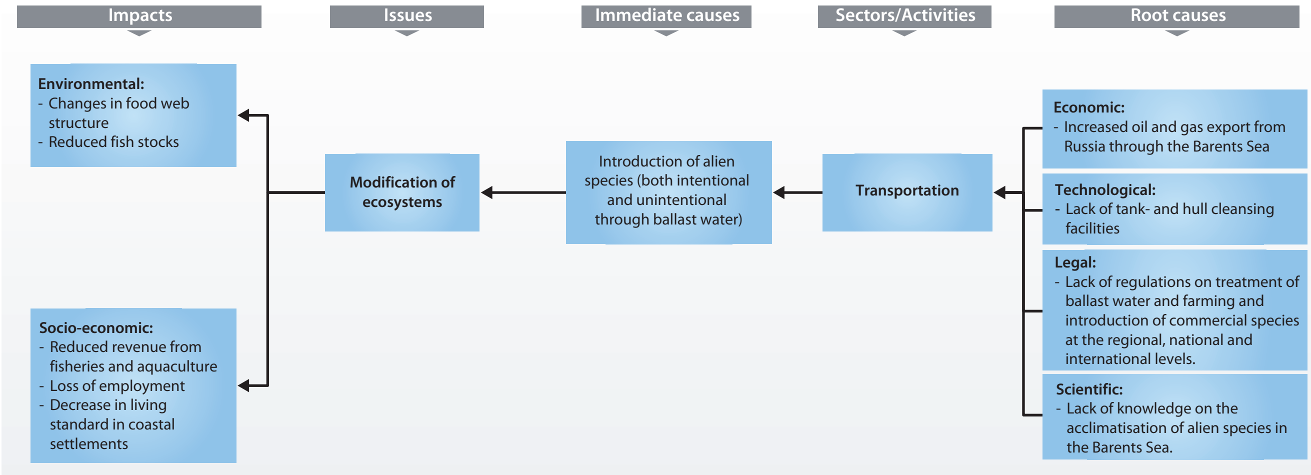


Figure 20 Causal chain diagram illustrating the causal links for modification of ecosytems.

scale activities aimed at deliberate introducing and acclimatising new commercial species in its national waters. The activities were regulated by state institutions and were strongly supported and approved by the State. The result of these activities is the two Pacific species, the Humpback salmon and the Red king crab, introduced intentionally into the Barents Sea with all the consequences that this implies.

Another root cause applies to unintentional introduction of alien species. The tactics of refuelling fishing vessels operating outside the Barents Sea from its home tankers, was generally applied in the former Soviet Union. This caused large volumes of fuel shipped through the Barents Sea all the year round and the corresponding volumes of ballast water discharged into the Barents Sea.

Nowadays Russia is implementing a long-term energy programme aimed at intensive development of the Arctic shelf and exploiting its oil and gas reserves. The major focus here is on the increased export of oil and gas. Russia places great hopes on oil and gas export, as it will provide for the social and economic development of its Northwest region, as well as of the country as a whole. All this implies increased tanker navigation through the Barents Sea.

However, Russia is somewhat unprepared for its long-term energy requirements since it still lacks appropriate regulations and a well-balanced programme for the development of the Arctic. This hampers the Russian oil companies from investing into re-equipping the tanker fleet, as well as into ecological programmes, including those aimed at decreasing the introduction of alien species with ballast water from tankers. It is not very likely that any of the ships calling at Russian ports have treatment systems on board and there are still no international regulations on treatment of ballast water.

Conclusions

The analysis allows concluding that the immediate causes of the modification of ecosystems in the Barents Sea are the alien species introduced intentionally and unintentionally. The latter are related to the increased shipping and discharge of ballast water. The root causes underlying these processes are the following:

- Economic: increased oil and gas export from Russia through the Barents Sea.
- Technological: lack of tank- and hull cleansing facilities.
- Legal: lack of regulations on treatment of ballast water and farming and introduction of commercial species at the regional, national and international levels.
- Scientific: lack of knowledge on the acclimatisation of alien species in the Barents Sea. A large-scale biological experiment was initiated and conducted without scientific assessment of its consequences for the ecosystem as a whole.

The linkages between the root and immediate causes and their environmental and socio-economic consequences are presented in the casual chain diagram (Figure 20).

Radionuclides

Environmental impact

A stable tendency towards decrease in atmospheric fallout of artificial radionuclides has been observed during the last decades. Within the years 1981-1993, the input of tritium into the Kola Bay via river run-off decreased by 1.5. The input of ^{137}Cs in 1965-1989 decreased 11-fold while the input of ^{90}Sr in the period 1961-1989 only decreased by a factor of 1.2.

A major source for the Kola Bay pollution by ^{137}Cs and ^{90}Sr is discharges from the treatment of liquid radioactive waste at ATOMFLOT in Murmansk. The annual discharge of these nuclides was greatest during 1992; 2.1×10^8 and 2.6×10^7 Bq/year, respectively. From 1989 to 1994 the average annual values were 1.6×10^7 and 7.6×10^7 Bq/year respectively. In the 1990s ^{137}Cs levels in the Barents Sea surface waters varied within the ranges 2-15 Bq/m^3, ^{90}Sr 1-7 Bq/m^3, $^{239.240}Pu$ 4-8 Bq/m^3, which corresponds to the global radioactive background.

^{137}Cs and $^{239.240}Pu$ concentrations in the Barents Sea bottom sediments clearly correlate with the type of deposits and correspondingly increase up to a maximum in clay silts of the shelf troughs. In the 1980-1990s the accumulative levels of radionuclides in the Barents Sea biota reflected global fallout and was low.

Immediate causes

At present, there are about 100 decommissioned nuclear powered submarines on the naval bases of the Russian Northern Navy, some with nuclear fuel on board. The fuel is kept on board the submarines due to the shortage of coastal depositories. Economic and technical problems also hamper the transport of spent nuclear fuel for processing at the Mayak plant in Chelyabinsk Region. Decommissioned submarines are based in naval stations of the Kola Peninsula and in Severodvinsk, and the Arkhangelsk Region, with practically no maintenance and upkeep. In addition to decommissioned submarines, there are coastal depositories for spent nuclear fuel (SNF) and radioactive waste located in naval bases. The largest storage for SNF from submarine reactors is located in the Andreyeva Guba (inlet), Zapadnaya Litsa Bay (Figure 14). SNF from about 90 reactors is stored there at present. The storage, which was constructed in the 1980s, needs urgent upkeep. Another large storage of radioactive waste is located in the naval base in Gremikha, on the east of Kola Peninsula.

Enterprises of the nuclear industry emit and discharge radioactive substances in low volumes in the course of their technological process. However, in certain years there have been a number of large leaks and accidents accompanied by uncontrolled emissions of radioactive substances into the water and the atmosphere. The accident in the storage of radioactive waste located in the Andreyeva Bay, which happened in 1982, resulted in a leak of radionuclides into the water area with a total activity of 37×10^{12} Bq. An accident on a submarine in the Ara Bay, which happened in 1989, leaked radionuclides into the water area with a total activity of 74×10^{12} Bq. Since 1989, the treatment plant for liquid radioactive waste at ATOMFLOT is an acting source of radioactive pollution (Matishov & Matishov 2001).

Wrecks of nuclear powered submarines and surface vessels are a serious threat to the environment. At least three nuclear powered submarines have sunk in the Barents Sea since 1989: Komsomolets (1989), Kursk (2000), and K-159 (2003). At present, two of them are still lying on the sea bottom with their reactors on board. Another threat is posed by the numerous small accidents continuously happening when exploiting nuclear reactors and nuclear weapons.

Root causes

In the 1950s, a unique combination of geopolitical factors resulted in the creation of a nuclear powered surface and submarine fleet on the Kola Peninsula. This is perceived by many as a root cause for the increased potential threat of radioactive contamination. The creation of the nuclear powered fleet required in turn the creation of an infrastructure for nuclear fuel supplies and reprocessing of radioactive waste. Active operation of the nuclear powered fleet resulted in a large amount of radioactive waste and caused problems in storage and burial.

Nowadays no other place on the earth has such a concentration of nuclear energy as the Kola Peninsula. There are four reactors of the Kola Nuclear Power Plant, 13 reactors of the Civil Atomic Fleet, and more than 200 reactors of the Northern Navy. There are four plants maintaining nuclear reactors of the Civil Atomic Fleet and the Northern Navy. In addition to this, there are two ore-processing plants, in Lovozero and Kovdor, extracting and processing natural radioactive raw material. From 1972 until 1984, three subterranean explosions of low power were made for research purposes in the vicinity of the town of Kirovsk.

Near the town of Murmansk, there is a depository for radioactive waste from the Radon plant, which within the period 1964-1994 received solid radioactive waste from enterprises located in the Murmansk and Arkhangelsk regions. Radioactive waste has not been buried there since 1995. However, this storage is a potential threat to the environment, since it needs reconstructing (State Environmental Committee of the Murmansk Region 1999). Nowadays, the level of radiological protection on the Kola Peninsula, in general, meets the requirements of regulations and recommendations of international organisations.

Conclusion

The economic crisis in Russia in the 1990s generated a number of serious problems. In particularly, it significantly reduced the possibilities of the state funding for the activities related to reduction in the number of nuclear weapons, decommissioning nuclear powered submarines, reprocessing of large amounts of radioactive waste and maintenance of nuclear power plants.

Oil spills

Environmental impacts

No severe effects of oil spills have been registered in the Barents Sea. However, as a potential threat to the ecosystem of the Barents Sea oil spills should be taken into account in the light of the rapid development of activities on the Russian Arctic shelf and the dramatically increased oil and gas exploitation and transport in the Barents Sea. Table 35 presents likely effects oil spills in the Barents Sea ecosystem. The coastal zone of the Kola Peninsula (the Barents and White Seas) is notable for high levels of biodiversity, including rare and especially protected birds and mammals.

Socio-economic impacts

According to the strategy for the development of the Murmansk Region until year 2015, the restoration of coastal settlements of the Kola Peninsula is dependent on the development of coastal fishery and aquaculture (western Murman). In the 12-nautical mile zone about 40% of cod and 32% of haddock, most of the Red king crab and other valuable bioresources are concentrated. The aquaculture production of salmon by 2015 is planned to be 15 000 tonnes per year. Deterioration of the environment in the coastal zone because of oil spills will upset the planned socio-economic programme and cause unemployment in coastal settlements. The Barents and White Seas coasts of the Kola Peninsula are of important cultural and historical value, and constitute perspective resources for tourism and recreation. With the development of the region, all this will attract numerous tourists. Oil spills will likely decrease the economic, recreational and aesthetic value of most prominent sites for tourism.

Immediate causes

Increased oil transport through the Barents Sea

At present, the shipping of crude oil and oil products is carried out along the coast of the Murmansk Region from the ports of Vitino, Arkhangelsk, and Murmansk for further export to European countries and the United States. Some petroleum products from ports in the White Sea and oil deposits located in the east of the Barents Sea are transported to the Murmansk area where they are reloaded onto large-tonnage tankers to be further exported to the west.

This technology is expected to be further developed in the very near future and the export volume is expected to increase up to 9 million tonnes. For these purposes, three reloading complexes are planned in the Kola Bay (in the area of Kulonga, Belokamenka, and Mishukovo).

Table 35 Possible effects of oil spills on marine organisms and communities in pelagic (1) and littoral (2) zones.

Group of organisms	Situation and parameters of impacts	Possible impacts
Phytoplankton	1	Changes in photosynthesis, species composition, and other impacts, which disappear after the dissipation of the oil spill (within hours or days).
Zooplankton	1	Physiological and biochemical anomalies, local decrease in numbers, and other impacts, which disappear within several days after the dissipation of the oil spill.
Zoobenthos (pelagic zone)	1	Negative changes are unlikely due to the absence of oil contamination in bottom sediments.
Zoobenthos (littoral zone)	2	Possible sub-lethal reactions, decrease in numbers, and local destruction of species composition of benthic communities with the period of rebuilding up to 1 year and more.
Ichthyofauna (pelagic zone)	1	Behavioral reactions in the form of avoidance of contaminated areas by fish; ichthyoplankton lesion; population changes are indistinguishable on the background of natural fluctuations.
Ichthyofauna (littoral zone)	2	Decrease of food for fish; possible changes in fish migration and population changes of local character.
Mammals	1, 2	Reaction of avoidance of contaminated areas by mammals, destruction of habitats, physiological stresses, injuries. For animals with hair cover, direct contact with oil can lead to lethal outcome.
Birds	1, 2	Stresses and death from the contact with oil, deterioration of habitat and reproduction conditions in the contaminated areas, reversible population changes of local character.

Notes: 1 = Temporary (up to several days) contamination by oil of the surface water layer with the concentration of oil hydrocarbons up to 1 mg/l at depth of 1 m.
2 = Temporary (up to several months and more) contamination of the coastal zone with concentration of oil hydrocarbons in the water in the range 0.1-1 mg/l and their accumulation in bottom sediments up to a level of 10^2 mg/kg.
(Source: Patin 2001)

The annual volume of petroleum products transported from the port of Vitino in 2002 was 2.8 million tonnes. In winter the oil was shipped by tankers of 20 000 tonnes deadweight, while in summer tankers of 40 000 tonnes were used. From the port of Arkhangelsk 2 million tonnes of oil were shipped in 2002 by tankers of 20 000 tonnes. From the Varandey terminal 240 000 tonnes of oil were transported in 2002; from Kolguev Island 120 000 tonnes; and 100 000 tonnes of gas condensate from the basin of the rivers Ob and Lena. Some of the oil transported from these points was reloaded on tankers of 100 000-150 000 tonnes in the Murmansk area. In 2002, 700 000 tonnes of oil were transported to the Murmansk area from the Barents Sea to be further reloaded and transported to European ports. In addition to this, 600 000 tonnes of petroleum products were transported by railway to the Murmansk fishing port, and then reloaded on tankers for further export. Thus, in total 5.86 million tonnes of oil were shipped for export along the coast of Kola Peninsula in 2002 (Murmansk Region Administration 2003).

In addition to the oil transport for export, the shipping of fuel oil for icebreakers and other types of vessels is carried out along the Murman coast in the period from May until October. The volume of fuel oil shipped through the Barents Sea constitutes 5 000 tonnes. The transport of petroleum products to the ports of the Novaya Zemlya

Island and Vil'nitskiy Island and to the ports on the Pechora Sea and the Yenisey Bay, constitutes about 10 000 tonnes.

The volumes of oil transport planned for 2005, 2010 and 2015 along the coast of the Murmansk Region are shown in Table 36. The total transport in 2005 is planned to be 8.5 million tonnes. In 2010, 6.5 million tonnes of oil is planned to be transported from the port of Varandey if ice-class tankers with a deadweight of 70 000 tonnes are constructed by that time. If not, the volume of oil transport from the port of Varandey will be 3 million tonnes. In total 19.6 million tonnes of oil are planned to be transported along the coast of the Kola Peninsula in 2010.

Table 36 Planned oil transport along the coast of the Murmansk Region.

Port/oil terminal	Planned oil transport (million tonnes)		
	2005	2010	2015
Varandey terminal	3	6.5[1]	12[1]
Kolguev Island and Ob-Yenisey basin	0.4	0.9	1.5
Port of Vitinio	3	3.4	4
Port of Arkhangelsk	2.1	2.3	2.5
Prirazlomnoe deposit	-	6.5	8
Port of Belomorsk	-	-	0.5[2]
Total	8.5	19.6	28.5

Notes: [1]Only if ice-class tankers with a deadweight of 70 000 tonnes are constructed by that time, otherwise the volume will be 3 million tonnes. [2]The port is planned to be constructed by that time.

(Source: Murmansk Region Administration 2003)

In 2015, 12 million tonnes of oil are planned to be shipped from the port of Varandey if ice-class tankers are constructed by that time. In addition, construction of a new pipeline is planned, by which oil will be piped from deposits in West Siberia to Murmansk, to be reloaded there on large-capacity tankers. The pipeline will be laid either on the bottom of the White Sea Gorlo (the strait connecting the White Sea with the Barents Sea) or on land from the Leningrad Region. The planned volumes of oil transport by the pipeline are 80 million tonnes per year (Murmansk Region Administration 2003).

Lack of experience in large-tonnage tanker navigation under Arctic conditions

Tanker transportation under Arctic conditions entails a set of natural factors; polar night, seasonal ice and frequent storms. All this presupposes special requirements of the crew. With the increase of tonnage (from 20 000-49 000 tonnes to 150 000-300 000 tonnes), hydrometeorological and navigational risks grow correspondingly, especially in narrow passages, close by the coastline and under ice conditions when icebreakers pilot the tankers.

Oil and petroleum products in the Arctic are mainly shipped by ice-class tankers. Most tankers have a deadweight of less than 20 000 tonnes. A binding requirement for ice-class tankers is double hull and sides regulated by the International MARPOL Convention. To ship oil products in the Arctic, until recently the ice-class tankers of the Ventspils and Partizanok Classes with deadweights of 16 500 and 2 500 tonnes were used in Russia.

In 1984-1985 a series of six Ventspils Class tankers with double hull was constructed. At present, these vessels are out of date and their operation under Arctic conditions are limited. To replace them the Astrakhan' Class tanker was proposed, which can operate without being escorted by an icebreaker and which is able to break ice 0.5-1 m thick. Eight such vessels with a deadweight of 20 000 tonnes have been constructed. These are exactly the vessels that are in focus when speaking of the increased oil transport in the region. During recent years, Finnish tankers of Vikia, Tebo Olimpia and Kihu Classes mainly carried out the shipping of oil from Murmansk. Some of them have double hulls.

Insufficient potential of emergency services

The main controlling body over oil spills in the Russian part of the region is the Murmansk Basin Agency for Emergency Situations equipped with necessary equipment for cleaning up relatively small oil spills (up to 500 tonnes) in the vicinity of the Kola Peninsula coast. However, this organisation is unable to cope with large-scale oil spills especially any occurring under ice conditions in the remote areas of the Pechora Sea.

Root causes

Economic and political (strategic)

An export-oriented Russian economy is perceived by many as a root cause for increased oil and gas exploitation and transport in the Barents Sea, and, as a result, for possible increase in oil spill accidents. At present, this leads to:

The opening of new oil and gas provinces including those of the Arctic shelf

According to the energy strategy of Russia for the period before 2020, the exploitation of oil and gas deposits on the sea shelf is defined as one of the priority directions in the development of the Russian oil and gas industry. The marine share of oil extraction in Russia might reach 10 to 15% by the year 2010 with further growth anticipated. The reserves of the continental shelf are able to provide for high levels of oil extraction, which may constitute in 2020 up to 20% of the total volume of oil and up to 45% of the total volume of gas in Russia.

The Pechora and south Barents areas are the most prominent as regards to oil and gas supplies on the Russian shelf. 10 million tonnes of oil and

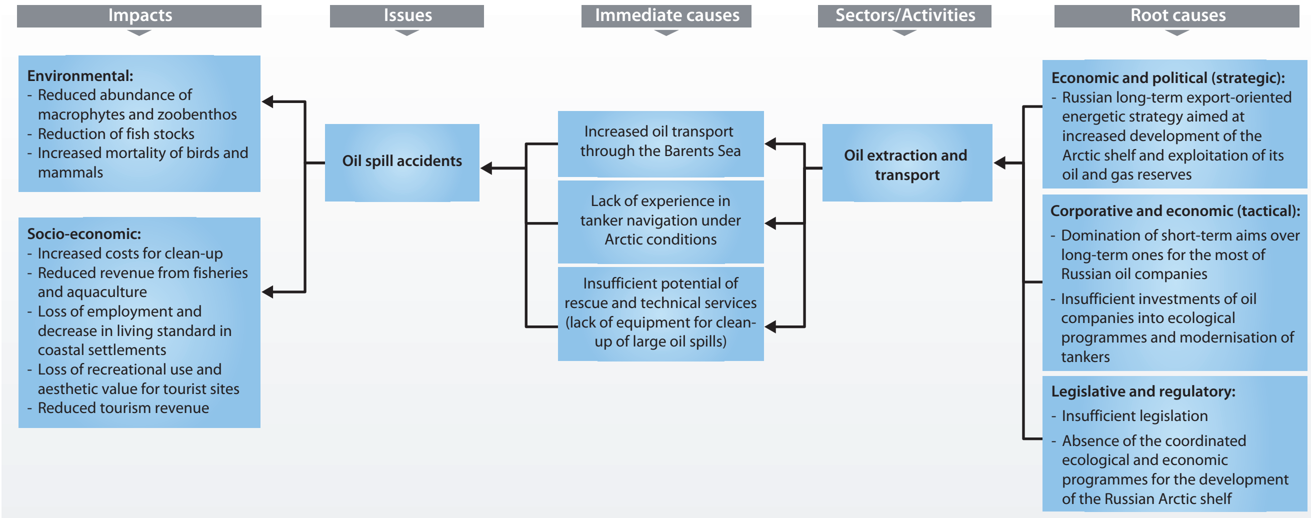


Figure 21 Causal chain diagram illustrating the causal links for oil spills.

50 million m^3 of gas are expected to be extracted there in 2010 with an increase by the year 2020 of up to 30 million tonnes and 130 million m^3 respectively (Murmansk Region Administration 2003).

The oil and gas complexes in the region will be based on the deposits already exploited (Prirazlomnoe, Severo-Medynskoye, Severo-Gulyayevskoye, Varandey-more, Pomorskoye, and Dolginskoye) and will be further developed with the opening of new oil and gas deposits. The basis for gas exploitation is the Stockman gas condensate deposit. Its supplies, together with the Ledovoye and Ludlovskoye deposits, constitute a good resource potential for gas extraction. Coastal and marine oil and gas complexes will be able to use the system of oil and gas pipes already existing and those planned for construction for home and export purposes.

The other way of oil and gas transport for export to the west (the U.S. and European countries) and to the East (the U.S. and countries of the Asian-Pacific region) is the Northern Sea Rout. The leading role here will belong to large-tonnage ice-class tankers (Murmansk Region Administration 2003).

Rapid growth of oil export volume

At present, part of the oil from the ports in the White Sea and oil deposits located in the eastern part of the Barents Sea, in the Nenets Autonomous Region and Siberia, is transported to the port of Murmansk. There it is reloaded on large-tonnage tankers to be further exported to the west. This technology is going to be further developed in the very near future with an increase in export volume of up to 9 million tonnes. For this purpose, three floating terminals are intended in the Kola Bay (in the areas of Kulonga, Belokamenka and Mishukovo). A new oil pipeline is going to be laid from Siberia to the Murman coast (the area of Teriberka, Kil'din Island and Ura Bay). This will significantly increase the export volume of oil through the Barents Sea.

Corporative and economic (tactical)

- Dominance of short-term and medium-term goals over the long-term for most of the Russian oil companies;
- Insufficient investment in infrastructure (information centres, emergency services, monitoring systems, construction of double-hull tankers, etc.) in most of the companies;
- The absence of coordinated plans and activities on the exploitation of oil deposits, oil transport to temporary terminals and to export destinations.

Legislative and regulatory

- There are still too many gaps in the Russian legislation, including that concerning the Arctic. An insufficient legislative system, not answering to the Arctic conditions, is a serious problem effecting further development of the Russian Arctic and consequently its impact on the environment.
- Russia has not yet joined the OSPAR international conventions and the Protocol of the European Commission on Strategic Environmental Assessment.
- The absence of EIA procedures for complex oil and gas activities in Russia (fitting out several neighbouring oil deposits, floating terminals and other sources of potential danger for environment).
- The absence of a coordinated ecological and economic programme for the development of oil and gas activities on the Arctic shelf in the framework of sustainable exploitation of, and management over, marine resources of the region.

Conclusion

The analysis suggests the following immediate causes of potential oil spills in the Barents Sea:

- Increased oil transport through the Barents Sea;
- Lack of experience in large-tonnage tanker navigation under Arctic conditions;
- Underdevelopment of emergency services (lack of equipment for clean-up of large oil spills).

The root causes of the issue are:

- Economic and political; overall direction of the Russian economy in the sphere of oil and gas exploitation to the increased export of, and prospecting for oil and gas, where the Russian Arctic shelf plays a significant role;
- Absence of long-term, well-coordinated plans for the development of the Arctic shelf, preventing oil companies from investing into ecological programmes and re-equipment of the tanker fleet;
- Lack of legislative initiative.

The linkages between root and immediate causes and their environmental and socio-economic consequences are presented in Figure 21.

Policy options

This section aims to identify feasible policy options that target key components identified in the Causal chain analysis in order to minimise future impacts on the transboundary aquatic environment. Recommended policy options were identified through a pragmatic process that evaluated a wide range of potential policy options proposed by regional experts and key political actors according to a number of criteria that were appropriate for the institutional context, such as political and social acceptability, costs and benefits and capacity for implementation. The policy options presented in the report require additional detailed analysis that is beyond the scope of the GIWA and, as a consequence, they are not formal recommendations to governments but rather contributions to broader policy processes in the region.

According to the results of the Scaling and scoping, and the Causal chain analysis, the following issues were chosen for the Policy option analysis:

- Overexploitation of fish;
- Modification of ecosystems;
- Oil spills;
- Radionuclides.

Overexploitation of fish

Problems

The analysis of the root causes behind the overexploitation of fish concludes that the existing fisheries practices during the past two decades have the potential to completely undermine the stocks of the commercially most valuable fish species in the Barents Sea. However, such a pessimistic prediction is believed to be unlikely, as an understanding of the necessity to stabilise the situation in the fisheries sector has increased in both Russia and Norway. Overfishing is also a focus of interest of the UNO, FAO and other world organisations related to the environmental protection. Thus, although the concern Unsustainable exploitation of fish and other living resources was assessed as having moderate impact at present, it was predicted to improve by 2020, both regarding the environmental and the socio-economic impacts.

Root causes

The root causes behind overexploitation of fish were identified as:

- Economic: overinvestment, unequal payments for the access to bioresources, price of vessels' quota-rights, high taxes and fish prices, failures of economic reforms in Russia, and market failures.
- Technological: low selectivity of fishing gear, and lack of alternative fishing gear.
- Political: disagreements within the Joint Norwegian-Russian Fisheries Commission regarding the setting of annual TAC.
- Governance: imperfection of fishery control systems, gaps in fishery statistics, and faults in the fishery management system.
- Legal: inappropriate legislation regulating the fisheries sector in Russia.
- Knowledge: scientific uncertainty, and inappropriate assessment methods.

Policy framework

The legal basis for fishery policies in the Barents Sea region is the Third United Nations Conference on the Law of the Sea (UNCLOS) from 1982, and national regulations on the protection of water living resources adopted in accordance with the Law of the Sea Convention.

The national regulations relevant to overexploitation of fish are:

a) In Norway:

- Law on the Norwegian Territorial Sea and contingent zone of 27.06.2003, establishing a 12 nautical mile territorial sea.

- Law on the Norwegian Exclusive Economic Zone of 17.12.1976, establishing the Norwegian Exclusive Economic Zone (EEZ).
- The Law on the right to participate in the fisheries of 26.03.1999, which regulates the participation in the fisheries. It establishes that participation is limited to nationals, technical criteria for the fishing vessels and registration and licensing regulations.
- The Law on first-hand sales of fish of 14.12.1951, which regulates the sale of fish at first-hand, from fisher to buyer. It dictates that all such sales shall be conducted through mandated sales organisations. These organisations have the mandate to regulate prices and, in specific cases, the conduct of fisheries.

b) In Russia:

- Federal Law on the continental shelf of the Russian Federation from 1995.
- Federal Law on the Exclusive Economic Zone of the Russian Federation.

The principles regulating the work of the Joint Norwegian-Russian Fisheries Commission (Norwegian Ministry of Fisheries 2004) have also been taken into consideration. The Commission sets total allowable catches (TACs) for the shared fish stocks (cod, haddock and capelin), throughout their migratory routes across borders of jurisdiction in the Barents Sea. The TACs are based on scientific advice from the International Council for the Exploration of the Sea (ICES 2003b) and national research institutions. The parties also exchange fishing quotas according to established fishing patterns and provide mutual access to fish in each others national EEZs. During the 1990s, cooperation in control and enforcement as well as in marine research has been strengthened.

For the policy option analysis, other international documents and agreements, aimed at improvement and better coordination of international cooperation on the problem of overfishing, have also been used, e.g. United Nations Food and Agriculture Organization (FAO 2004) and FAO's Code of Conduct for Responsible Fisheries (FAO 1995).

Also at the international level the policy to achieve sustainable fisheries management and sustainable development of marine and coastal areas and their resources was defined in the text of the two international documents: World Summit on Sustainable Development (WSSD 2002) and United Nations Conference on Environment and Development (UNCED 1992).

At the World Summit on Sustainable Development in Johannesburg in 2002, sustainable fisheries were discussed and an action plan was agreed upon and several actions to achieve sustainable fisheries were suggested (WSSD 2002). The UNCED Agreement sketched the key provisions for the protection of the marine environment and coastal areas and protection, rational use and development of living marine resources.

The above-mentioned national and international laws and agreements have formed the basis for the suggested policy options.

Achievements and unsolved problems

Although measures to decrease overexploitation of fish have been taken in both Norway and Russia in recent years, serious problems still remain. Therefore, both the main achievements leading to improvement of the situation in the fisheries sector and the obstacles that still remain are presented.

Achievements

- The United Nations Fish Stocks Agreement of 1995 (UN 1995), applying to straddling fish stocks such as cod and herring, dictates that States shall apply the precautionary approach (Article 6). To execute this agreement, the principles, parameters and models applied for stock assessments in the Barents Sea have been changed. For example, recommendations have changed from one specific catch-level, to a series of options with various consequences. ICES's recommendations have changed from being based on maximum sustainable yields (MSY) to be based on the basis of the precautionary approach. Moreover, following a revision of historical catch data, the precautionary reference points (B_{pa}[1] and B_{lim}[2]) for the cod stock were altered (ICES 2003).

- To handle political pressures within the Joint Norwegian-Russian Fisheries Commission and the scientific uncertainties related to the development of fish stocks, the parties have established a decision-making rule for the setting of TACs for cod and haddock entering into force in 2004. Based on the scientific estimates of F_{pa}[3] for the following 3 years, the TACs shall be set according to the average value of the 3-years prediction. The following year, the same procedure is followed, however the TACs shall not vary more than ±10% for cod and ±25 for haddock, from the previous year's TAC (Norwegian Ministry of Fisheries 2002). In cases where the stocks fall bellow precautionary levels (B_{pa}), lower quotas shall be considered by the Commission. The effectiveness of the decision-making rule to ensure the sustainability of the Barents Sea fisheries remains to be seen.

- Since 1993, Norway and Russia have increased their cooperation on control and enforcement through a permanent working-

[1]B_{pa} = Biomass precautionary approach reference point. [2]B_{lim} = Biomass below which recruitment is impaired. [3]F_{pa} = Fishing mortality precautionary approach reference point.

Figure 22 Fishing boat at sea.
(Photo: Getty Images)

group under the Joint Norwegian-Russian Fisheries Commission. The cooperation of enforcement agencies has been formalised facilitating the exchange of catch information, inspection data and exchange of inspectors. In addition, both parties have implemented vessel-monitoring systems (VMS), in the Norwegian case for vessels over 24 m. In Russia, to decrease negative effects of overexploitation of fish stocks, the time at sea for vessels was limited in 2002 and the above-mentioned vessel-monitoring system was introduced. However, such practices, already introduced in some EU countries, have proven to have low effectiveness as they only reduce but do not eliminate overfishing (Ozolin'sh & Spiridonov 2001).

- Norway is to establish an integrated management plan for the Barents Sea in 2005. The aim of this plan is to provide for industrial development and environmental protection within the framework of an ecosystem approach. The plan is to be developed in cooperation between the Ministries of Fisheries, the Environment, and Foreign Affairs and of Petroleum and Energy.
- In 2003, Russia established the Conception of the development of its fishery sector till the year 2020. The conception defines the main directions of the state policy in the sphere of the development of the fisheries sector of Russia for a long-term period. The conception presents an analysis of the current situation in the Russian fisheries sector, its problems, aims and tasks to be solved.

Existing problems

a) General problems:

- Increased competition in the world fisheries and general deterioration of fisheries conditions.
- Dominance of political and economical considerations in the work of the Joint Norwegian-Russian Fisheries Commission, which in some cases leads to TACs being set beyond scientific recommendations. Negotiations of the Joint Norwegian-Russian Fisheries Commission on the setting of TACs are not open to the public.
- Inability of the Commission to establish other regulatory measures.
- Overcapacity of the fishing fleet exceeding the stocks of commercial species in the Barents Sea.

- Lack of an efficient state regulatory system for sustainable long-term management of marine living resources.
- Vulnerability of fisheries to the impact of anthropogenic factors and natural variability which increases the financial risk both in fisheries and the fishing industry as a whole.
- Lack of efficient state policy to decrease unemployment among fishermen, to support the coastal fishery and to increase the living standard of coastal settlements, for which the fishery is the traditional backbone of the economy.
- Lack of an efficient mechanism to control illegal fishing.
- Gaps in fisheries statistics, low quality of collected data on which science is based.
- Lack of knowledge on the ecology of some commercial species and the features of the Barents Sea ecosystem. All this implies great scientific uncertainty.
- Lack of knowledge on the impacts of natural variability and anthropogenic factors on the Barents Sea ecosystem, which makes their effects difficult to forecast and reduces the quality of long-term predictions.

b) Russian problems:

- Economic crisis resulting from mistakes made in the transitional period. Lack of efficient state policy and state support for the national fishery sector under the conditions of market reforms.
- High level of mechanical wear and obsolescence of the fishing fleet in Russia, and a low selectivity of the fishing gear.
- Overfishing of the commercially most valuable species on the world market (cod and haddock) together with the decrease in state control over the fishermen's export activities.
- Increased export-oriented fishery with a reduction in fish consumption by the population in Russia.
- Lack of an efficient policy to control by-catches and discards and lack of financial support for the processing of fish of low market value.
- Lack of transparency in the system of allocation of fishing quotas, which leads to increased corruption, illegal transactions and conflicts between groups of fishermen.
- Under-development of financial-credit relationships, lack of an efficient market for fish products and market infrastructure.
- Absence of a Federal Law on fishery, protection and conservation of marine living resources, which would meet the requirements of sustainable exploitation of living resources, market realities and prevention of poaching and corruption. Without such a law many provisions of the "Conception of the development of the fishery sector of the Russian Federation till the year 2020" cannot be realised.

The analysis of the root causes and achievements in the sphere of the protection of living resources, and existing problems, allows an array of measures to be developed, aimed at sustainable exploitation of living resources in the Barents Sea.

Policy options

Table 37 presents the root causes and policy options for overexploitation of fish. Some of the policy options have been discussed by Government of the Russian Federation (2003), Dvornyakov (2000), Voitolovsky et al. (2003) and Titova (2003).

The main purpose of the development of the fisheries sector for the period till 2020 is the restoration of the fish stocks and the increased sustainability of their exploitation. There are several international agreements relating to sustainable fisheries and suggested actions to increase sustainability of the world fisheries.

World Summit on Sustainable Development (WSSD) concerning Sustainable Fisheries

Paragraph 31 of the WSSD (2002) suggests to; "maintain or restore stocks to levels that can produce the maximum sustainable yield with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015". The Barents Sea ecosystem is dynamic, and capelin and herring undergo cycles, which not only has consequences for these stocks but also the availability of food for cod and haddock (major commercial species in the Barents Sea fisheries). Thus, managers have to take into account ecosystem considerations (anthropogenic and biophysical factors) in the management of the Barents Sea fisheries.

The document also suggests an "implementation of the 1995 Code of Conduct for Responsible Fisheries…" and a development of national and regional plans of action for eliminating illegal, unreported and unregulated fisheries by 2004. Another suggestion was to "establish effective monitoring, reporting and enforcement, and control of fishing vessels" (WSSD 2002).

United Nations Conference on Environment and Development

Chapter 17 in UNCED (1992) "Protection of the Oceans, All Kinds of Seas, Including Enclosed and Semi-enclosed Seas, and Coastal Areas, and the Protection, Rational Use and Development of Their Living Resources" suggests several actions:

- "To consider establishing, or where necessary strengthening, appropriate coordinating mechanisms (such as a high-level policy planning body) for integrated management and sustainable development of coastal and marine areas and their resources, at both the local and national levels."

Table 37 Root causes and policy options for overexploitation of fish in the Barents Sea region.

Root cause	Policy option
Political: - Disagreements within the Joint Norwegian-Russian Fisheries Commission regarding the setting of annual TACs.	- To develop the joint Norwegian-Russian conception for the sustainable exploitation of fish in the Barents Sea and a long-term strategy to realise its conceptional provisions. - To improve the legislative and organisation base for cooperation between the two countries to create favourable conditions in the Barents Sea for sustainable exploitation of fish on the basis of the precautionary approach. - To ensure the transparency of the work of the Joint Norwegian-Russian Fisheries Commission when setting the TACs for public non-governmental organisation.
Legal: - Inappropriate legislation regulating the fisheries sector in Russia.	- To adopt the Law on the Protection and Exploitation of Marine Living Resources of the Russian Federation aimed at establishing the principles of sustainable fishery. - To form priorities of the policy aimed at sustainable exploitation of living resources and creation of a single state system to realise these priorities.
Economic: - Over-investment; - Unequal payments for the access to bioresources; - Price of vessels quota-right; - High taxes and fish price; - Failures of economic reforms in Russia; - Market failures; - Socio-economic problems in the fisheries sector.	- To develop long-term national programmes to realise the provisions of the Code of Conduct for Responsible Fisheries under the conditions of the Barents Sea. - To develop and realise financial mechanisms contributing to establishing the principles of responsible fisheries. - To create state funds to support the reduction in number of fishing vessels operating in the fisheries sector to decrease the overcapacity of the fishing fleet. - State support of alternative measures to decrease the fishing load on the natural fish stocks (e.g. artificial reproduction of fish stocks, development of aqua- and mariculture). - To develop and realise measures to increase socio-economic sustainability of the fisheries sector. - To adjust the taxation system to the specific character of the fisheries sector (increased risk due to instability of fish reserves), reinforcement of control over the increased prices for fuel. - To initiate the protection of interests of coastal fishery and coastal fishing settlements and communities. - For Russia: To develop and realise the state social strategy for the fisheries sector aimed at securing optimal employment and stable earnings of the employed in the fisheries sector. - State support of the development of coastal infrastructure of the fishing industry and aquaculture on the coast of the Barents Sea.
Technological: - Low selectivity of fishing gear; - Lack of alternative fishing gear; - Illegal fishing methods.	- To develop legislative and organisation measures to establish the system for ecologically safe fisheries (ecological certification of fisheries) (see Annex IV). - For Russia: To adapt to Russian conditions the positive Norwegian experience in the struggle against by-catches and discards. - To develop measures of state support to increase the selectivity of the fishing gear and re-equip the fishing fleet. - State support of the development of the system for processing of commercially less valuable fish, which is caught as by-catch.
Governance: - Imperfection of fishery control system; - Gaps in fishery statistics; - Fault of the fishery management system.	- To develop and realise measures to increase the effectiveness of the system of the state control over the exploitation and protection of marine living resources. - More stringent measures on enforcement and control. - More stringent control over vessel documentation and fishing statistics. - For Russia: To adjust the quotas to the vessels capacity (e.g. a quota should not be less than 70% of the vessel capacity as low quotas provoke increased illegal fishery). - More stringent control over the time of vessels at sea. - To increase the transparency and justice of the state system of quotas allocation, providing of free quotas for small-scale coastal fishery and coastal settlements. - Obligatory registration of all catches and all export transactions on land. - Reinforcement of state control over the export of fish.
Knowledge: - Scientific uncertainty; - Inappropriate assessment methods.	- Detailed analysis of the gaps in knowledge, development of long-term research programme for their elimination.

- "To undertake measures to maintain biological diversity and productivity of marine species and habitats under national jurisdiction."
- "To improve their capacity to collect, analyse, assess and use information for sustainable use of resources, including environmental impacts of activities affecting the coastal and marine areas."
- "To cooperate internationally."

Code of Conduct for Responsible Fisheries

The Food and Agriculture Organization, FAO, has developed this code of conduct to set out principles and international standards of behaviour for responsible practices (FAO 1995). The objective is to prepare guidelines for the effective conservation, management and development of living aquatic resources, with due respect to the ecosystem and biodiversity. Here four fishing management measures relevant for overfishing in the Barents Sea Region are stated:

- States should ensure that the level of fishing permitted is commensurate with the state of fisheries resources.
- Where excess fishing capacity exists, mechanism should be established to reduce capacity to levels commensurate with the sustainable use of fisheries resources so as to ensure that fisheries operate under economic conditions that promote responsible fisheries. Such mechanisms should include monitoring of the capacity of fishing fleets.
- The efficacy of conservation and management measures and their possible interactions should be kept under constant review.
- States and sub-regional and regional fisheries management organisations and arrangements, in the framework of their respective competences, should introduce measures for depleted resources and those resources threatened with depletion that facilitate the sustained recovery of such stocks. They should make every effort to ensure that resources and habitats critical to the well-being of such resources, which have been adversely affected by fishing or other human activities, are restored.

The policy options concerning elimination of gaps in knowledge and scientific uncertainty identified in this report are closely connected to the actions suggested by WSSD (2002) paragraph 36 such as: "improving the scientific understanding and assessment of marine and coastal ecosystems as a fundamental basis for sound decision making…" and "building capacity in marine science, information and management, through, inter alia, promoting the use of environmental impact assessments and environmental evaluation and reporting techniques, for projects or activities that are potentially harmful to the coastal and marine environments and their living and non-living resources". The above-mentioned international agreements have formed a basis for the suggested policy options for the Barents Sea region.

Conclusions

In the course of the Causal chain analysis the GIWA Task team concluded that the root causes behind overexploitation of fish are difficult to change in a short-term period; time and considerable resources are required. In addition to compliance to international agreements, disagreements in the decision-making process within the Joint Norwegian-Russian Fisheries Commission should be eliminated. The elimination of root causes of overexploitation first of all relates to the development and implementation of measures to formulate compatible rules for all countries. Furthermore, measures to reduce unemployment among fishermer must be taken to establish a system of social protection for coastal settlements and coastal fishery. For Russia a matter of special concern is improving of standard of living of the population.

Modification of ecosystems

Problems

The following problems can be defined:

- Intentional introduction of commercial species into the Barents Sea by the former Soviet Union;
- Increased export volumes of oil shipped through the Barents Sea and a corresponding increase in volume of ballast water into the Barents Sea;
- Inadequate infrastructure; the absence of tank/hull cleansing facilities;
- Lack of national and regional regulations for farming and introduction of commercial species, as well as for treatment of ballast water.

Root causes

The root causes identified for modification of ecosystems were:

- Economic: increased oil and gas export from Russia through the Barents Sea.
- Technological: lack of tank- and hull cleansing facilities.
- Scientific: lack of knowledge on the acclimatisation of alien species in the Barents Sea. A large-scale biological experiment was initiated and conducted without scientific assessment of its consequences for the ecosystem as a whole.
- Legal: lack of regulations on treatment of ballast water and farming and introduction of commercial species at the regional, national and international levels.

Policy framework

The major international document on mitigation of the modification of ecosystems and maintenance of their biological diversity is the Convention on Biological Diversity (CBD 1992). At least 157 States, including Russia and Norway, signed the Convention. The objectives of this Convention, to be pursued in accordance with its relevant provisions, are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources, including appropriate access to genetic resources and appropriate transfer of relevant technologies, taking into account all rights over those resources and technologies, and appropriate funding.

Article 6 "General Measures for Conservation and Sustainable Use" of the CBD (1992) suggests: "Each Contracting Party shall, in accordance with its particular conditions and capabilities; Develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for their purpose existing strategies, plans or programmes which shall reflect, inter alia, the measures set out in this Convention relevant to the Contracting Party concerned; and Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral and cross-sectoral plans, programmes and policies."

Article 8 "In-situ Conservation" of the CBD (1992), also suggests actions such as: "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species" and to "develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species and populations" (CBD 1992). According to article 10 (CBD 1992) it is important to "integrate consideration of the conservation and sustainable use of biological resources into national decision-making".

The policy to achieve sustainable use of biological resources and avoid or mitigate the modification of ecosystems was also defined in the WSSD (2002), paragraph 34: "Enhance maritime safety and the protection of the marine environment from pollution by actions at all levels to: Accelerate the development of measures to address invasive alien species in ballast water. Urge the International Maritime Organization to finalise its draft International Convention on the Control and Management of Ship's Ballast Water and Sediments".

Other suggestions were to "effectively conserve and sustainably use biodiversity, promote and support initiatives for hot spot areas and other areas essential for biodiversity and promote the development of national and regional ecological networks and corridors" and to "strengthen national, regional and international efforts to control invasive alien species, which are one of the main causes of biodiversity loss, and encourage the development of effective work programme on invasive alien species at all levels" (WSSD 2002, paragraph 44).

Policy options

The above-mentioned international agreements have formed a basis for the suggested policy options, which are:

- Compliance to recommendations of scientific organisations when developing the policies, plans and programmes for the exploitation of the introduced species;
- Compliance to regulations for the transport of alien commercial species;
- Increased measures to control the introduction of invasive alien species, including the introduction through ballast water;
- Fines for non-compliance;
- Adoption of regulations at the international level, including those regulating the treatment of ballast water.

Radionuclides

Problems

The following problems can be defined in the field of ensuring nuclear and radioactive security in the region:

- Storage and treatment of spent nuclear fuel (SNF);
- Storage and treatment of liquid radioactive waste (LRW) and hard radioactive waste (HRW);
- Radiological safety of decommissioned nuclear powered submarines and coastal technical stations of the Russian Navy;
- Storage and transportation of radioactively dangerous materials, radioactive substances and isotope products;
- Radiation (radiological) terrorism.

Storage and treatment of spent nuclear fuel

Spent nuclear fuel (SNF) is a product of military and civil transport reactors. When unloaded from a reactor, SNF must be kept for about three years in special depositories at coastal stations of the Northern Navy and on the floating bases Lotta and Imandra of the Murmansk Shipping Company. SNF is transported to the radioactive waste treatment plant Mayak in a special train. Accumulation of large amounts of SNF is a potential source for radioactive accidents.

In addition to the problem of storage and transportation of SNF, there is another problem of considerable importance for the Kola Peninsula: the treatment of SNF that cannot be reprocessed at Mayak. There are 642 heat-emitting constructions no longer in use, with an activity 28×10^{15} Bq, that are kept on the floating technical base Lepse; SNF not subjected to treatment that is kept on the floating technical base Lotta; and defective SNF at coastal stations of the Northern Navy (State Environmental Committee of the Murmansk Region 1999).

Handling radioactive waste

Liquid radioactive waste (LRW)

The Civil Atomic Fleet has not been discharging LRW into the sea since 1986, and the Northern Navy not since 1992. Accumulation and temporary storage of LRW is carried out in special coastal depositories or on special vessels, which are almost totally filled in the Northern Navy. LRW is not accumulated in the Civil Atomic Fleet as it is being entirely reprocessed at the Repairing and Technological Enterprise (RTE) ATOMFLOT. LRW from the Northern Navy is only partially reprocessed at this enterprise. The experimental radioactive waste treatment plant at RTE ATOMFLOT is being modernised at present. The purpose of the modernisation is to increase its capacity from 2 000 to 5 000 m^3 per year and the possibility to reprocess LRW of all types. Realisation of this project will enable the problems of the treatment of LRW from the Civil Atomic Fleet and the Northern Navy based in the region to be solved.

Another vital problem for the Northern Navy is the technical state of special vessels used for the accumulation and storage of LRW. Their life (exploitation period) is over and their maintenance is highly expensive. Since the beginning of the exploitation of the Kola Nuclear Power Plant, more than 6 000 m^3 of LRW have been accumulated, which are now kept in special reservoirs. The reservoirs are filled up to 80% (State Environmental Committee of the Murmansk Region 1999).

Hard radioactive waste (HRW)

Most of the HRW comes from the maintenance and repair of nuclear power plants. At present more than 16 000 m^3 of HRW are kept in depositories of the Civil Atomic Fleet, Northern Navy and the Kola Nuclear Power Plant. The Kola Nuclear Power Plant reprocesses combustible HRW at a combustion installation. Other types of HRW are kept without treatment in depositories, which are now almost totally filled up. HRW from the Civil Atomic Fleet is kept in special depositories at RTE ATOMFLOT and on special vessels for technical maintenance. Depositories for the storage of definite types of HRW are now filled up to 100%.

The Northern Navy has not enough depositories for its HRW. Those available do not correspond to standards, are exposed to precipitation, and are not being equipped with drainage systems, thus contaminating the surrounding soils with radioactive substances.

The total activity of the accumulated HRW is 37×10^{12}Bq. The total volume of HRW increases by 1 000 m^3 each year. If the intensification of work on the treatment of decommissioned nuclear powered submarines is taken into account, the amount should be double that presently available. There is no equipment for environmental friendly conditioning of HRW in the Murmansk Region. All HRW is kept under unacceptable conditions (State Environmental Committee of the Murmansk Region 1999).

Radiation safety for decommissioned nuclear powered submarines and coastal technical stations of the Russian Navy

Since the end of the 1980s, many nuclear powered submarines have been decommissioned in Russia. The number of decommissioned submarines greatly exceeds those reprocessed. In total, by September 2003, 192 nuclear powered submarines have been decommissioned in Russia, of which only 89 have been reprocessed. The unsatisfactory technical state of decommissioned submarines may result in their accidental sinking, which may cause severe radio-ecological consequences for the environment.

Storage and transportation of radioactively dangerous materials, radioactive substances and isotope products

Each year about 1 800 transportations of radioactive waste are carried out. On average, six to seven special trains transport radioactive materials every day. However, the available number of special trains is unable to provide timely transport of radioactive materials from the Kola Peninsula. There is a Russian-Norwegian Agreement aiming at secure treatment of SNF, which may give the possibility of constructing new special carriages and vessels for the transport of SNF (State Environmental Committee of the Murmansk Region 1999).

Radio-ecological terrorism

Under the increasing threat of terrorism, the problem of security for nuclear and radioactively dangerous productions and objects is an issue of great concern. Radiological terrorism with the use of sources of ionising radiation, widely used in different spheres of life, is of considerable danger.

Root causes

The root causes identified for radionuclide pollution were:

- Geopolitical: creation of a powerful nuclear-powered navy and icebreaker fleet in the former Soviet Union, which has lead to the Kola Peninsula being overcrowded with radioactively dangerous sites, objects and decommissioned submarines.
- Economic: lack of funding for timely reprocessing of spent nuclear fuel and radioactive waste and nuclear reactors from decommissioned nuclear powered submarines and for radiological protection activities.

Policy options

To decrease the possibility of radioactive contamination in the region, the activities of the State in the field of ensuring nuclear and radiation security should encompass the following:

- Intensification of safety measures on the exploitation of civil and military nuclear reactors;
- Timely reprocessing of SNF and decommissioned nuclear powered submarines;
- Timely reprocessing of fissile substances from different kinds of weapon;
- Timely transport of radioactive waste to reprocessing plants;
- Intensification of safety measures on the storage of radioactive materials;
- Modernisation of systems of protection and control over radioactively dangerous objects;
- Construction of new temporary storages for spent nuclear fuel and radioactive waste.

The immediate cause of radioactive pollution is the large amount of potential sources of radioactivity in the Russian part of the Barents Sea region. The economic causes are related to the radiological protection activities, the timely reprocessing of spent nuclear fuel and radioactive waste, and the accident-free exploitation of nuclear reactors of any kind and radioactive waste storages. This is hampered by the overall economic situation in Russia and lack of funding and to a certain degree it also depends on taking political initiatives and on improving the legislative base and eliminating bureaucratic obstacles. Thus, the root causes of the issue are difficult to change in the near future and will largely depend on the political and economic initiatives at both national and regional levels.

Oil spills

Problems

On the basis of the causal chain analysis, the following conclusions have been made:

- Oil spill accidents in the region are inevitable in the future. They will be caused by a number of factors such as: increased navigation activity, severe climatic conditions, lack of experience in tanker navigation, imperfection of information system, and lack of double-hull tankers.
- The possible scenarios for oil spill accidents are the following: in the open sea, in ice, and in the coastal zone with the possible discharge of oil to the coast (or in the coastal zone under ice conditions). The environmental and socio-economic impacts for these three scenarios will be different but the most severe consequences are likely for the third case. The possible damage will depend on a number of factors such as: season, geographical extent, abundance of bioresources in the contaminated area, duration in time, etc.

Root causes

The root causes identified for oil spills were:

- Economic and political (strategic): the overall direction of the Russian economy in the sphere of oil and gas exploitation to the increased export of, and prospecting for, oil and gas where the Russian Arctic shelf plays a significant role.
- Corporative and economic (tactical): absence of long-term, well-coordinated plans for the development of the arctic shelf, preventing oil companies from investing into ecological programmes and re-equipment of the tanker fleet.
- Legal: lack of legislative initiative, and insufficient legislative base.

Achievements and unsolved problems

Achievements

At present in the Murmansk Region, the following measures are realised to decrease the risk of oil spill accidents:

- A plan for the clean-up of the Murmansk Region coast in case of an oil spill has been developed and approved by the Governor of the Murmansk Region;
- On the initiative of the Murmansk Marine Shipping Company, a system has been arranged for informing the governors of the northern counties of Norway, Sør-Varanger and Finnmark, of the number of Russian tankers heading westward along the Norwegian coast, and of their navigation schedule;
- The Murmansk Basin Agency for Emergency Situations carries out regular joint training at sea together with Norwegian rescue services;
- Negotiations are being carried out to create an International Centre for rescue operations at sea (Russia and Norway).

Unsolved problems

- Lack of appropriate equipment for the treatment of oil spills under ice conditions (Pechora Sea);
- The technical equipment and facilities of the Murmansk Basin Agency for Emergency Situations is insufficient for the treatment of large or remote oil spills occurring in areas hundreds of kilometres distant from the place of the Agency's location (e.g. in the Pechora Sea);
- Lack of double-hull tankers;
- The general delay for five to seven years in the previously agreed timetable of the development of the Russian Arctic shelf is hampering the funding of ecological programmes by oil and gas companies on a long-term basis;
- Increased volumes of oil transport in the Barents Sea increase the risk of oil spill accidents under the conditions of under-development of coastal services;
- Russia still lacks a federal law regulating the responsibility for oil pollution like the Oil Pollution Act in the U.S.

The Oil Pollution Act (OPA) was prepared by the U.S. Congress and signed into law in August 1990, largely in response to rising public concern following the Exxon Valdez incident. The OPA improved the nation's ability to prevent and respond to oil spills by establishing provisions that expand the federal government's ability, and provide the money and people necessary, to respond to oil spills. The OPA also created the national Oil Spill Liability Trust Fund, which is available to provide up to 1 billion USD per spill incident.

The OPA increased penalties for regulatory non-compliance, broadened the response and enforcement authorities of the Federal government, and preserved State authority to establish law governing oil spill prevention and response. Russia has no similar law, while the existing legislation related to oil spills is discrepant and does not provide strict control over the responsibility for oil pollution or effective measures to prevent and respond to oil spills.

Policy framework

Measures to prevent oil spills accidents in the region are legislative and technical. The legislative measures include international conventions and agreements, national and regional legislation of the Russian Federation. At the international level, measures on the prevention and clean-up of oil spills are regulated by international conventions.

OSPAR Convention

The Convention for the protection of the marine environment of the North-East Atlantic (known as the OSPAR Convention) is the basis for national laws governing the discharge of off-shore drilling waste in the waters of the OSPAR signatory states: Belgium, Denmark (including, for these purposes, the self-governing provinces of the Faeroe Islands), Finland, France, Germany, Iceland, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom of Great Britain and Northern Ireland. OSPAR regulations thus cover all the oil-producing states of Western Europe. The EU is also a signatory, as are Luxembourg and Switzerland. Russia has not yet joined this international agreement.

The International Convention for the prevention of pollution of ships, 1973 (MARPOL 73/78)

The Convention was adopted in 1973. This convention was subsequently modified by the Protocol 1978 relating thereto, which was adopted in 1978. The Protocol introduced stricter regulations for the survey and certification of ships. It is to be read as one instrument and is usually referred to as MARPOL 73/78.

This International Maritime Organization (IMO) Convention is the most important global treaty for the prevention of pollution from the operation of ships. It governs the design and equipment of ships; establishes the system of certificates and inspections; and requires states to provide reception facilities for the disposal of oily waste and chemicals. It covers all the technical aspects of pollution from ships, except the disposal of waste into the sea by dumping, and applies to ships of all types, although it does not apply to pollution arising out of the exploration and exploitation of sea-bed mineral resources.

The Regulations for the Prevention of Pollution by Oil

The Regulations entered into force 2 October 1983 and provide details on the discharge criteria and requirements for the prevention of pollution by oil and oily substances. They maintain predominantly the oil discharge criteria prescribed in the 1969 amendments to the 1954 Oil Pollution Convention. Besides technical guidelines they contain the concept of "special areas" which are considered to be vulnerable to pollution by oil. Discharges of oil within them have been completely prohibited, with minor well-defined exceptions.

Convention on Biological Diversity, 1992

The Convention is a key instrument for the conservation and sustainable use of biological diversity. The objectives of the Convention are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources (CBD 1992). According to the Convention: "States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction".

National level

At the national level in Russia, the measures to control oil spill accidents are regulated by:

- The Federal Law on environmental protection (adopted 27 December 2001);
- The Federal Law on the wild life;
- The Law on the protected territories;
- The Law on the ecological expertise;
- The Water Codex of the Russian Federation.

Local level

At the local level, control, treatment and remediation of oil spills are regulated by the Regional Plan for the Liquidation of Oil-spill Accidents. The link between the legislative base and concrete plans and programmes is the Resolution of the Government of the Russian Federation of 21 August 2000 "Urgent measures to minimise the risk of oil spill accidents" (the last wording of 15 April 2002). The Resolution approves "The general requirements for the development of plans on prevention and elimination of oil spill accidents". According to the Resolution, oil spills are classified as an emergency and are to be eliminated according to the legislation of the Russian Federation.

Depending on the size and volume, the oil spill accidents are classified as follows:

- Local - the volume of oil spill is up to 500 tonnes;
- Regional - from 500 to 5 000 tonnes;
- Federal - more than 5 000 tonnes.

Depending on the location of an oil spill and climatic conditions, the category of emergency may be increased. The plan on the prevention and elimination of oil spill accidents is developed on the basis of the existing regulations allowing for the maximum possible volume of an oil spill.

The plan encompasses:

- Monitoring of possible oil spill accidents;
- Number of forces and facilities needed for treatment and remediation following an oil spill accident and their correspondence to the tasks of treatment activities;

- Organisation of cooperation between forces;
- Composition and location of forces and facilities;
- System of control and warning;
- Securing of constant readiness of all forces, appointing the organisations responsible for their upkeep;
- System of information exchange;
- Immediate actions after an emergency alarm;
- Geographical, navigational, hydrographical, climatic and other features of the area of an oil spill accident, which should be taken into account when planning treatment and remediation activities;
- Safety of the population, provision of medical aid;
- Technical, engineering and financial provision.

When defining the number of facilities and forces needed for the liquidation of oil spill accidents, the following aspects should be taken into account:

- The maximum possible volume of leakage;
- The area where the damaged object was brought into operation and the year of the last overhaul of an oil spill;
- The maximum volume of oil kept at an object;
- Physical and chemical properties of the spilled oil;
- Climatic, hydrographical, geographical and other conditions influencing the spreading of an oil spill;
- The presence of terminals for the transport, storage and processing of oil waste;
- The transport infrastructure in the area of an oil spill accident;
- The time needed for the transport of treatment and remedial forces to the area of an oil spill accidents;
- The time of oil spill localisation, which should be less than 4 hours for an accident at sea and less than 6 hours for an accident on land.

Conclusions and recommendations

The assessment carried out according to the GIWA methodology identified Unsustainable exploitation of fish and other living resources, Pollution, and Habitat and community modification as the most important concerns for the Barents Sea region.

Among these concerns, Unsustainable exploitation of fish has the most severe impacts on the Barents Sea aquatic system under present conditions. Within this concern, overexploitation of fish is the most pressing issue. The Causal chain analysis identified the following root causes for the overexploitation of fish:

- Economic: overinvestment, unequal payments for the access to bioresources, price of vessels' quota-rights, high taxes, high fish prices, failures of economic reforms in Russia, and market failures;
- Technological: low selectivity of fishing gear, and lack of alternative fishing gear;
- Political: disagreements within the Joint Norwegian-Russian Fisheries Commission regarding the setting of annual TAC;
- Governance: imperfection of fishery control systems, gaps in fishery statistics, and fault of the fishery management system;
- Legal: inappropriate legislation regulating the fisheries sector in Russia;
- Knowledge: scientific uncertainty, and inappropriate assessment methods.

Numerous scientific investigations have shown that all of the above-mentioned root causes aggravate the situation in the fisheries of the Barents Sea. To improve fisheries management, the following set of policy options have been suggested:

- Use the Joint Norwegian-Russian Fisheries Commission to develop measures for the sustainable exploitation of fish in the Barents Sea, including regulatory and economic instruments;
- Develop measures for cooperation and integration of environmental and socio-economic aspects into the decisions of the Joint Norwegian - Russian Fisheries Commission;
- Ensure that the work of the Joint Norwegian-Russian Fisheries Commission when setting the TACs, is fully transparent to the public as well as non-governmental organisations.

Pollution was identified as the second most important concern in the Barents Sea region. The analysis performed in the framework of this report, as well as other publications of the past few years, has demonstrated that pollution of the Barents Sea is relatively low at the present time. The analysis suggests that the Barents Sea is much cleaner than other European seas, and that pollution does not constitute a threat to human health or ecosystems. However, due to the expansion of oil and gas industries in the region, as well as increased shipments of oil and gas from east to west through the Barents Sea, the risk of accidental oil spills is expected to increase in the near future.

Root causes for potential oil spills were identified as:

- Economic and political (strategic): overall direction of the Russian economy to increase exports of oil and gas, where prospecting and oil and gas development in the Russian Arctic shelf plays a significant role;
- Corporate and economic (tactical): absence of long-term well-coordinated plans for the development of the Arctic shelf, which prevents oil companies from investing in ecological programmes and re-equipment of the tanker fleet;
- Legal: lack of legislative initiatives, and insufficient legislative base.

Based on the world's experience in oil production on the sea shelf and taking into account the climatic and hydrographic features of the Barents Sea, a set of measures have been suggested to reduce the risk of potential emergencies, including develop safety plans to prevent accidental oil spills, and contingency plans to respond to accidents, which would encompass:

- Systems of safety and monitoring of oil spill accidents;
- Forces and facilities needed for treatment and remediation following an oil spill accident;
- Organise cooperation between forces;
- Features of the area of an oil spill accident (geographic, navigational, hydrographic, climatic, etc.) should be taken into account when planning treatment and remediation activities.

The Murmansk Region houses more radioactive waste than any other region of the world. Although current levels of radioactivity are low and do not pose any threat to human health or the environment, there is need for long-term strategies for the handling of stored nuclear material in the region, as there are apprehensions that storage facilities could result in radioactive contamination of the environment.

The root causes identified for radioactive pollution in the region were:

- Geopolitical: radioactive wastes on the Kola Peninsula are a legacy of the former Soviet Union's powerful nuclear-powered navy and icebreaker fleet, as well as infrastructure for their maintenance;
- Economic: lack of funding for activities such as the timely reprocessing of spent nuclear fuel and radioactive wastes, the decommissioning of nuclear powered submarines, and radiological protection.

To decrease the possibility of radioactive contamination in the region, the activities of the State in the field of ensuring nuclear and radiation safety should encompass the following:

- Enhance safety measures on the exploitation of civilian and military nuclear reactors;
- Spent nuclear fuel and radioactive material from different weapons should be reprocessed in a timely fashion;
- Dismantling of decommissioned nuclear submarines combined with the safe transport of radioactive wastes to reprocessing plants;
- Construction of new temporary storage facilities for spent nuclear fuel and radioactive wastes, and the intensification of safety measures for stored radioactive materials;
- Modernise systems of protection and control for radioactively dangerous sites.

The fourth most important issue for the Barents Sea is the Modification of ecosystems by invasive species. It is also possible that the significance of this issue will increase substantially in the future. The composition of the Barents Sea fauna has been changed by the intentional introduction of the Red king crab, as well as other alien species. There are concerns that competition between the Red king crab and commercial and non-commercial species for forage reserves could result in the decrease of some commercially important fish stocks of the Barents Sea.

Another aspect of the problem is the unintentional introduction of alien species through ballast water of oil tankers. Alien species introduced unintentionally form a serious threat to the economy of northern Norway as well as to coastal communities in Russia. Due to the ecological and socio-economic value of living marine resources in the Barents Sea, and their sensitivity to the threats associated with human development, the potential risks posed by the introduction of alien species should be taken very seriously.

Identified root causes for the modification of ecosystems by invasive species include:

- Scientific: intentional introduction of new commercial species into the Barents Sea by the former Soviet Union;
- Economic: increased export of oil shipped through the Barents Sea, and a corresponding increase in the volume of ballast water discharged into the Barents Sea;
- Technological: inadequate infrastructure, and absence of tank/hull cleansing facilities;
- Legal: lack of national and regional regulations for aquaculture, the introduction of commercial species, as well as for the issue of discharges of ballast water.

The following policy options are recommended to mitigate the impacts of invasive species:

- Policies, plans and programmes for the exploitation of introduced species should be based on scientific knowledge and recommendations;
- Regulations for the transport of exotic commercial species should be enforced;
- Regulations at the international level should be adopted, including those for regulating the treatment of ballast water.

References

Aibulatov, N.A. (ed.) (2001). Geoecology of the shelf and shores of the Russian seas. Moscow, Noosfera. (In Russian).

Alekseev, A.P. and Ponomarenko, V.P. (1998). On the fishery forecasts expertise. Abstracts of presentations of the VII All-Russian Conference on the problems of the sea forecasts. Murmansk, 7-9 October 1998. p 24-25. (In Russian).

AMAP (1998). Assessment Report: Arctic Pollution Issues. Oslo: Arctic Monitoring and Assessment Programme (AMAP).

AMAP (2002). Arctic Monitoring and Assessment Program Vol. II (AMAP). Hansen, J.C., Gilman, A., Klopov, V. and Odland, J.O. (eds.) Assessment Report: Arctic Pollution Issues. Oslo: AMAP Secretariate: In press.

Amundsen, P.-A. Staldvik, F., Lukin, A., Kashulin, N., Reshetnikov, Y.S. and Popova, O. (1993). Ecology and heavy metal contaminations in the fish communities of the Pasvik River System. Report. Norwegian College of Fishery Science, University of Tromsø.

Amundsen, P.-A., Staldvik, F., Lukin, A., Kashulin, N., Reshetnikov, Y. S. and Popova, O.A. (1997). Heavy metal contaminations in freshwater fish from the border region between Norway and Russia. The Science of the Total Environment 201: 211-224.

Anker-Nilssen, T., Bakken, V., Strom, H., Golovkin, A.N., Bianki, V.V., and Tatarinkova, I.P. (eds.) (2000). The Status of marine birds breeding in the Barents Sea Region. Rapport 113. Norsk Polarinstitutt. Tromsø. 213 pp.

APN (2003). Environmental status of the Varanger-Kola Coastal area. Report APN-414.2127.

Arkhangelsk Region Administration (2003). From the official web-site of the Arkhangelsk Region Administration (In Russian): http://www.dvinaland.ru

Arkhangelsk Region Directorate of Natural Resources and Environmental Protection (2002). Environmental status and protection in the Arkhangelsk Region in 2001. Report. Arkhangelsk, Russia. (In Russian).

Arnesen, R.T., Traaen, T.S., Moiseenko, T., Mokrotovarova, O., and Kudryavtseva, L. (1996). Heavy metals from the Nikel area Investigation in Kolosjoki river 1995, Kola Peninsula, Russia. Norwegian Institute for Water Research. Report 3543.

AWI (1994). Berichte zur Polarforschung. Alfred Wegener Institute for Polar and Marine Research. Bremenhaven. Vol. 144.

Barbier, E.B. (2001). A note on the economics of biological invasions. Ecological Economics 39(2):197-202.

Batchaev A.R., Slutsky E.G., Sovershaeva L.P., Solodukhin Yu.N., Khazova E.V. and Khodachek A.N. (2002). Major directions of the strategy for social and economic development of the Northwest Federal District of the Russian Federation till the year 2015. St. Petersburg, Russia. (In Russian).

Berger, V. and Dahle, S. (eds.) (2001). White Sea. Ecology and Environment. Tromsø, Akvaplan-Niva AS. Zoological Institute, St. Petersburg.

Bochkov, L.P., Vakulovsky, S.M., Nikitin, A.I., Tertyshnik, E.G. and Chumichev V.B. (1983). On the cesium 137 contents in the surface watres of the land. Meteorology and hydrology, 8:79-83. (In Russian).

Borovkov, V.A., Shevelev, M.S. and Shleinik V.N. (2001). Current status and dynamics of the commercial ecosystem of the Barents Sea. Biological resources of the Russian Arctic coastal zone: materials to symposium. Belomorsk. April. Moscow, VNIRO. p 13-18. (In Russian)

Botnen, H. and Jelmert, A. (2002). Ballastvann - en fare for det norske havmiljøet? (Ballast water - dangerous for the Norwegian marine environment?). Havets Miljø, 2002. (In Norwegian).

Bryzgalo, V.A., Graevsky, A.P. and Ivanov, V.V. (1999). Accidental oil-spill impact in the Pechora River on water and bottom sediments in the mouth part. Ecological chemistry. 8:177-185. (In Russian).

Bryzgalo, V.A. and Ivanov, V.V. (1999a). Hydrochemical regime of the Pechora River under the conditions of anthropogenic impact. Ecological chemistry. 8:91-100. (In Russian).

Bryzgalo, V.A. and Ivanov, V.V. (1999b). Ecological consequences of the anthropogenic impact on the mouth areas of the rivers of the Russian Arctic Seas. Ecological chemistry. 8(4):224-241. (In Russian)

Carlton, J.T. and Geller, J.B. (1993). Ecological roulette: The global transport of non-indigenous marine organisms. Science261:78-82.

CBD (1992). Convention on Biological Diversity. United Nations Conference on Environment and Development. Rio de Janeiro, Brazil. 3-14 June. Available at: www.biodiv.org/convention/articles.asp

Central Directorate of Geodesy and Cartography (1983). Atlas of the USSR, Moscow.

Cheluykanov, V.V. and Savel'ev, V.A. (1992). On the radiation situation in the area of the polygon for nuclear weapons tests on the Novaya Zemlya. Meteorology and hydrology. 2:107-109. (In Russian).

Churchill, R. and Ulfstein, G. (1992). Marine Management in disputed areas: the case of the Barents Sea. London, Routledge.

Commission of the European Community (1990). The Radiological Exposure of the Population of the European Community from the Radioactivity in the North European Marine Waters. Project Marina, Report No. EUR 12483, Office for Official Publication of the European Community, Luxembourg.

Costanza, R., R., D'Arge, R., De Groot, S., Farber, M., Grasso, B., Hannon, S., Naeem, K., Limburg, J., Paruelo, R.V., O'Neill, R., Raskin, P., Sutton and van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. Nature 387:253-260.

Dahle, S., Matishov, G., Savinov, V., Savinova, T., Velvin, R., Jørgensen, E., Virin, A. and Evanset, A. (2000). Organochlorines in harbours in northern Norway and Russia. In: Workshop on Persistent Organic Pollutants (POPs) in the Arctic: Human health and Environmental Concerns, Rovaniemi 18-20 January 2000.

Denisov, V.V. (2002). Ecological and geographical basis for the efficient nature-use in shelf seas (ecological geography of the sea). Apatity, Russia. (In Russian).

Dotterud, L.K., Odland, J.O., and Falk, E.S. (2000). Atopic diseases among adults in the two geographically related arctic areas Nikel, Russia and Sor-Varanger, Norway: possible effects of indoor and outdoor air pollution. Journal of the European Academy of Dermatology and Venereology 14:107-111.

Dotterud L.K., Odland, J.O., and Falk E.S. (2001). Atopic diseases among schoolchildren in Nikel, Russia, an Arctic area with heavy air pollution. Acta Dermato-Venereologica 81:198-201.

Dvornyakov, V.A. (2000). Fisheries of Russia: on the eve of change. Moscow, International relations. (In Russian).

FAO (1993). Marine Fisheries and The Law of the Sea: A Decade of Change. Special chapter (rev.) in The State of Food and Agriculture 1992. Fisheries Circular FAO, No. 853. Rome.

FAO (1995). Code of Conduct for Responsible Fisheries. Twenty-eighth FAO Conference, 31 December 1995. Available at: http://www.fao.org/fi/agreem/codecond/codecon.asp

FAO (1997). Review of the state of world aquaculture. FAO Inland Water Resources and Aquaculture Service, Fishery Resources Division. FAO Fisheries Circular. No. 886, Rev. 1. Rome, FAO. Retrieved from: http://www.fao.org/docrep/003/w7499e/w7499e09.htm

FAO (2004). Fisheries Information Center. United Nations Food and Agriculture Organization. Retrieved from: http://www.fao.org./fi/default_all.asp

Fiskeridirektoratets havforskningsinstitutt (1997). The Precautionary Approach to North Sea Fisheries Management. Oslo, 9-10 Sept., 1996: Seminar report. Fisken og havet #1.

Glukhovsky, B.Kh. (ed.) (1991). Hydrometeorology and hydrochemistry of the seas of the UUSR. Volume 2. White Sea. Leningrad, Hydrometeoizdat. (In Russian).

Gollasch, S. and Leppäkoski, E. (eds.) (1999). Initial risk assessment of alien species in Nordic coastal waters. Nord 1999:8.

Government of the Russian Federation (2003). The Conception of the Development of the Fisheries Sector of the Russian Federation for the period until 2020. Report #1265-r (02.09.2003). (In Russian).

Green, N. (1997). Joint Assessment and Monitoring Program (JAMP). National Comments to the Norwegian data for 1995. Norwegian Pollution Control Authority, Monitoring report no 685/97 TA no. 1405/1997. NIVA pr. 80106, report N 3597-97: 124 pp.

Green, N. (1999). Joint Assessment and Monitoring Program in Norway (JAMP). Contaminants- Oslofjord area, Lista, Sørfjorden, Hardangerfjorden, Bømlo, Lofoten and Varangerfjord. NIVA pr. 80106, 18.1.1999.

Henriksen, A., Mannio, J., Wilander, A., Moiseenko, T., Traaen, T.S., Skjelkvåle, B.L., Fjeld, E. and Vuorenmaa, J. (1997). Regional lake survey in the Barents region of Finland - Norway - Sweden and Russian Kola 1995 - results. Acid Rain Research Report 45.

Hoel, A.H. (1994). The Barents Sea: Fisheries Resources for Europe and Russia. In: Stokke, O.S. and Tunander, O. (eds.) The Barents Sea Region. Cooperation in Arctic Europe. London, SAGE Publications.

Holm, P., Rånes, S.A. and Hersoug, B. (2002). Political attributes of rights-based management systems: the case of individual vessel quotas in the Norwegian coastal cod fishery. In: Symes, D. (ed.) Powerty rights and regulatory systems in the fisheries. Oxford, Fishing News Books, p 113-126.

Hønneland, G. (2000). Coersive and Discussive Compliance Mechanisms in the Management of Natural Resources. A case study from the Barents Sea Fisheries. Kluwer Academic Publishers.

Hopkins, C.C.E. (2000). A review of introductions and transfers of alien marine species in the North Sea area. Report to the Norwegian Ministry of the Environment for the Fifth Ministerial Conference on the Protection of the North Sea. AquaMarine Advisers.

Hopkins, C.C.E. (2001). Actual and potential effects of introduced marine organisms in Norwegian waters, including Svalbard. Report to the Norwegian Directorate of Nature Management. Research Report DN 2001-1..

ICES (1995). ICES Code of Practice on the Introductions and Transfers of Marine Organisms 1994. ICES Coop. Res. Rep. No. 204.

ICES (2000). Report of the Working Group on Introductions and Transfers of Marine Organisms, Parnu, Estonia, 27-29 March 2000. International Council for the Exploration of the Sea, Copenhagen. ICES CM 2000/ACME: 07 Ref.: E+F, Copenhagen.

ICES (2003a). Report of the ICES Advisory Committee on Fishery Management 2002. ICES Cooperative Research Report No. 255.

ICES (2003b). International Council for the Exploration of the Sea. Retrieved from: http://www.ices.dk/

Illin, G.V., and Dahle, S. (1997). Heavy metals in bottom sediments. Kola Bay: oceanography, biology, ecosystems, pollutants. Russian Academy of Sciences, Kola Scientific Center, Apatity.

IMO (1997). Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens. Resolution A.868(20), International Maritime Organization, London.

Institute of Marine Research (2002). Havets Ressurser. Havforsknings-instituttet. Bergen.

Isaksen, K. and Wiig, O. (eds.) (1995). Conservation value assessment and distribution of selected marine mammals in the Northern Barents Sea. Editors:. Norsk Polarinstitutt. Oslo, Norway.

Iudicello, S., Weber, M., and Wieland, R. (1999). Fish, Markets, and Fishermen. The Economics of Overfishing. London. EARTHSCAN.

Ivanov, G.I. (2002). Methodology and results of the Barents Sea ecogeochemical research. St. Petersburg. (In Russian).

Joint Norwegian-Russian Expert Group (1992). A Survey of Artificial Radionuclides in the Kara Sea. Results from the Russian-Norwegian 1992 expedition to the Barents and Kara Seas. Joint Norwegian-Russian Expert group for Investigation of Radioactive Contamination in the Northern Areas. Norway.

Kashulin, N.A., Reshetnikov, Y.S. and Amundsen, P.-A. (1997). Response of whitefish (Coregonus lavaretus L.) to heavy metal pollution in lakes at the Norwegian-Russian border. In: Reiersen, L.-O., Stone, D., Liljelund, L.-E., Facius, F. and Wilson, S. (eds.) The AMAP International Symposium on Environmental Pollution in the Arctic, Tromsø, June 1-5, 1997. p 210-212.

Kashulin, N.N., Lukin, A.A. and Amundsen, P.-A. (1999). Fish of subarctic freshwater systems as bioindicators of industrial pollution. Kola Science Centre, Russian Academy of Sciences. Monograph. (In Russian with an English summary).

Kashulin, N.A., Amundsen, P.-A. Bøhn, T., Dalsbø, L., Koroleva, I.M., Kudrecetcheva, L.P., Sandimirov, S.S. and Terentev, P.M. (2003). Environmental monitoring in the Pasvik watercourse 2002. Report, INEP Kola Science Centre, and NFH, University of Tromsø.

Klungsøyr, J., Saetre, R., Føtn, L. and Loeng, H. (1995). Man's impact on the Barents Sea. Arctic 48(3): 279-296.

Kolvulehto, M., Saxen, R., Tuominen, K. (1980). Radioactivity in Finland, 1978. Annual Report, STL-A-32, Helsinki.

Konieczny R.M. (1996). Sonderende undersøkelser i norske havner og utvalgte kystomreder. Miljøgifter i sedimenter pe strekningen Ramsund-Kirkenes. NIVA-rapport nr. 0-93177. SFT-rapport nr. 608/95, TA nr. 1215/1995. - Oslo: NIVA. 1996. (In Norwegian).

Kotenev, V.N. (2000). Problems of the home fishery. The ways out of the crisis. Fishery of Russia. # 3. p 11-14. (In Russian).

Krasnov, Yu.V., Matishov, G.G., Galaktionov, K.V. and Savinova, T.N. (1995). Murman's colonial seabirds. St. Petersburg, Nauka. (In Russian).

Kuzmin, S.A., Akhtarin, S.M. and Menis, D.T. (1998). First founding of snow crab Chionoecetes opilio (Fabricius) (Decapoda, Majidae) in the Barents Sea. Zoological Journal. 77(4):489-491. (In Russian).

Kuzmin S.A., Akhtarin S.M. and Menis D.T. (1999). The first finding of the snow crab Chionoecetes opilio (Fabricius) (Decapoda, Majidae) in the Barents Sea. Canadian Technical Report of Hydrography and Ocean Sciences. 5667:1-5.

Kuzmin, S.A. and Gudimova, E.N. (2002). Introduction of the red king crab in the Barents Sea. Peculiarities of biology, perspectives of fishery. Apatity, KSC RAS Publishing House. (In Russian).

Kuzmin, S.A. (2001). New data on the distribution of snow crab Chionoecetes opilio (Fabricius) in the Barents Sea. In: Ivanov B.G. (ed.) Investigations of commercial crustaceans and algae biology in Russian seas: Collection of scientific papers. Moscow. VNIRO. p 94-97. (In Russian).

Kuzmin, S.A. (2000). Spreading of snow crab Chionoecetes opilio (Fabricius) in the Barents Sea. In: ICES C.M Documents 2000 (88th Statutory Meeting, Annual Science Conference 2000, Bruges, Belgium and the 2000 ICES Annual Report.

Larsen, L.H.,Fieler, R., Øiestad, V., Bjørvatn, T. and Aslaksen, J.A. (1994). Masterplan for Aquaculture in Northweatern Russian Federation. Ministry of Foreign Affairs, Norway.

LENKA (1990). National-wide suitability assessment of the Norwegian coastal zone and rivers for aquaculture. Norwegian official report (NOU):22. (In Norwegian).

Leppäkoski, E., S. Gollasch and Olenin, S. (2003). Invasive aquatic species of Europe - distribution, impact and management. Kluwer Academic Publishers, Dordrecht, the Netherlands.

Loring, D.H., Naes, K., Dahle, S., Matishov, G.G. and Illin, G. (1995). Arsenic, trace metals, and organic micro comtaminants in sediments from the Pechora Sea, Russia. Marine Geology. International Journal of Marine Geology, Geochemistry and Geophysics, 128(3-4):153-167.

Makarevich, P.R., Druzhkov, N.V. and Bobrov, Yu.A. (1991). Phytoplankton of the mixing zone between Barents and White Seas. In: Agarova, I.Ya. and Gupalo, E.Yu. (eds.). Phytoplankton researches in monitoring of Baltic and other seas of the USSR. Moscow: 121-134. (In Russian).

Makarevich, P.R. and Larionov, V.V. (1992). Taxonomic composition of phytoplankton and history of phytoplankton studies in the Barents Sea. In: Kuznetsov, L.L. (ed.) Phytoplankton of the Barents Sea. Apatity: 17-51. (In Russian).

Makhon'ko, K.P. (ed.) (1987). Radiation situation on the territory of the UUSR. Annual-book. Obninsk. SPA "Typhoon". (In Russian).

Makhon'ko, K.P. (ed.) (1988). Radiation situation on the territory of the UUSR. Annual-book. Obninsk. SPA "Typhoon". (In Russian).

Makhon'ko, K.P. (ed.) (1989). Radiation situation on the territory of the UUSR. Annual-book. Obninsk. SPA "Typhoon". (In Russian).

Makhon'ko, K.P. (ed.) (1990). Radiation situation on the territory of the UUSR. Annual-book. Obninsk. SPA "Typhoon". (In Russian).

Makhon'ko, K.P. (ed.) (1991). Radiation situation on the territory of the UUSR. Annual-book. Obninsk. SPA "Typhoon". (in Russian)

Makhon'ko, K.P. (ed.) (1992). Radiation situation on the territory of Russia and adjacent states. Annual-book. Obninsk. SPA "Typhoon". (In Russian).

Makhon'ko, K.P. (ed.) (1993). Radiation situation on the territory of Russia and adjacent states. Annual-book. Obninsk. SPA "Typhoon". (In Russian).

Makhon'ko, K.P. (ed.) (1994). Radiation situation on the territory of Russia and adjacent states. Annual-book. Obninsk. SPA "Typhoon". (In Russian).

Makhon'ko, K.P. (ed.) (1995). Radiation situation on the territory of Russia and adjacent states. Annual-book. Obninsk. SPA "Typhoon". (In Russian).

Makhon'ko, K.P., Avramenko, A.S., Bobovnikova, C.I. and Chumichev, V.B. (1977). Coefficient of strontium 90 and cesium 137 discharge from the surface of the soils of river basin. Meteorology and hydrology, #10. (In Russian).

Matishov, G.G. (ed.) (1986a). Life and conditions of its existence in the Barents Sea benthal zone. Apatity. (In Russian).

Matishov, G.G. (ed.) (1986b). Fish fauna and conditions of its existence in the Barents Sea. Monograph. Apatity. (In Russian).

Matishov, G.G. (ed.) (1997). The Kola Bay: oceanography, biology, ecosystems, pollutants. Apatity: Publ. KSC RAS.

Matishov, G.G. (ed.) (1998). Harvesting and perspective algae and invertebrates for uses of the Barents and white Seas. Apatity, KSC RAS Publishing House. (In Russian).

Matishov, G.G. (ed.) (1999). Adaptation and evolution in biota of polar seas under the oceanic periglacial conditions. Apatity, KSC RAS Publishing House. (In Russian).

Matishov, G.G. and Rodin, A.V. (eds.) (1996). Atlantic cod: biology, ecology, and fishery. St. Petersburg. Publ. "Nauka". (In Russian).

Matishov, G.G. and Nikitin, B.A. (eds.) (1997). Scientific and methodological approaches to the environmental impact assessment of oil and gas extraction on the ecosystems of Arctic seas. Apatity.

Matishov, G.G. and Denisov, V.V. (2000). Ecosystems and biological resources of Russian European Seas on the turn of the 21st century. Murmansk, MMBI.

Matishov, D.G. and Matishov, G.G. (2001). Radiation ecological oceanology. Apatity: Publishing House of the Kola Scientific Center RAS. (In Russian).

Matishov, G.G., Matishov, D.G., Shchipa, E. and Rissanen, K. (1994). Radionuclides in the ecosystem of the Barents and Kara Sea region. Apatity, Publishing House of the Kola Scientific Center RAS. (In Russian).

Matishov, G.G., Zuev, A., Golubev, V., Adrov, N., Slobodin, V., Levitus S. and Smolyar I. (1998). Climatic atlas of the Barents Sea 1998: temperature, salinity, oxygen. Murmansk Marine Biological Institute, National Oceanographic Data Center, Ocean Climate Laboratory, Washington, U.S.

Matishov, G., Makarevich, P., Timofeev, S., Kuznetsov, L., Druzhkov, N., Larionov, V., Golubev, V., Zuyev, A., Adrov, N., Denisov, V., Iliyn, G., Kuznetsov, A., Denisenko, S., Savinov, V., Shavikyn, A. Smolyar, I., Levitus, S., O'Brien, T. and Baranova, O. (2000). Biological Atlas of Artic Seas - Plankton of the Barents and Kara Seas. Silver Spring. World Oceanographic Data Center.

Matishov, G.G., Denisov, V.V., Dzenyuk, S.L., Tarasov, G.A. and Khasankaev, V.B. (2001). Problems and methods of ecological monitoring of the west arctic seas and coastal zones. Apatity, KSC RAS Publishing House. (In Russian).

MegaPesca. (1999). Study of the discards in Fisheries. Draft Final Report No. EP/IV/B/STOA/98/1701. April 1999. Portugal. Available at: http://www.megapesca.com/stoapo~2.htm

Molvær, J., Knutzen, J., Magnusson, J., Rygg, B., Skei, J and Sørensen, J. (1997). Klassifisering av miljøkvalitet i fjorder og kystfarvann. Veiledning. (Classification of environmental quality in fjords and coastal waters. A guide) SFT veiledning 97: 03. (In Norwegian).

Muir, D., Savinova, T., Savinov, V., Alexeeva, L., Potelov, V., and Svetochev, V. (2003). Bioaccumulation of POPs and chlorinated pesticides in seals, fishes and invertebrates from the White Sea, Russia. The Science of the Total Environment 306:111-132

Mukhin, A.I. and Solodovnikov, L.G. (2002). All-Russian fishery in 2001 (Review). Fishery 2:21-27. (In Russian).

Murmansk Region Administration (2001). Conception of the social and economic development of the Murmansk Region for the period till 2015. Report #47-pg of 08.02.2001. Apatity-Murmansk. (In Russian).

Murmansk Region Administration (2002). Major principles of the strategy for the development of the Murmansk Region for the period till 2015. Report #251-pp of 20.12.2001. Apatity-Murmansk. (In Russian).

Murmansk Region Administration (2003). The Plan for the clean-up of the Murmansk Region coast in the case of an oil-spill. Saint-Petersburg, 2003. (In Russian).

Murmansk Region Directorate of Natural Resources and Environmental Protection (1999). Environmental Status and Protection in the Murmansk Region in 1998. Annual Report. (In Russian)

Murmansk Region Directorate of Natural Resources and Environmental Protection (2001). Environmental Status and Protection in the Murmansk Region in 2000. Annual Report. (In Russian).

Nakken, O. (1998). Past, Present and Future Exploitation and Management of Marine Resources in the Barents Sea and Adjacent Areas. Fisheries Research. V. 37/1-3. p 23-35.

Namyatov, A.A. (1998). Radiation contamination of the Kola and Motovsky Bays of the Barents Sea. Thesis for a Candidate's Degree (11.00.11). Saint-Petersburg.

Norwegian Directorate of Fisheries (2001). Notat. Tiltak for a styrke ressurskontrollen, Bergen. (In Norwegian)

Norwegian Directorate of Fisheries (2002). Economic and biological key figures from Norwegian Fisheries. Available at: http://www.fiskeridir.no/sider/statistikk/nokkeltall/nokkeltall02.pdf.

Norwegian Directorate of Fisheries (2003). Finnmark and Norges Råfisklag Available at: www.rafisklaget.no. (In Norwegian)

Norwegian Directorate of Fisheries (2004). Retrieved from: www.fiskeridir.no

Norwegian Ministry of Fisheries (2002). Protocol for the 31 Session of the Joint Norwegian-Russian Fisheries Commission, November, 2002. Available at: http://odin.dep.no./fid/.

Norwegian Ministry of Fisheries (2002-2003). St meld # 20, Attachment 5

Norwegian Ministry of Fisheries (2004). Retrieved from: http://odin.dep.no./fid/

NSIDC (2004). Sea ice trends and climatologies from SMMR and SSM/I. Retrieved May 2004 from: http://nsidc.org/data/smmr_ssmi_ancillary/gis/index.html

Objectives and uncertainties in fisheries management with emphasis on three north Atlantic ecosystems (1997). An international Fisheries Symposium Bergen, Norway 3-5 June 1997, Bergen, Norway, 1997.

Odland, J.O., Nieboer, E., Romanova, N., Thomassen, Y., Norseth, T. and Lund, E. (1999). Urinary nickel concentrations and selected pregnancy outcomes in delivering women and their newborns among arctic populations of Norway and Russia. Journal of Environmental Monitoring 1:153-161.

Odland, J.O. (2000). Doctoral thesis: Environmental and occupational exposure, life-style factors and pregnancy outcome in arctic and sub-arctic populations of Norway and Russia. ISM Skriftserie Nr. 50. Institute of Community Medicine, University of Tromsø, 2000.

Orlov, Yu.I. (1965). On the Works on the acclimatisation of the Kamchatka crab in the Barents Sea//ICES CM 1965. Shellfish Committee. №124:2

Orlov, Yu.I. (1977). Introduction of commercial crabs into the Barents Sea. Fishery 9. p 20-22. (In Russian).

Orlov, Yu.I. (1978). Red king crab - a new inhabitant of the Barents Sea. Nature 3. (In Russian).

ORNL (2003). Landscan 2002. Oak Ridge National Laboratory. Retrieved November 2003 from: http://www.ornl.gov/gist

Ozolin'sh, A.V. and Spiridonov, V.A. (2001). The strategy for conservation of the coastal zone biodiversity of the Fareastern ecoregion. WWF Project. Vladivostok. (In Russian).

Patin, S.A. (2001). Oil and continental shelf ecology. Moscow. VNIRO. (In Russian).

PINRO (2000). Recommendations of the VIII All-Russian Conference on the problems of the sea forecasts. Murmansk, 23-25 October. (In Russian).

Porter, G. (1997). The Role of Trade Policies in the Fishing Sector // Background paper for UNEP/WWF Workshop, Fishing Subsidies, Overfishing, and Trade, June 2-3, Geneva, Switzerland.

Research Institute of the Atmospheric Air Protection (1998). Pollutant discharges into the atmosphere of the cities and regions of the Russian Federation in 1997. Annual-book.. St. Petersburg. (In Russian).

Richter, G.D. (ed.) (1966). The North of the European Part of the USSR. Moscow: Nauka. (In Russian).

Salo, A., Voipio, A. (1972). Transport of radionuclides in lake and river system flowing through areas characterized by Precambrian bedrock peat bogs. Radioactive Contamination of the Marine Environment. Proceedings of a Symposium, Seattle, 10-14 July.

Sandlund, O.T., Schei, P.J. and Viken, A. (eds.) (1996). Proceedings of the Norway/UN Conference on Alien Species. Trondheim, Norway, 1-5 July 1996. Directorate for Nature Management (DN) and Norwegian Institute for Nature Research (NINA).

Sapozhnikov, V.A. and Sokolova, S.A. (1994). Contaminants in the White Sea water and Bottom sediments. Complex investigations of the White Sea ecosystem. Moscow, VNIRO. (In Russian).

Savinov, V., Savinova, T., Carroll, J., Matishov, G., Dahle, S. and Naes, K. (2000). Polycyclyc aromatic hydrocarbons (PAHs) in sediments of the White sea, Russia. Marine Pollution Bulletin 40: 807-818.

Savinova, T., Chernyak, S., Dahle, S., Matishov, G., Begnoche, L., James, P., Hickey, J., Savinov, V. and Virin, A. (2000). Levels and distribution of organochlorine residues in surface bottom sediments from the Kola Bay and Guba Zapadnaya Litsa, Barents Sea; Russia. In: Workshop on Persistent Organic Pollutants (POPs) in the Arctic: Human health and Environmental Concerns", Rovaniemi 18-20 January 2000.

Savinov, V., Savinova, T., Matishov, G.G., Dahle, S. and Naes, K. (2003a). Polycyclic aromatic hydrocarbons (PAHs) and organochlorines (OCs) in bottom sediments of the Guba Pechenga, Barents Sea, Russia. Science of the Total Environment 306:39-56.

Savinov, V., Savinova, T. and Gabrielsen, G. (2003b). Cadmium, zinc, copper, arsenic, selenium and mercury in seabirds from the Barents sea: levels, inter-specific and georgaphical differences. Science of the Total Environment 306:1333-158.

Semina, H.I. and Sergeeva, O.M. (1983). Plankton flora and bio-geographical description of phytoplankton of the White Sea. Trugy Belomorskoy Biologicheskoy stantsii MGU. 6: 3-17.

Seterås, S. (2001). Kommersiell fangst av kongekrabbe i 2002. In "Fiskets gang". (In Norwegian).

Sevgidromet (1992). Annual-book of the sea waters quality by hydrochemical indices for 1991. "Obninsk". (In Russian).

Sevgidromet (1994). Annual-book of the sea waters quality by hydrochemical indices for 1993. "Obninsk". (In Russian).

Sevgidromet (1995). Annual-book of the sea waters quality by hydrochemical indices for 1994. "Obninsk". (In Russian).

Sevgidromet (1996). Annual-book of the sea waters quality by hydrochemical indices for 1995. "Obninsk". (In Russian).

SFT (2002). Air Pollution Effects in the Norwegian - Russian Border Area. Norwegian Pollution Control Authority. TA 1860/2002.

Shevchenko, V.V., Nikonorov, I.V. and Komlichenko, V.V. (2001). Biological and economic efficiency of marine resources exploitation in the Northern Basin of Russia. Problems in fishery. Vol. 2. 2(6):194-222 (In Russian).

Shevelev, M.S. and Yaragina, N.A. (1998). Investigations of the Barents Sea bottom fish species from "Andrey Pervozvanny" to nowadays. Abstracts of presentations of the VII All-Russian Conference on the problems of the sea forecasts. Murmansk, 7-9 October. p 188-189. (In Russian).

Sirenko, B.I. (ed.). (2001). List of species of free-living invertebrates of Eurasian arctic seas and adjacent deep waters. St. Petersburg.

Skjelkvåle, B.L., Andersen, T., Fjeld, E., Mannio, J., Wilander, A., Johansson, K., Jensen, J.P., and Moiseenko, T. (2001). Heavy metal surveys i Nordic lakes; concentrations, geographic patterns and relation to critical limits. Ambio 30:2-10.

Skjoldal, H.R. (2000). Management of Marine Living Resources in a Changing Ocean Climate. Institute of Marine Research. Bergen, Norway.

Smith-Sivertsen, T., Bykov, V., Melbye, H., Tchachtchine, V., Selnes, A. and Lund E. (2001). Sulphur dioxide exposure and lung function in a Norwegian and Russian population living close to a nickel smelter. International Journal of Circumpolar Health 60(3):342-59.

SRW/MMBI (2000). Contamination assessment of the Barents Sea commercial species. Regional program. Report on the SRW/MMBI KSC RAS, 2000. Murmansk. (In Russian).

State Committee for Sanitary and Epidemiological Control of the Russian Federation (1997). Hygienic requirements for the quality and safety of foodstuffs, sanitary standards and rules (SanPin 2.3.2.). Report #27 (24.10.96). Moscow: State System of Sanitary-epidemiological regulations of the Russian Federation, 1997: 560-96. (In Russian).

State Environmental Committee of the Murmansk Region (1999). Environmental status and ecological problems on the Kola Peninsula in 1998. Report. Murmansk. (In Russian).

State Statistics Committee of the Russian Federation (2001). Regions of Russia. Statistics Reference Book. Moscow. (In Russian).

State Statistics Committee of the Russian Federation (2002a). Demographic Annual. Statistics Annual Book. Moscow. (In Russian).

State Statistics Committee of the Russian Federation (2002b). Regions of Russia. Statistics Reference Book. Moscow. (In Russian).

State Statistics Committee of the Russian Federation (2002c). The Industry of Russia. Statistics Reference Book. Moscow (In Russian).

State Statistics Committee of the Russian Federation (2003). Demographic Annual. Statistics Annual Book. Moscow. (In Russian).

Sundet, J. (2003). Kongekrabbe. In: Michalsen, K. (ed.) Havets Ressurser 2003, Fiske og Havet, 1:130-132. (In Norwegian).

Tchachtchine, V.P. and Talykova, L.V. (1997). Air pollution and non-violent mortality in arctic cities of Russia: a time trend analysis. The AMAP International Symposium on Environmental Pollution in the Arctic. Tromso, Norway, June 1-5, 1997.

Terziev, F.S. et al. (eds.). 1990. Hydrometeorology and hydrochemistry of the seas of the UUSR. Volume 1. Barents Sea. Issue 1. Hydrometeorological conditions. Leningrad, Hydrometeoizdat. (In Russian).

Titova, G. (2001). Rental Payments for Aqua Bioresources. Part 1. An evaluation of Russia's state quotas management system. UK. Geophylos, Autumn No. 01(2), p 116-128

Titova, G.D. (2003). Crisis in the world fisheries: economic and legal problems. St. Petersburg. (In Russian).

Toresen, R. (ed.) 2000. Havets Ressurser. Fisken og havet, 1:2000. Havforsknings instituttet, Med Bidrag Fra Fiskeriforskning Februar 2000.

Traaen, T.S., Moiseenko, T., Dauvalter, V., Rognerud, R., Henrikesen A. and L.Kudravseva (1991). Acidification of Surface Waters, Nickel and Copper in Water and Lake Sediments in the Russian-Norwegian Border Areas. Progress Report for 1989-1990. Working Group for Water and Environmental Problems under the Norwegian-Soviet Environmental Protection Commission. Oslo and Apatity.

UN (1995). Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. United Nation Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks. Sixth session. New York. 24 July - 4 August 1995. Available at: http://www.un.org/Depts/los/convention_agreements/texts/fish_stocks_agreement/CONF164_37.htm

UNCED (1992). United Nations Conference on Environment and Development. Rio de Janeiro, Brazil. 3-14 June 1992. Agenda 21, the United Nations Program of Actions from Rio. Available at: www.un.org/esa/sustdev/documents/Agenda21/

UNCLOS (1982). United Nations Convention on the Law of the Sea. Montego Bay, Jamaica, 10 December. Available at: http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm

USGS (2002). Global GIS database: Global Land Cover Characteristics. CD-rom. US Department of the Interior, US Geological Survey, Flagstaff, USA.

USGS (2003). GROPO30. Retrieved September 2003 from: http://edcdaac.usgs.gov/gtopo30.asp

Vakulovsky, S.M., Nikitin, A.I. and Chumichev, V.B. (1985). On the contamination of the Arctic seas by the wastes from the West European radio-technical enterprises. Atomic energy. 58(6):445-449. (In Russian).

Vakulovsky, S., Nikitin, A., Chumichev, V. and Malyshev, S. (1993). Radioactive Contamination of the Barents and Kara Seas. International meeting on Assessment of Actual and Potential Consequences of Dumping of Radioactive Waste into the Arctic Seas. Working material. p 53-55.

VNIERH (1997). Decree of the XLIII Plenum of the Interdepartmental ichthyological Commission dated March 20, 1997. Moscow. (In Russian).

Voitolovsky, G.K., Kireev, V.E., Korzun, V.A., Ranenko, V.V. and Titova, G.D. (2003). Reflecting on fisheries (in search of solution). Moscow, SOPS. (In Russian).

Weidema, I.R. (ed.) (2000). Introduced species in the Nordic countries. Nord 2000:13.

WSSD (2002). World Summit on Sustainable Development. Johannesburg, South Africa. 26 August - 4 September. Available at: www.johannesburgsummit.org/html/documents/summit_docs/131302_wssd_report_reissued.pdf

Annexes

Annex I
List of contributing authors and organisations

Name	Organisation/Institution	Country
Prof. Academician Gennady G. Matishov	Murmansk Marine Biological Institute KSC RAS, Director	Russia
Dr. Natalia I. Golubeva	Murmansk Marine Biological Institute KSC RAS, Director's Deputy	Russia
Dr. Galina D. Titova	Ecological Safety Scientific Research Centre RA	Russia
Dr. Are K. Sydnes	Norwegian College of Fishery Science, University of Tromsø	Norway
Ms. Barbara Voegele	Akvaplan-niva	Norway
Dr. Tatiana N. Savinova	Akvaplan-niva	Norway
Dr. Vladimir V. Denisov	Murmansk Marine Biological Institute KSC RAS, Director's Deputy	Russia
Dr. Sergey L. Dzhenyuk	Murmansk Marine Biological Institute KSC RAS, Science Secretary	Russia
Mr. Anatoly M. Vasilyev	Arctic Centre of the Economical Problems Institute KSC RAS, Director's Deputy	Russia
Dr. Sergey A. Kuzmin	Murmansk Marine Biological Institute KSC RAS	Russia
Ms. Nadezhda E. Kasatkina	Murmansk Marine Biological Institute KSC RAS	Russia
Mr. Vitaly V. Ponomarev	Murmansk Marine Biological Institute KSC RAS	Russia
Dr. Dmitry G. Matishov	Murmansk Marine Biological Institute KSC RAS, Deputy Director	Russia
Mr. Roman Mikhalyuk	Murmansk Marine Biological Institute KSC RAS	Russia
Dr. Konstantin V. Drevetnyak	Polar Scientific Research Institute of Fisheries and Oceanography (PINRO)	Russia
Dr. Nikolay A. Kashulin	The North Industrial Ecology Problems Institute KSC RAS, Director's Deputy	Russia
Prof. Martin G. Khublaryan	Institute of Water Problems RAS, Director	Russia
Dr. Georgy P. Kiselyev	The North Ecological Problems Institute of the Ural Branch RAS	Russia
Ms. Valentina M. Knyagnitskaya	Murmansk Regional Natural Resources Committee of the Ministry of Natural Resourcesof the Russian Federation	Russia
Dr. Petr A. Lozovik	The North Water Problems Institute of the Karelian Scientific Centre RAS, Hydrochemistry and hydrogeological Laboratory Chief	Russia
Ms. Olga I. Mokrotovarova	Murmansk Regional Administration for Hydrometeorology and Environment Monitoring, Environmental Monitoring Centre Chief	Russia
Dr. Aleksey A. Namyatov	Murmansk Marine Biological Institute KSC RAS	Russia
Dr. Natalia F. Plotitsina	Polar Scientific Research Institute of Fisheries and Oceanography (PINRO)	Russia
Dr. Tatiana I. Roskoshnaya	Ecological Safety Scientific Research Centre RAS.	Russia
Dr. Vladimir S. Selin	Economical Problems Institute KSC RAS, Director	Russia
Mr. Anatoly V. Semenov	Murmansk Regional Administration for Hydrometeorology and Environment Monitoring, Director	Russia

Annex II
Detailed scoring tables

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
1. Modification of stream flow	0	-	Freshwater shortage	1
2. Pollution of existing supplies	2	-		
3. Changes in the water table	0	-		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	1	-
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	0	-
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	-
Weight average score for Economic impacts		**1**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	1	-
Degree of severity	Minimum – Severe 0 1 2 3	1	-
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	-
Weight average score for Health impacts		**1**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	0	-
Degree of severity	Minimum – Severe 0 1 2 3	0	-
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	-
Weight average score for Other social and community impacts		**0**	

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
4. Microbiological	0	-	Pollution	1
5. Eutrophication	0	-		
6. Chemical	1	-		
7. Suspended solids	0	-		
8. Solid wastes	1	-		
9. Thermal	0	-		
10. Radionuclide	1	-		
11. Spills	1	-		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	2	-
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	1	-
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	-
Weight average score for Economic impacts		**2**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	1	-
Degree of severity	Minimum – Severe 0 1 2 3	1	-
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	-
Weight average score for Health impacts		**1**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	0	-
Degree of severity	Minimum – Severe 0 1 2 3	0	-
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	-
Weight average score for Other social and community impacts		**0**	

III: Habitat and community modification

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
12. Loss of ecosystems	1	-	Habitat and community modification	1
13.Modification of ecosystems or ecotones, including community structure and/or species composition	1	-		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small — Very large 0 1 2 3	1	-
Degree of impact (cost, output changes etc.)	Minimum — Severe 0 1 2 3	0	-
Frequency/Duration	Occasion/Short — Continuous 0 1 2 3	1	-
Weight average score for Economic impacts		**1**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small — Very large 0 1 2 3	0	-
Degree of severity	Minimum — Severe 0 1 2 3	0	-
Frequency/Duration	Occasion/Short — Continuous 0 1 2 3	0	-
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small — Very large 0 1 2 3	0	-
Degree of severity	Minimum — Severe 0 1 2 3	1	-
Frequency/Duration	Occasion/Short — Continuous 0 1 2 3	1	-
Weight average score for Other social and community impacts		**1**	

IV: Unsustainable exploitation of fish and other living resources

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
14. Overexploitation	3	-	Unsustainable exploitation of fish	2
15. Excessive by-catch and discards	1	-		
16. Destructive fishing practices	1	-		
17. Decreased viability of stock through pollution and disease	0	-		
18. Impact on biological and genetic diversity	2	-		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small — Very large 0 1 2 3	2	-
Degree of impact (cost, output changes etc.)	Minimum — Severe 0 1 2 3	2	-
Frequency/Duration	Occasion/Short — Continuous 0 1 2 3	2	-
Weight average score for Economic impacts		**2**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small — Very large 0 1 2 3	1	-
Degree of severity	Minimum — Severe 0 1 2 3	1	-
Frequency/Duration	Occasion/Short — Continuous 0 1 2 3	1	-
Weight average score for Health impacts		**1**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small — Very large 0 1 2 3	2	-
Degree of severity	Minimum — Severe 0 1 2 3	2	-
Frequency/Duration	Occasion/Short — Continuous 0 1 2 3	2	-
Weight average score for Other social and community impacts		**2**	

V: Global change

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
19. Changes in the hydrological cycle	0	-	Global change	0
20. Sea level change	0	-		
21. Increased UV-B radiation as a result of ozone depletion	0	-		
22. Changes in ocean CO_2 source/sink function	0	-		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small 0 1 2 3 Very large	0	-
Degree of impact (cost, output changes etc.)	Minimum 0 1 2 3 Severe	0	-
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	0	-
Weight average score for Economic impacts		**0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small 0 1 2 3 Very large	0	-
Degree of severity	Minimum 0 1 2 3 Severe	0	-
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	0	-
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small 0 1 2 3 Very large	0	-
Degree of severity	Minimum 0 1 2 3 Severe	0	-
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	0	-
Weight average score for Other social and community impacts		**0**	

Comparative environmental and socio-economic impacts of each GIWA concern

	Types of impacts									
Concern	Environmental score		Economic score		Human health score		Social and community score		Overall score	Priority
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)		
Freshwater shortage	1	1	1	1	1	1	0	0	**1**	**4**
Pollution	1	2	2	2	1	2	0	0	**2**	**2**
Habitat and community modification	1	2	1	2	0	0	1	0	**1**	**3**
Unsustainable exploitation of fish and other living resources	2	2	2	2	0	0	2	1	**2**	**1**
Global change	0	1	0	0	0	0	0	0	**0**	**5**

Annex III
Detailed assessment tables

Concern: Pollution under present conditions / **Issue:** Chemical pollution / **Score given:** 1

Environmental impact indicator	Format	Extent or area covered	Duration and frequency	Reliability	Availability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
Volumes of discharges of contaminants into the atmosphere in the Barents Sea (tonnes/year); annual values of wet fallouts of pollutants on the Barents Sea surface (g/m^2).	Tables, reports	The Barents Sea region	1995-1999 annually	High to average (small sample size)	Available in open publications in Russian	MMBI research, published data of the Ministry of Environmental Protection and Natural Resources of the Russian Federation, Roshydromet, scientific literature	Copper, nickel, chromium and lead are believed to be the main pollutants entering the Barents Sea from the atmosphere as a result of the long-range atmospheric transport and from regional sources. Persistent organic pollutants enter the region mainly by long-range atmospheric transport; their concentrations are consistent with levels in other background areas[1] of the world.
Levels of contaminants in the estuarine parts of the Severnaya Dvina, Pechora, Kola, Pechenga rivers.	Table, report	Estuarine parts of the Severnaya Dvina, Pechora, Kola, Pechenga rivers	1995-2001 annually	High	Available in open publications in Russian	Published data of the Ministry of Environmental Protection and Natural Resources of the Russian Federation, Roshydromet, scientific literature	The prevailing pollutants are heavy metals (mainly copper, nickel and manganese), and organic substances. It should be stressed that the Kola and Severnaya Dvina rivers are the sources of drinking water for the towns and settlements situated within this area, including the largest towns of the region; Arkhangelsk and Murmansk. For this reason, there is a shortage of high-quality fresh drinking water. At the same time the river run-off volumes are low, resulting in heavy metal impacts in the near-shore zone only.
Levels of pollutants in the water and bottom sediments in different areas of the Barents Sea.	Report	The Barents Sea	1988-2000 intermittently investigations	Average	Available in open publications in Russian and English	MMBI Scientific Reports, Roshydromet published data, data of the Murmansk Administration of Hydrometeorological Service, Russian and foreign scientific literature	Despite the Kola Peninsula's metallurgic, mining, smelting and other industries, water and bottom sediment pollution is registered only for the Kola Bay.
Levels of pollutants in biota.	Report	The Barents Sea	1995-2000 intermittent investigations	Average	Available in open publications in Russian and English	MMBI Scientific Reports, Russian and foreign scientific literature	Despite the presence of regional sources of pollution, concentrations of heavy metals in biota are less than MAC[2]. Concentrations of chlorinated hydrocarbons in fish and invertebrates are much lower than the allowable limits.

Notes: [1] Background area = area located significantly far from emission sources. [2] MAC – Maximum Allowable Concentration

Concern: Pollution under present conditions / **Issue:** Radionuclides / **Score given:** 1

Environmental impact indicator	Format	Extent or area covered	Duration and frequency	Reliability	Availability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
Artificial radionuclide fallout in the Russain Polar North (10^7 Bq/km^2 per year) and surface water of the Kola Bay (10^9 Bq per year).	Tables, reports	The Barent Sea region	1986-1993 periodically	High	Available in open publications in Russian	MMBI scientific reports, monograph	A stable decrease of atmospheric fallout of artificial radionuclides is observed.
Input of ^{90}Sr, ^{137}Cs and tritium (10^9 Bq per year) into the Kola Bay with river run-off.	Tables, reports	The Kola Bay and adjacent coastal area	1961-1989 (strontium & cesium) 1986-1993 (tritium) annually	High	Available in open publications in Russian	MMBI scientific reports, monograph	For the period 1981-1993 the input of tritium into the Kola Bay with river run-off decreased by 1.5 times. The input of ^{137}Cs for 1965-1989 decreased by 11 times and ^{90}Sr for 1961-1989 by 1.2 times.
Concentrations of radionuclides in liquid radioactive waste discharged from RTE ATOMFLOT. Total inventory of discharges over time from RTE ATOMFLOT.	Table, reports	The Kola Bay and adjacent coastal area	1989-1994 annually	High	Available in open publications in Russian	MMBI scientific reports, monograph	Discharges from the RTE ATOMFLOT in 1992 of ^{137}Cs and ^{90}Sr into the Kola Bay with the river run-off were 2.1×10^8 and 2.6×10^7 Bq/year respectively. The annual discharge of these nuclides was the largest in 1992, the average year values for 1989-1994 were 1.6×10^7 and 7.6×10^7 Bq/year respectively.
Concentrations of artificial radionuclides in Barents Sea water (Bq/m^3).	Table	The Barents Sea	1990-2000 periodically	High	Available in open publications in Russian and English	Monograph	In the 1990s concentrations of ^{137}Cs, ^{90}Sr and $^{239,240}Pu$ in surface waters of the Barents Sea varied within the ranges 2-15, 1-7, and 4-8 Bq/m^3 correspondingly, which is consistent with background levels of global radioactive fallout.
Concentrations of artificial radionuclides in bottom sediments of the Barents Sea (Bq/kg).	Reports	The Barents Sea	1990-2000 periodically	High	Available in open publications in Russian and English	MMBI scientific reports, monograph	^{137}Cs and $^{239,240}Pu$ concentrations in Barents Sea bottom sediments clearly correlate with sediment type and are highest in clay silts deposited in shelf troughs.
Accumulation of artificial radionuclides in marine biota (Bq/kg).	Reports	The Barents Sea	1990-2000 periodically	High	Available in open publications in Russian and English	MMBI scientific reports, monograph	In 1980-1990s the accumulative level of radionuclides in the Barents Sea biota was low, reflecting input from global fallout.

Concern: Pollution under present conditions / **Issue:** Oil spills / **Score given:** 1

Environmental impact indicator	Format	Extent or area covered	Duration and frequency	Reli-ability	Avail-ability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
Oil hydrocarbon levels in the Barents Sea surface waters (mg/l) and bottom sediments (mg/g).	Report, table, scheme	The Barents Sea	1984-1993 annually, since 1993 Periodically	High	Available in open publications in Russian	MMBI scientific research, Roshydromet published data, scientific literature	On average, the level of oil contamination is not high and does not exceed MAC (0.05 mg/l). In the western areas the mean long-term concentration of oil products is 0.03 mg/l, and in the eastern areas 0.026 mg/l. The zone of the polar front is distinguished by a chain of areas with an increased concentration, up to 0.05 mg/l. Locally mean annual concentration of oil hydrocarbons may reach 0.46-1.13 mg/l. Oil hydrocarbon levels in bottom sediments varies within a wide range (202-2 176 mg/g) and is on average 676 mg/g.
Oil hydrocarbon concentration in surface waters (mg/l) and bottom sediments (mg/g) of the coastal and southeastern areas of the Barents Sea (the Pechora Sea).	Report, schemes	The Kola Bay, the coastal areas of the Kola Peninsula, the Pechora Sea	1990-2000 annually for Kola Bay, episodically for other areas	High	Available in open publications in Russian and English	MMBI scientific research, Roshydromet published data, scientific literature	Coastal waters, especially the Kola Bay, are the most polluted waters, caused by activities of local sources, which discharge petroleum products into the marine environment. The concentration of oil hydrocarbons can reach three and more MAC. Oil hydrocarbon levels in bottom sediments of Kola Bay might reach 1 280 mg/g dw.
PAH concentrations in bottom sediments (ng/g) in different areas of the Barents Sea.	Report, schemes	The open sea of the Barents Sea, the Kola Bay, the coastal area of the Kola Peninsula, the Pechora Sea	1990-2000 Periodically	Average	Available in open publications in Russian and English	MMBI scientific research, Roshydromet published data, scientific literature	ΣPAH levels in bottom sediments in the central part of the Barents Sea average 110 ng/g, reaching their highest value of 10 812 ng/g in the Kola Bay area.

Concern: Pollution under future conditions / **Issue:** Chemical pollution / **Score given:** 1

Environmental impact indicator	Format	Extent or area covered	Duration and frequency	Reli-ability	Avail-ability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
Air pollution changes over the Barents Sea associated with long-range atmospheric transport.	Table	The Barents Sea drainage basin	1995-1999 annually	High	Available in open publications	Survey/Review of the environment pollution in the Russian Federation for the year 2000. Roshydromet, Moscow, 2001.	On the basis of several years' monitoring data, there is nothing that suggests an increase of the atmospheric pollution over the Barents Sea water area from the Russian territory due to long-range and regional transport of sulfur and nitrogen compounds, heavy metals, or persistent organic pollutants.
The presence of contaminants in the Severnaya Dvina, Pechora, Kola, Pechenga rivers, in the Kola Bay, the Barents and White Seas.	Expert assess-ment	The Barents Sea drainage basin	Intermittent	Low	Available in open publications	Main regulations of the Murmansk Region development strategy for the period until 2015. Main directions of the strategy of socio-economic development of the Northwestern Federal Region of the Russian Federation for the period until 2015.	According to the plans for the development of the regions of the Russian Federation included into the Barents Sea region, considerable changes are not expected in the levels of heavy metals and persistent organic pollutants in the rivers flowing into the Barents Sea, or in Barents Sea itself.

Concern: Pollution under future conditions / **Issue:** Radionuclides / **Score given:** 1

Environmental impact indicator	Format	Extent or area covered	Duration and frequency	Reli-ability	Avail-ability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
Self-purification of marine waters.	Report	The Barents Sea region	1986-2002 periodically	High	Available in open publications in Russian and English	Monograph	High biological productivity together with thermohaline, hydrodynamic and lithodynamic factors leads to self-purification of the system so that cumulative impact from radionuclides on marine ecosystems is negligible.

Concern: Pollution under future conditions / **Issue:** Oil spills / **Score given**: 1

Environmental impact indicator	Format	Extent or area covered	Duration and frequency	Reli-ability	Avail-ability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
Barents Sea waters.	Report	The Barents Sea	Increasing cases of accidents	High	Available in open publications in Russian	MMBI scientific research, scientific literature	With increasing oil and gas activities on the Barents Sea shelf, the contamination of the waters of the Barents Sea will increase. The degree of increase in contamination will depend on reliability of the technologies used.

Concern: Unsustainable exploitation of fish under present conditions / **Issue:** Overexploitation / **Score given:** 3

Environmental impact indicator	Format	Extent or area covered	Duration and frequency	Reli-ability	Avail-ability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
Reductions in quotas, catches and stocks of commercially valuable fish for the last 30 years, vessel-quota, annual catch of commercial fish in tonnes.	Data, tables, diagrams, graphs, report	Barents and Norwegian Seas	Data for more than 20 years	High	Free	State Statistics, documents of the Joint Norwegian- Russian Fisheries Commission, scientific prognoses, reports and publications	Stable reductions of catches of cod, haddock, capelin and other commercially valuable fish during the last 30 years.
More than one species is exploited beyond MSY or VAC.	Data, tables, diagrams, graphs, report	Barents and Norwegian Seas	Data for more than 20 years	High	Free	State Statistics, documents of the Joint Norwegian- Russian Fisheries Commission, scientific prognoses, reports and publications	According to the experts' assessments, main commercial species are overfished by approximately 20%.

Concern: Unsustainable exploitation of fish under present conditions / **Issue:** Excessive by-catch and discards / **Score given:** 2

Environmental impact indicator	Format	Extent or area covered	Duration and frequency	Reli-ability	Avail-ability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
30-60% of catches consist of by-catch and discards into the sea.	Explanatory text	The Barents Sea	Data for more than 20 years	Low	Free	Scientific reports and publications	Data on the by-catch and discards are not adequately reflected in the official statistics. They can be judged on the basis of experts' assessments and scientific publications, indicating a wide prevalence of this phenomenon.

Concern: Unsustainable exploitation of fish under present conditions / **Issue:** Destructive fishing practices / **Score given:** 2

Environmental impact indicator	Format	Extent or area covered	Duration and frequency	Reli-ability	Avail-ability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
1-10 cases of sea bottom trawling take place annually.	Report	Barents Sea	Data for more than 20 years	High	Free	State statistics, scientific prognoses, reports and publications	There is a stable decrease in catches of cod, haddock, capelin and other commercially valuable fish during the last 30 years. The by-catch of other species, which are discarded into the sea, is possible.
Increased overcapacity of the fishing fleet significantly exceeding TAC.	Report, data, table	Barents Sea	Data for more than 20 years	High	Free	State statistics, scientific prognoses, reports and publications	The capacity of the fishing fleet exceeds TAC by a factor of 3-4. According to the experts' assessments, the main commercial fisheries are overfished approximately by 20%.

Concern: Unsustainable exploitation of fish under future conditions / **Issue:** Overexploitation, Excessive by-catch and discards, Destructive fishing practices / **Score given:** 2

Environmental impact indicator	Format	Extent or area covered	Duration and frequency	Reli-ability	Avail-ability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
Decreased fish stocks and quotas.	Report	Barents Sea	Till 2020	Low, due to scientific uncertainty and the lack of financial resources for monitoring	Free	Long-term prognoses, scientific reports and publications	The stocks and catches of commercially valuable species will continue decreasing in the nearest years if considerable amendments to the quotas management are not introduced and the methods of setting of TACs are not clarified, and/or political decisions on the fishers employment are not made.

Concern: Unsustainable exploitation of fish under present conditions / **Socio-economic impacts**

	Socio-economic indicator	Format	Extent or area covered	Duration or frequency	Reli-ability	Avail-ability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
Economic impacts Score: 3	Reduced economic returns.	Text, data, table	Northern fishery basin of Russia	More than 10 years	Average	Free	Scientific reports and publications, confidential sources	As a result of complex impact of natural and anthropogenic (overexploitation) factors, quotas for cod (the main fishery) for Russia decreased by 50% in 2002, compared to 1997. The profit of fishing companies and earning of fishers decreased correspondingly by 30-40%.
Health impacts Score: 1	Loss of food sources (e.g. sources of protein) for human or animal consumption.	Report	Russia fishing industry in the Barents and White Sea fisheries	Long-term	Low	Free	Scientific reports and publications	Average human consumption of marine products per person decreased more than twice in 2001, compared to 1990.
Other social and community impacts Score: 2	Loss of employment/livelihood.	Report data, table	Northern fishery basin of Russia	For more than 10 years	Average	Free	State statistics, scientific reports and publications	The reduction of quotas leads to a decrease in the number of fishing vessels and the unemployment. From 1997 to 2001, the number of fishers in the northern basin decreased from 30 000 to 22 000. The employment in fishery decreased from 6-12 months per year to 2-6 months by the year 2001, compared to the early 1990s. The unemployment increased by 50%.
	Conflict between user groups for shared resources including space.							The number of illegal bargains and conflicts has increased because of increased competition for quotas.
	Inter-generational equity issues (access to resources).							

Concern: Unsustainable exploitation of fish under future conditions / **Socio-economic impacts**

	Socio-economic indicator	Format	Extent or area covered	Duration or frequency	Reli-ability	Avail-ability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
Economic impacts Score: 2	Reduced economic returns and potential new employment possibilities.	Text	Barents Sea	Till 2020	Low	Free	Confidential sources, scientific reports and publications	It is expected that some legislative measures and political decisions will be taken, intended to increase control and enforcement in the fisheries, struggle against overexploitation, discards and by-catches, and decrease the unemployment in the fishing industry. Nevertheless, the economic returns in the fisheries sector are expected to decrease.
Health impacts Score: 1	Loss of food sources (e.g. sources of protein) for human or animal consumption.							Human consumption of marine products in Russia per person will not exceed 10-15 kg per year, while the recommended standard is 25 kg.
Other social and community impacts Score: 2	Loss of employment/livelihood.	Prognoses	Northern fishery basin of Russia	Till 2020	High	Free	Scientific reports, publications	There is an expected reduction of the fishery fleet capacity by a factor of 3. It will inevitably decrease the number of fishers by half. It is expected that overfishing and discards will take place, which may increase the overall crisis in the fisheries sector and the unemployment among fishers.
	Conflict between user groups for shared resources including space.							It is expected that crisis in the fisheries will increase the level of conflict between user groups.
	Inter-generational equity issues (access to resources).							

Concern: Unsustainable exploitation of fish under future conditions / **Issue:** Overexploitation, Excessive by-catch and discards, Destructive fishing practices (Finnmark, Norway)

Environmental impact indicator	Format	Extent or area covered	Duration and frequency	Reli-ability	Avail-ability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
Status of fish stocks and quotas.	Text	Barents Sea	Medium- to long-term	Low	Free	Report, official publication	Joint Norwegian-Russian Fisheries Commission has agreed upon a decision-making procedure based on scientific recommendations, restricting the parties when setting TACs for the Barents Sea fisheries.

Concern: Unsustainable exploitation of fish under present conditions / **Socio-economic impacts** (Finnmark, Norway)

	Socio-economic indicator	Format	Extent or area covered	Duration or frequency	Reli-ability	Avail-ability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
Economic impacts Score: 3	Reduced economic returns.	Text, data, tables	Norwegian fishing industry in the Barents Sea fisheries	Medium-term	High	Free	Scientific Reports	Reductions in fish stocks have led to decreased economic returns in the fishing industry.
Other social and community impacts Score: 2	Loss of employment/ livelihood.	Text, data, tables	Norwegian fish-processing industry and fleet in the Barents Sea fisheries	Medium- to long-term	High	Free	Scientific Reports	Reductions in fish stocks and market competition have led to a decrease in the number of fish-processing plants and a substantial long-term reduction in the number of fishing vessels and fishers.

Concern: Unsustainable exploitation of fish under future conditions / **Socio-economic impacts** (Finnmark, Norway)

	Socio-economic indicator	Format	Extent or area covered	Duration or frequency	Reli-ability	Avail-ability	Source	Explanation or justification how the indicator supports the conclusion made in the Assessment
Other social and community impacts Score: 1	Loss of employment.	Reports	Norwegian marine sector	Long-term	Moderate	Free	Official publications, Norwegian Ministry of Oil and Energy, Norwegian Ministry of Fisheries, Finnmark County	There is an expected long-term reduction in the employment of the fishing industry. However, it is expected that increased aquaculture and the drilling for gas in the Barents Sea may reduce the social and community impacts of reduced fishing opportunities.
	Conflicts between user groups for shared resources, including space.	Reports and statements	Norwegian marine sector	Medium-term	Moderate	Free	Official publications, Norwegian Ministry of Oil and Energy, Norwegian Ministry of Fisheries, Finnmark County	It is expected that a more diversified marine activity in the Barents Sea – that is, drilling, fisheries and aquaculture – may increase the level of conflict between user groups, within and between marine sectors.

Annex IV
Certification of fisheries to the MSC Standard

In 1997, the international corporation Unilever in cooperation with WWF established a certification programme for sustainable fisheries, known as the Marine Stewardship Council (MSC). This became an independent non-profit organisation in 1999. The mission of the MSC is the support of the ecologically safe, socially profitable and economically vigorous fishery practices. Unilever is one of the largest producers of frozen fish products selling them under its brands Iglo, Birds Eye, Gorton etc. MSC is working in partnership with the well known auditor firms assessing the candidates for the ecological logo. Those meeting the MSC requirements obtain the ecological certificate. The certificate gives products advantages on the ecologically sensitive market, increases the trust for fishery companies from its potential partners and creditors, creates a positive image, and in the end increases profit.

MSC assesses each fishery against five indicators: fisheries research, quota system, regulatory tools, control systems, and long-term management plan. The effect of fishing on marine ecosystems is also taken into account. These data forms the rating of a fishing company. A fishery that is deemed sustainable is encouraged to seek certification to the MSC Standard. The main principle here is not to reveal the negative features of this or that fishery, which are well known for many, but the orientation on the best fishery practices and best-managed fisheries. Good rating works for the company, its partners and creditors. It also gives priorities in quotas allocation, preferential terms for obtaining credits and subsidies, increases ecological reputation of products through mass media, which contributes to better realisation of products at the world markets, etc.

Certification to the MSC Standard is a rather expensive process, and not every fishing company can afford this. Still, analysts do believe that fisheries, especially coastal ones, have a good potential to be certified (Ozolin'sh & Spiridinov 2001).

Annex V
List of important water-related programmes and assessments

Barents Region Environment Action Program, 1994

Adopted in June 1994 by the Barents Environment Ministers at their First Barents Environment Council Meeting. Declarations of Barents Region Environment Ministers have been made in 1994, 1995, 1997, and 1999.

Arctic Environmental Protection Strategy (AEPS), 1991

- Protect the Arctic ecosystems, including humans;
- Provide for the protection, enhancement and restoration of environmental quality and sustainable utilisation of natural resources, including their use by local populations and indigenous peoples in the Arctic;
- Recognise and, to the extent possible, seek to accommodate the traditional and cultural needs, values and practises of indigenous peoples as determined by themselves, related to the protection of the Arctic environment;
- Review regularly the state of the Arctic environment to identify, reduce and, as a final goal, eliminate pollution.

The five programmes established under the AEPS are:

- Arctic Monitoring and Assessment Programme (AMAP):
  An international organisation established to implement components of the AEPS. AMAP has responsibilities to monitor the levels of, and assess the effects of, anthropogenic pollutants in all compartments of the Arctic environment, including humans. AMAP is now a programme group of the Arctic Council, and its current objective is "providing reliable and sufficient information on the status of, and threats to, the Arctic environment, and providing scientific advice on actions to be taken in order to support Arctic governments in their efforts to take remedial and preventive actions relating to contaminants".
- Conservation of Arctic Flora and Fauna (CAFF):
  The Program for the Conservation of Arctic Flora and Fauna, under the AEPS, was established to address the special needs of Arctic species and their habitats in the rapidly developing Arctic region. CAFF has responsibilities to facilitate the exchange of information and coordination of research on species and habitats of Arctic flora and fauna.
- Emergency Prevention, Preparedness and Response (EPPR):
  Established as an expert forum to evaluate the adequacy of existing arrangements and to recommend the necessary system of cooperation.
- Protection of the Arctic Marine Environment (PAME):
  PAME addresses policy and non-emergency response measures related to protection of the marine environment from land and sea-based activities. PAME has responsibilities to take preventative and other measures, directly or through competent international organisations, regarding marine pollution in the Arctic, irrespective of origin.
- Sustainable Development Working Group (SDWG):
  Established by Arctic Ministers in 1998. The objective is to protect and enhance the economies, culture and health of the inhabitants of the Arctic, in an environmentally sustainable manner.

Arctic Climate Impact Assessment (ACIA)

An international project organised under the auspices of the Arctic Council to evaluate and synthesise knowledge on climate variability, climate change, and increased ultraviolet radiation and their consequences.

International Arctic Science Committee, IASC

IASC is a non-governmental organisation to encourage and facilitate cooperation in all aspects of Arctic research, in all countries engaged in Arctic research and in all areas of the Arctic region. The IASC member organisations are national science organisations covering all fields of Arctic research.

Arctic Environmental Impact Assessment (ARIA)

The purpose of the project is to develop Guidelines for EIA in the Arctic. A circumpolar ad hoc group, whose task was to evaluate a proposal for an electronic information system supporting arctic EIAs, has recommended that an electronic network on the Internet should be established.

Barents GIT, National Land Survey of Finland

GIT means General Information of Geographic Information Technology within the Barents region. The overall objective of the project is to "produce homogeneous geographic information that can be used for planning and decision-making concerning the environment, land use, natural resources, industry, trade and tourism and transport in the Barents Region. It will also be an important information source for educational institutions at all levels and for all who require a complete and comprehensive picture of and data about the Barents Region. A further intermediate objective for the project is to create an infrastructure for the storage and exchange of geographic information in the Barents Region".

Research

Barents Sea Impact Study (BASIS)

The Barents Sea Impact Study (BASIS) is a global change research project developed under the auspices of the International Arctic Science Committee (IASC). After a planning phase of five years (1992-1996), a research proposal was submitted in 1997 to the IV Framework Environment and Climate Programme of the European Commission. This proposal was accepted and has received funding for an initial period of two years (1998-1999).

State of the environment

Barentswatch

"Barentswatch 1998" provides extensive and current information on the state of the environment and natural resources of the Barents region. Barentswatch 1998 was published by Svanhovd Environmental Centre in Norway in cooperation with the Norwegian Directorate for Nature Management, the Norwegian Polar Institute, and GRID-Arendal. The publication is available in English, Russian and Norwegian.

Arctic Monitoring and Assessment Programme (AMAP): State of the Environment Report

During its initial phase of operation (1991-1996), AMAP designed and implemented a monitoring programme and conducted its first assessment of the State of the Arctic Environment with respect to pollution issues. A special group (the AMAP Assessment Steering Group) was established to oversee the preparation of the AMAP Assessment, which is based on input from several hundreds of scientific experts. Two Assessment reports were produced to present the results of the AMAP assessment firstly to decision makers and the general public (the SOAER; full text), and secondly to fully document the scientific basis for the assessment (the AAR). This first AMAP Assessment was presented in 1997.

Major environmental challenges and environmental problems

Summary of environmental problems and challenges in the region, compiled by Finnish Ministry of Trade and Industry and Finnish Ministry of Environment for the Barentsinfo database.

Progress Report on Barents Region Environmental Hot Spots

A report prepared 1998 by the Nordic Environment Finance Co-operation, NEFCO, as a summary of measures taken in the region since 1995.

Global Environment Outlook 2000 State of the Environment: Europe and Central Asia

GEO is:

- A global environmental assessment process, the GEO Process, that is cross-sectoral and participatory. It incorporates regional views and perceptions, and builds consensus on priority issues and actions through dialogue among policy-makers and scientists at regional and global levels.
- GEO outputs, in printed and electronic formats, including the GEO Report series. This series makes periodic reviews of the state of the world's environment, and provides guidance for decision-making processes such as the formulation of environmental policies, action planning and resource allocation. Other outputs include technical reports, a web-site and a publication for young people.

GEF Projects in the region

UNEP-GEF-International Waters

Support to the National Plan of Action in the Russian Federation for the Protection of the Arctic Marine Environment from Anthropogenic Pollution. The project will focus on pre-investment studies of identified priority hot spots with known significant transboundary consequences. Additional activities will include the necessary support in the development of legal, institutional and economic measures.

UNEP-GEF-Biodiversity

An integrated ecosystem approach to enhance biodiversity conservation and minimise habitat fragmentation in the Russian Arctic.

Other actors and initiatives

- European Union and the Northern Dimension;
- European Commission Report on the Northern Dimension, November 1998;
- Conclusions of the Foreign Ministers Conference on the Northern Dimension, November 1999.

INTERREG II

EU programmes in support of development and border region cooperation in the Barents/Arctic area.

Tacis

The Tacis Programme is a European Union initiative to provide grant-financed technical assistance to support the process of transition to market economies and democratic societies in the partner countries of Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Mongolia, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan. Priorities are greater concentration of the assistance to achieve maximum impact, and support for the objectives of the Partnership and Cooperation Agreements (PCAs).

EU and the Barents Region

A document, available also in Russian, published on the EU Tacis site about "the European Union and its neighbours in the North-East". Contains general information about the Barents Region; relations between the EU and the Russian Federation and Norway, respectively; regional cooperation in the Barents region; the scope of EU involvement in the Barents region; and EU support in the Barents region through structural funds (Regional Development Fund, Social Fund, and Agricultural Guarantee and Guidance Fund) and the Tacis programme.

INTERREG IIIB Northern Periphery Programme

The Interreg IIIB Northern Periphery Programme consists of the northern parts of Finland, Scotland, Sweden, Norway, the whole of Iceland, Greenland and Faroe Islands. Northwest Russia is part of the co-operation. The overall objective for Interreg is to prevent national borders from constituting barriers to the balanced development and integration of the European territory. Interreg IIIB concerns cooperation within larger transnational areas. The transnational cooperation between national, regional and local authorities aims to promote a higher degree of territorial integration across large groupings of European regions, with a view to achieving sustainable, harmonious and balanced development in the community and better territorial integration with candidate and other neighbouring countries.

Other actors

Barents Secretariat

The Secretariat is maintained by the three Norwegian provinces Nordland, Troms and Finnmark. Its main tasks are to coordinate national priorities and goals within the Barents cooperation; provide a resource centre in the handling of projects; conduct information activities and establish contacts to enhance the general knowledge and understanding of the Barents region; and make regional activities known and accepted. See the Barents Programme, which is the Regional Council's programme for concretising how to achieve the overall goals set up for the regional work and supporting the ongoing changes in the Russian part.

The Barents Sea - a Large Marine Ecosystem (LME)

A Large Marine Ecosystem is a region of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundary of continental shelves and the seaward margins of coastal current systems. It is a relatively large region characterised by distinct bathymetry, hydrography, productivity, and trophically dependent populations.

Russian programmes and projects related to the Barents Sea region

Water resources monitoring programme in the territory of the Murmansk Region (2003)

The programme is carried out by Murmansk Region Natural Resources Commission, Administration of the Dvina-Pechora water basin, Murmansk Region Administration for Hydrometeorology, and Administration of the Murmansk Region. The objective of the program is annual observations of the quality of surface waters on 30 rivers and 10 water reservoirs of the Murmansk Region, as well as in the Kola Bay; biotesting of water sources (Kola River, Pasvik River, sources of drinking water in the Kola and Pechenga Districts).

Assessment of Barents Sea fisheries contamination (1997-2004)

The regional programme is carried out by Murmansk Marine Biological Institute, Polar Scientific Research Institute of Fisheries and Oceanography, and Murmansk Region Natural Resources Commission. The programme is aimed at obtaining systematic data on the current state and tendencies of contamination of Barents Sea commercial fishes and invertebrates, and give prognosis for the accumulation of contaminants.

Federal programme "World Ocean", sub-programme "Investigations of the World Ocean Nature", project "Complex Investigations of processes, characteristics and resources of Russian Seas of the North-European Basin" (2003-2007)

The project is carried out by Murmansk Marine Biological Institute, Russian State Hydrometeorological University, Institute of Oceanography of the Russian Academy of Sciences, Institute of Arctic and Antarctic Research, All-Russian Research Institute of Oceanology, Institute of Water Problems of the North, Zoological Institute of the Russian Academy of Sciences, and State Oceanographic Institute.

The purpose of the project is complex oceanographic, hydrochemical and biological investigations of the Barents, White and Baltic Seas aimed at sustainable exploitation of their marine resources, assessment of their assimilative potential and level of chemical pollution, conservation of their biodiversity.

Federal scientific and technical programme "Investigations and elaborations on the prior directions in the development of science and technologies for civil use", project "Scientific substantiation of the methodology for environmental impact assessment of marine oil and gas exploitation on the marine environment of Arctic Seas" (2002-2004)

The project is carried out by Murmansk Marine Biological Institute with the aim of developing the methodology for the ecological and geographic analysis and prognosis of the consequences of large projects on marine oil and gas exploitation (Stockman, Prirazlomnoe and other oil and gas deposits in the Barents Sea).

Programme of the Ministry of Economic Development and Trade of the Russian Federation
Project "Meridian" (2002-2003)
The main task of the project, which is carried out by Murmansk Marine Biological Institute, is the development of scenarios for the impact of marine oil and gas exploitation on the ecosystems of the southern part of the Barents Sea.

Annex VI
List of conventions and specific laws that affect water use in the region

- Kirkenes Declaration (1993).
- Rovaniemi Declaration on the Protection of the Arctic Environment (1991).
- North-East Atlantic Fisheries Convention (1963).
- Convention for the Conservation of Salmon in the North Atlantic Ocean (1983).
- Convention on Biological Diversity, Rio (1992).
- OSPAR Convention (1992) Convention for the Protection of the Marine Environment of the North-East Atlantic.
- Berne Convention (1982). It is based on the principle that wild fauna and flora constitute a natural heritage that plays a vital role in maintaining biological balances. The Berne Convention requires 'each Contracting Party to strictly control the introduction of non-native species'.
- Bonn Convention (1983) on the Conservation of Migratory Species of Wild Animals, aims to conserve terrestrial, marine and avian migratory species throughout their range.

EU-Directives and specific laws

- Birds Directive (1979) The Council Directive on Wild Birds (79/409/EEC) concerns not only the protection of wild birds but also their habitats.
- Directive on Genetically Modified Organisms (GMOs) (1990) Council Directive (90/220/EEC) on the 'Deliberate Release into the Environment of Genetically Modified Organisms' (EC 1990).
- Habitats Directive (1992). Aim of the Council Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) is to contribute towards ensuring biodiversity through the conservation of natural and semi-natural habitats and of wild fauna and flora in the Member States.
- Natura 2000 is designed to establish a coherent European ecological network of Sites of Community Importance (SCIs) in order to maintain the distribution and abundance of threatened species and habitats, both terrestrial and marine.
- Water Framework Directive (2000) 2000/60/EC. A major policy initiative that is currently undergoing a complex and demanding implementation process via the development of a Common Implementation Strategy under the auspices of Working Groups with participants from Member States and the European Commission.
- EU Water Initiative, Johannesburg (2002).

The Global International Waters Assessment

This report presents the results of the Global International Waters Assessment (GIWA) of the transboundary waters of the Barents Sea. This and the subsequent chapter offer a background that describes the impetus behind the establishment of GIWA, its objectives and how the GIWA was implemented.

The need for a global international waters assessment

Globally, people are becoming increasingly aware of the degradation of the world's water bodies. Disasters from floods and droughts, frequently reported in the media, are considered to be linked with ongoing global climate change (IPCC 2001), accidents involving large ships pollute public beaches and threaten marine life and almost every commercial fish stock is exploited beyond sustainable limits - it is estimated that the global stocks of large predatory fish have declined to less that 10% of pre-industrial fishing levels (Myers & Worm 2003). Further, more than 1 billion people worldwide lack access to safe drinking water and 2 billion people lack proper sanitation which causes approximately 4 billion cases of diarrhoea each year and results in the death of 2.2 million people, mostly children younger than five (WHO-UNICEF 2002). Moreover, freshwater and marine habitats are destroyed by infrastructure developments, dams, roads, ports and human settlements (Brinson & Malvárez 2002, Kennish 2002). As a consequence, there is growing public concern regarding the declining quality and quantity of the world's aquatic resources because of human activities, which has resulted in mounting pressure on governments and decision makers to institute new and innovative policies to manage those resources in a sustainable way ensuring their availability for future generations.

Adequately managing the world's aquatic resources for the benefit of all is, for a variety of reasons, a very complex task. The liquid state of the most of the world's water means that, without the construction of reservoirs, dams and canals it is free to flow wherever the laws of nature dictate. Water is, therefore, a vector transporting not only a wide variety of valuable resources but also problems from one area to another. The effluents emanating from environmentally destructive activities in upstream drainage areas are propagated downstream and can affect other areas considerable distances away. In the case of transboundary river basins, such as the Nile, Amazon and Niger, the impacts are transported across national borders and can be observed in the numerous countries situated within their catchments. In the case of large oceanic currents, the impacts can even be propagated between continents (AMAP 1998). Therefore, the inextricable linkages within and between both freshwater and marine environments dictates that management of aquatic resources ought to be implemented through a drainage basin approach.

In addition, there is growing appreciation of the incongruence between the transboundary nature of many aquatic resources and the traditional introspective nationally focused approaches to managing those resources. Water, unlike laws and management plans, does not respect national borders and, as a consequence, if future management of water and aquatic resources is to be successful, then a shift in focus towards international cooperation and intergovernmental agreements is required (UN 1972). Furthermore, the complexity of managing the world's water resources is exacerbated by the dependence of a great variety of domestic and industrial activities on those resources. As a consequence, cross-sectoral multidisciplinary approaches that integrate environmental, socio-economic and development aspects into management must be adopted. Unfortunately however, the scientific information or capacity within each discipline is often not available or is inadequately translated for use by managers, decision makers and policy developers. These inadequacies constitute a serious impediment to the implementation of urgently needed innovative policies.

Continual assessment of the prevailing and future threats to aquatic ecosystems and their implications for human populations is essential if governments and decision makers are going to be able to make strategic policy and management decisions that promote the sustainable use of those resources and respond to the growing concerns of the general public. Although many assessments of aquatic resources are being conducted by local, national, regional and international bodies, past assessments have often concentrated on specific themes, such as biodiversity or persistent toxic substances, or have focused only on marine or freshwaters. A globally coherent, drainage basin based assessment that embraces the inextricable links between transboundary freshwater and marine systems, and between environmental and societal issues, has never been conducted previously.

International call for action

The need for a holistic assessment of transboundary waters in order to respond to growing public concerns and provide advice to governments and decision makers regarding the management of aquatic resources was recognised by several international bodies focusing on the global environment. In particular, the Global Environment Facility (GEF) observed that the International Waters (IW) component of the GEF suffered from the lack of a global assessment which made it difficult to prioritise international water projects, particularly considering the inadequate understanding of the nature and root causes of environmental problems. In 1996, at its fourth meeting in Nairobi, the GEF Scientific and Technical Advisory Panel (STAP), noted that: *"Lack of an International Waters Assessment comparable with that of the IPCC, the Global Biodiversity Assessment, and the Stratospheric Ozone Assessment, was a unique and serious impediment to the implementation of the International Waters Component of the GEF"*.

The urgent need for an assessment of the causes of environmental degradation was also highlighted at the UN Special Session on the Environment (UNGASS) in 1997, where commitments were made regarding the work of the UN Commission on Sustainable Development (UNCSD) on freshwater in 1998 and seas in 1999. Also in 1997, two international Declarations, the Potomac Declaration: Towards enhanced ocean security into the third millennium, and the Stockholm Statement on interaction of land activities, freshwater and enclosed seas, specifically emphasised the need for an investigation of the root causes of degradation of the transboundary aquatic environment and options for addressing them. These processes led to the development of the Global International Waters Assessment (GIWA) that would be implemented by the United Nations Environment Programme (UNEP) in conjunction with the University of Kalmar, Sweden, on behalf of the GEF. The GIWA was inaugurated in Kalmar in October 1999 by the Executive Director of UNEP, Dr. Klaus Töpfer, and the late Swedish Minister of the Environment, Kjell Larsson. On this occasion Dr. Töpfer stated: *"GIWA is the framework of UNEP´s global water assessment strategy and will enable us to record and report on critical water resources for the planet for consideration of sustainable development management practices as part of our responsibilities under Agenda 21 agreements of the Rio conference"*.

The importance of the GIWA has been further underpinned by the UN Millennium Development Goals adopted by the UN General Assembly in 2000 and the Declaration from the World Summit on Sustainable

The Global Environment Facility (GEF)

The Global Environment Facility forges international co-operation and finances actions to address six critical threats to the global environment: biodiversity loss, climate change, degradation of international waters, ozone depletion, land degradation, and persistent organic pollutants (POPs).

The overall strategic thrust of GEF-funded international waters activities is to meet the incremental costs of: (a) assisting groups of countries to better understand the environmental concerns of their international waters and work collaboratively to address them; (b) building the capacity of existing institutions to utilise a more comprehensive approach for addressing transboundary water-related environmental concerns; and (c) implementing measures that address the priority transboundary environmental concerns. The goal is to assist countries to utilise the full range of technical, economic, financial, regulatory, and institutional measures needed to operationalise sustainable development strategies for international waters.

United Nations Environment Programme (UNEP)

United Nations Environment Programme, established in 1972, is the voice for the environment within the United Nations system. The mission of UNEP is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

UNEP work encompasses:

- Assessing global, regional and national environmental conditions and trends;
- Developing international and national environmental instruments;
- Strengthening institutions for the wise management of the environment;
- Facilitating the transfer of knowledge and technology for sustainable development;
- Encouraging new partnerships and mind-sets within civil society and the private sector.

University of Kalmar

University of Kalmar hosts the GIWA Co-ordination Office and provides scientific advice and administrative and technical assistance to GIWA. University of Kalmar is situated on the coast of the Baltic Sea. The city has a long tradition of higher education; teachers and marine officers have been educated in Kalmar since the middle of the 19th century. Today, natural science is a priority area which gives Kalmar a unique educational and research profile compared with other smaller universities in Sweden. Of particular relevance for GIWA is the established research in aquatic and environmental science. Issues linked to the concept of sustainable development are implemented by the research programme Natural Resources Management and Agenda 21 Research School.

Since its establishment GIWA has grown to become an integral part of University activities. The GIWA Co-ordination office and GIWA Core team are located at the Kalmarsund Laboratory, the university centre for water-related research. Senior scientists appointed by the University are actively involved in the GIWA peer-review and steering groups. As a result of the cooperation the University can offer courses and seminars related to GIWA objectives and international water issues.

Development in 2002. The development goals aimed to halve the proportion of people without access to safe drinking water and basic sanitation by the year 2015 (United Nations Millennium Declaration 2000). The WSSD also calls for integrated management of land, water and living resources (WSSD 2002) and, by 2010, the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem should be implemented by all countries that are party to the declaration (FAO 2001).

International waters and transboundary issues

The term "international waters", as used for the purposes of the GEF Operational Strategy, includes the oceans, large marine ecosystems, enclosed or semi-enclosed seas and estuaries, as well as rivers, lakes, groundwater systems, and wetlands with transboundary drainage basins or common borders. The water-related ecosystems associated with these waters are considered integral parts of the systems.

The term "transboundary issues" is used to describe the threats to the aquatic environment linked to globalisation, international trade, demographic changes and technological advancement, threats that are additional to those created through transboundary movement of water. Single country policies and actions are inadequate in order to cope with these challenges and this makes them transboundary in nature.

The international waters area includes numerous international conventions, treaties, and agreements. The architecture of marine agreements is especially complex, and a large number of bilateral and multilateral agreements exist for transboundary freshwater basins. Related conventions and agreements in other areas increase the complexity. These initiatives provide a new opportunity for cooperating nations to link many different programmes and instruments into regional comprehensive approaches to address international waters.

The conceptual framework and objectives

Considering the general decline in the condition of the world's aquatic resources and the internationally recognised need for a globally coherent assessment of transboundary waters, the primary objectives of the GIWA are:

- To provide a prioritising mechanism that allows the GEF to focus their resources so that they are used in the most cost effective manner to achieve significant environmental benefits, at national, regional and global levels; and
- To highlight areas in which governments can develop and implement strategic policies to reduce environmental degradation and improve the management of aquatic resources.

In order to meet these objectives and address some of the current inadequacies in international aquatic resources management, the GIWA has incorporated four essential elements into its design:

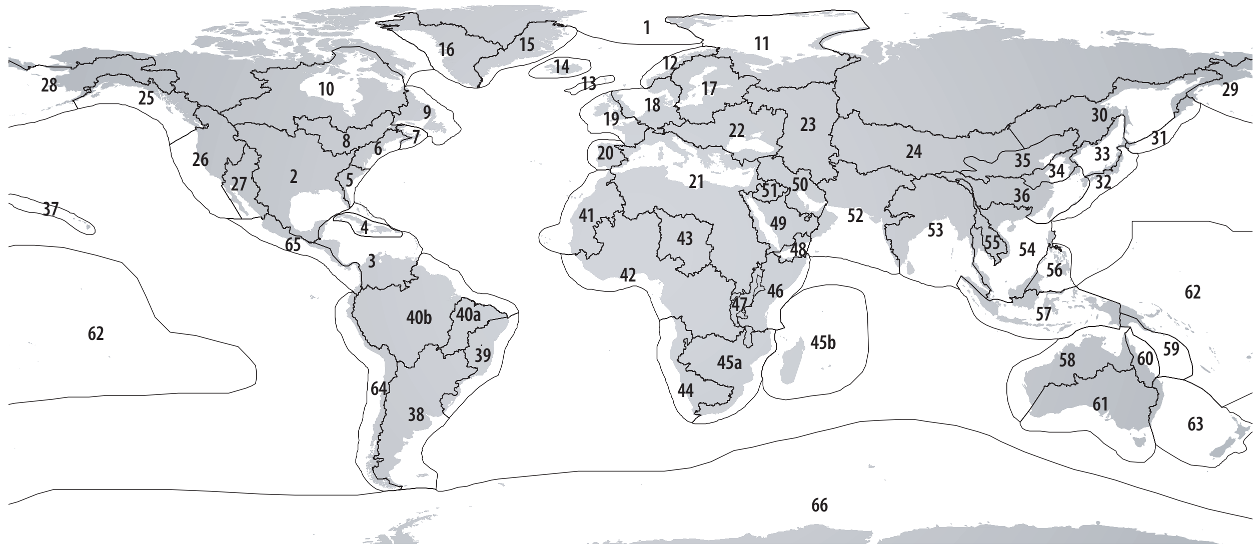
- A broad transboundary approach that generates a truly regional perspective through the incorporation of expertise and existing information from all nations in the region and the assessment of all factors that influence the aquatic resources of the region;
- A drainage basin approach integrating freshwater and marine systems;
- A multidisciplinary approach integrating environmental and socio-economic information and expertise; and
- A coherent assessment that enables global comparison of the results.

The GIWA builds on previous assessments implemented within the GEF International Waters portfolio but has developed and adopted a broader definition of transboundary waters to include factors that influence the quality and quantity of global aquatic resources. For example, due to globalisation and international trade, the market for penaeid shrimps has widened and the prices soared. This, in turn, has encouraged entrepreneurs in South East Asia to expand aquaculture resulting in the large-scale deforestation of mangroves for ponds (Primavera 1997). Within the GIWA, these "non-hydrological" factors constitute as large a transboundary influence as more traditionally recognised problems, such as the construction of dams that regulate the flow of water into a neighbouring country, and are considered equally important. In addition, the GIWA recognises the importance of hydrological units that would not normally be considered transboundary but exert a significant influence on transboundary waters, such as the Yangtze River in China which discharges into the East China Sea (Daoji & Daler 2004) and the Volga River in Russia which is largely responsible for the condition of the Caspian Sea (Barannik et al. 2004). Furthermore, the GIWA is a truly regional assessment that has incorporated data from a wide range of sources and included expert knowledge and information from a wide range of sectors and from each country in the region. Therefore, the transboundary concept adopted by the GIWA extends to include impacts caused by globalisation, international trade, demographic changes and technological advances and recognises the need for international cooperation to address them.

The organisational structure and implementation of the GIWA

The scale of the assessment

Initially, the scope of the GIWA was confined to transboundary waters in areas that included countries eligible to receive funds from the GEF. However, it was recognised that a truly global perspective would only be achieved if industrialised, GEF-ineligible regions of the world were also assessed. Financial resources to assess the GEF-eligible countries were obtained primarily from the GEF (68%), the Swedish International Development Cooperation Agency (Sida) (18%), and the Finnish Department for International Development Cooperation (FINNIDA)



1 Arctic
2 Gulf of Mexico (LME)
3 Caribbean Sea (LME)
4 Caribbean Islands
5 Southeast Shelf (LME)
6 Northeast Shelf (LME)
7 Scotian Shelf (LME)
8 Gulf of St Lawrence
9 Newfoundland Shelf (LME)
10 Baffin Bay, Labrador Sea, Canadian Archipelago
11 Barents Sea (LME)
12 Norwegian Sea (LME)
13 Faroe plateau
14 Iceland Shelf (LME)
15 East Greenland Shelf (LME)
16 West Greenland Shelf (LME)
17 Baltic Sea (LME)
18 North Sea (LME)
19 Celtic-Biscay Shelf (LME)
20 Iberian Coastal (LME)
21 Mediterranean Sea (LME)
22 Black Sea (LME)
23 Caspian Sea
24 Aral Sea
25 Gulf of Alaska (LME)
26 California Current (LME)
27 Gulf of California (LME)
28 East Bering Sea (LME)
29 West Bering Sea (LME)
30 Sea of Okhotsk (LME)
31 Oyashio Current (LME)
32 Kuroshio Current (LME)
33 Sea of Japan/East Sea (LME)
34 Yellow Sea (LME)
35 Bohai Sea
36 East-China Sea (LME)
37 Hawaiian Archipelago (LME)
38 Patagonian Shelf (LME)
39 Brazil Current (LME)
40a Brazilian Northeast (LME)
40b Amazon
41 Canary Current (LME)
42 Guinea Current (LME)
43 Lake Chad
44 Benguela Current (LME)
45a Agulhas Current (LME)
45b Indian Ocean Islands
46 Somali Coastal Current (LME)
47 East African Rift Valley Lakes
48 Gulf of Aden
49 Red Sea (LME)
50 The Gulf
51 Jordan
52 Arabian Sea (LME)
53 Bay of Bengal S.E.
54 South China Sea (LME)
55 Mekong River
56 Sulu-Celebes Sea (LME)
57 Indonesian Seas (LME)
58 North Australian Shelf (LME)
59 Coral Sea Basin
60 Great Barrier Reef (LME)
61 Great Australian Bight
62 Small Island States
63 Tasman Sea
64 Humboldt Current (LME)
65 Eastern Equatorial Pacific
66 Antarctic (LME)

Figure 1 The 66 transboundary regions assessed within the GIWA project.

(10%). Other contributions were made by Kalmar Municipality, the University of Kalmar and the Norwegian Government. The assessment of regions ineligible for GEF funds was conducted by various international and national organisations as in-kind contributions to the GIWA.

In order to be consistent with the transboundary nature of many of the world's aquatic resources and the focus of the GIWA, the geographical units being assessed have been designed according to the watersheds of discrete hydrographic systems rather than political borders (Figure 1). The geographic units of the assessment were determined during the preparatory phase of the project and resulted in the division of the world into 66 regions defined by the entire area of one or more catchments areas that drains into a single designated marine system. These marine systems often correspond to Large Marine Ecosystems (LMEs) (Sherman 1994, IOC 2002).

Large Marine Ecocsystems (LMEs)

Large Marine Ecosystems (LMEs) are regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundaries of continental shelves and the outer margin of the major current systems. They are relatively large regions on the order of 200 000 km^2 or greater, characterised by distinct: (1) bathymetry, (2) hydrography, (3) productivity, and (4) trophically dependent populations.

The Large Marine Ecosystems strategy is a global effort for the assessment and management of international coastal waters. It developed in direct response to a declaration at the 1992 Rio Summit. As part of the strategy, the World Conservation Union (IUCN) and National Oceanic and Atmospheric Administration (NOAA) have joined in an action program to assist developing countries in planning and implementing an ecosystem-based strategy that is focused on LMEs as the principal assessment and management units for coastal ocean resources. The LME concept is also adopted by GEF that recommends the use of LMEs and their contributing freshwater basins as the geographic area for integrating changes in sectoral economic activities.

Considering the objectives of the GIWA and the elements incorporated into its design, a new methodology for the implementation of the assessment was developed during the initial phase of the project. The methodology focuses on five major environmental concerns which constitute the foundation of the GIWA assessment; Freshwater shortage, Pollution, Habitat and community modification, Overexploitation of fish and other living resources, and Global change. The GIWA methodology is outlined in the following chapter.

The global network

In each of the 66 regions, the assessment is conducted by a team of local experts that is headed by a Focal Point (Figure 2). The Focal Point can be an individual, institution or organisation that has been selected on the basis of their scientific reputation and experience implementing international assessment projects. The Focal Point is responsible for assembling members of the team and ensuring that it has the necessary expertise and experience in a variety of environmental and socio-economic disciplines to successfully conduct the regional assessment. The selection of team members is one of the most critical elements for the success of GIWA and, in order to ensure that the most relevant information is incorporated into the assessment, team members were selected from a wide variety of institutions such as universities, research institutes, government agencies, and the private sector. In addition, in order to ensure that the assessment produces a truly regional perspective, the teams should include representatives from each country that shares the region.

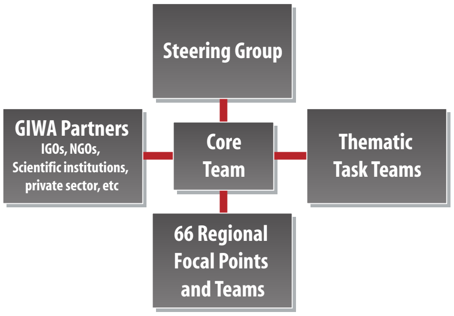


Figure 2 The organisation of the GIWA project.

In total, more than 1 000 experts have contributed to the implementation of the GIWA illustrating that the GIWA is a participatory exercise that relies on regional expertise. This participatory approach is essential because it instils a sense of local ownership of the project, which ensures the credibility of the findings and moreover, it has created a global network of experts and institutions that can collaborate and exchange experiences and expertise to help mitigate the continued degradation of the world's aquatic resources.

GIWA Regional reports

The GIWA was established in response to growing concern among the general public regarding the quality of the world's aquatic resources and the recognition of governments and the international community concerning the absence of a globally coherent international waters assessment. However, because a holistic, region-by-region, assessment of the condition of the world's transboundary water resources had never been undertaken, a methodology guiding the implementation of such an assessment did not exist. Therefore, in order to implement the GIWA, a new methodology that adopted a multidisciplinary, multi-sectoral, multi-national approach was developed and is now available for the implementation of future international assessments of aquatic resources.

UNEP Water Policy and Strategy

The primary goals of the UNEP water policy and strategy are:

(a) Achieving greater global understanding of freshwater, coastal and marine environments by conducting environmental assessments in priority areas;

(b) Raising awareness of the importance and consequences of unsustainable water use;

(c) Supporting the efforts of Governments in the preparation and implementation of integrated management of freshwater systems and their related coastal and marine environments;

(d) Providing support for the preparation of integrated management plans and programmes for aquatic environmental hot spots, based on the assessment results;

(e) Promoting the application by stakeholders of precautionary, preventive and anticipatory approaches.

The GIWA is comprised of a logical sequence of four integrated components. The first stage of the GIWA is called Scaling and is a process by which the geographic area examined in the assessment is defined and all the transboundary waters within that area are identified. Once the geographic scale of the assessment has been defined, the assessment teams conduct a process known as Scoping in which the magnitude of environmental and associated socio-economic impacts of Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, and Global change is assessed in order to identify and prioritise the concerns that require the most urgent intervention. The assessment of these predefined concerns incorporates the best available information and the knowledge and experience of the multidisciplinary, multi-national assessment teams formed in each region. Once the priority concerns have been identified, the root causes of these concerns are identified during the third component of the GIWA, Causal chain analysis. The root causes are determined through a sequential process that identifies, in turn, the most significant immediate causes followed by the economic sectors that are primarily responsible for the immediate causes and finally, the societal root causes. At each stage in the Causal chain analysis, the most significant contributors are identified through an analysis of the best available information which is augmented by the expertise of the assessment team. The final component of the GIWA is the development of Policy options that focus on mitigating the impacts of the root causes identified by the Causal chain analysis.

The results of the GIWA assessment in each region are reported in regional reports that are published by UNEP. These reports are designed to provide a brief physical and socio-economic description of the most important features of the region against which the results of the assessment can be cast. The remaining sections of the report present the results of each stage of the assessment in an easily digestible form. Each regional report is reviewed by at least two independent external reviewers in order to ensure the scientific validity and applicability of each report. The 66 regional assessments of the GIWA will serve UNEP as an essential complement to the UNEP Water Policy and Strategy and UNEP's activities in the hydrosphere.

Global International Waters Assessment

References:

AMAP (1998). Assessment Report: Arctic Pollution Issues. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway.

Barannik, V., Borysova, O. and Stolberg, F. (2004). The Caspian Sea Region: Environmental Change. Ambio, 33:45-51.

Brinson, M.M. and Malvárez, A.I. (2002). Temperate freshwater wetlands: types, status, and threats. Environmental Conservation, 29:115-133.

Daoji, L. and Daler, D. (2004). Ocean Pollution from Land-based Sources: East China Sea, China. Ambio, 33:98-106.

FAO (2001). Reykjavik conference on responsible fisheries in the marine ecosystem. Iceland, 1-4 October 2001.

IOC (2002). IOC-IUCN-NOAA Consultative Meeting on Large Marine Ecosystems (LMEs). Fourth Session, 8-9 January 2002, Paris, France.

IPCC (2001). Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. In: Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., van der Linden, P.J., Dai, X., Maskell, K. and Johnson, C.A. (eds). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kennish, M.J. (2002). Environmental threats and environmental future of estuaries. Environmental Conservation, 29:78-107.

Myers, R.A. and Worm, B. (2003). Rapid worldwide depletion of predatory fish communities. Nature, 423:280-283.

Primavera, J.H. (1997) Socio-economic impacts of shrimp culture. Aquaculture Research, 28:815-827.

Sherman, K. (1994). Sustainability, biomass yields, and health of coastal ecosystems: an ecological perspective. Marine Ecology Progress Series, 112:277-301.

United Nations conference on the human environment (1972). Report available on-line at http://www.unep.org

United Nations Millennium Declaration (2000). The Millennium Assembly of the United Nations, New York.

WHO-UNICEF (2002). Global Water Supply and Sanitation Assessment: 2000 Report.

WSSD (2002). World Summit on Sustainable Development. Johannesburg Summit 2002. Key Outcomes of the Summit, UN Department of Public Information, New York.

The GIWA methodology

The specific objectives of the GIWA were to conduct a holistic and globally comparable assessment of the world's transboundary aquatic resources that incorporated both environmental and socio-economic factors and recognised the inextricable links between freshwater and marine environments, in order to enable the GEF to focus their resources and to provide guidance and advice to governments and decision makers. The coalition of all these elements into a single coherent methodology that produces an assessment that achieves each of these objectives had not previously been done and posed a significant challenge.

The integration of each of these elements into the GIWA methodology was achieved through an iterative process guided by a specially convened Methods task team that was comprised of a number of international assessment and water experts. Before the final version of the methodology was adopted, preliminary versions underwent an extensive external peer review and were subjected to preliminary testing in selected regions. Advice obtained from the Methods task team and other international experts and the lessons learnt from preliminary testing were incorporated into the final version that was used to conduct each of the GIWA regional assessments.

Considering the enormous differences between regions in terms of the quality, quantity and availability of data, socio-economic setting and environmental conditions, the achievement of global comparability required an innovative approach. This was facilitated by focusing the assessment on the impacts of five pre-defined concerns namely; Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources and Global change, in transboundary waters. Considering the diverse range of elements encompassed by each concern, assessing the magnitude of the impacts caused by these concerns was facilitated by evaluating the impacts of 22 specific issues that were grouped within these concerns (see Table 1).

The assessment integrates environmental and socio-economic data from each country in the region to determine the severity of the impacts of each of the five concerns and their constituent issues on the entire region. The integration of this information was facilitated by implementing the assessment during two participatory workshops that typically involved 10 to 15 environmental and socio-economic experts from each country in the region. During these workshops, the regional teams performed preliminary analyses based on the collective knowledge and experience of these local experts. The results of these analyses were substantiated with the best available information to be presented in a regional report.

Table 1 Pre-defined GIWA concerns and their constituent issues addressed within the assessment.

Environmental issues	Major concerns
1. Modification of stream flow 2. Pollution of existing supplies 3. Changes in the water table	**I Freshwater shortage**
4. Microbiological 5. Eutrophication 6. Chemical 7. Suspended solids 8. Solid wastes 9. Thermal 10. Radionuclide 11. Spills	**II Pollution**
12. Loss of ecosystems 13. Modification of ecosystems or ecotones, including community structure and/or species composition	**III Habitat and community modification**
14. Overexploitation 15. Excessive by-catch and discards 16. Destructive fishing practices 17. Decreased viability of stock through pollution and disease 18. Impact on biological and genetic diversity	**IV Unsustainable exploitation of fish and other living resources**
19. Changes in hydrological cycle 20. Sea level change 21. Increased uv-b radiation as a result of ozone depletion 22. Changes in ocean CO_2 source/sink function	**V Global change**

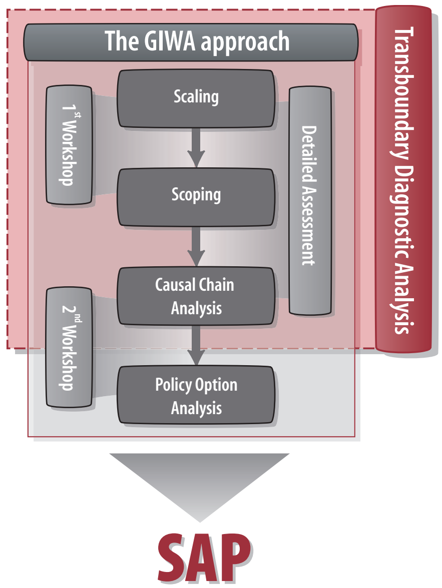


Figure 1 Illustration of the relationship between the GIWA approach and other projects implemented within the GEF International Waters (IW) portfolio.

The GIWA is a logical contiguous process that defines the geographic region to be assessed, identifies and prioritises particularly problems based on the magnitude of their impacts on the environment and human societies in the region, determines the root causes of those problems and, finally, assesses various policy options that addresses those root causes in order to reverse negative trends in the condition of the aquatic environment. These four steps, referred to as Scaling, Scoping, Causal chain analysis and Policy options analysis, are summarised below and are described in their entirety in two volumes: *GIWA Methodology Stage 1: Scaling and Scoping*; and *GIWA Methodology: Detailed Assessment, Causal Chain Analysis and Policy Options Analysis*. Generally, the components of the GIWA methodology are aligned with the framework adopted by the GEF for Transboundary Diagnostic Analyses (TDAs) and Strategic Action Programmes (SAPs) (Figure 1) and assume a broad spectrum of transboundary influences in addition to those associated with the physical movement of water across national borders.

Scaling – Defining the geographic extent of the region

Scaling is the first stage of the assessment and is the process by which the geographic scale of the assessment is defined. In order to facilitate the implementation of the GIWA, the globe was divided during the design phase of the project into 66 contiguous regions. Considering the transboundary nature of many aquatic resources and the transboundary focus of the GIWA, the boundaries of the regions did not comply with political boundaries but were instead, generally defined by a large but discrete drainage basin that also included the coastal marine waters into which the basin discharges. In many cases, the marine areas examined during the assessment coincided with the Large Marine Ecosystems (LMEs) defined by the US National Atmospheric and Oceanographic Administration (NOAA). As a consequence, scaling should be a relatively straight-forward task that involves the inspection of the boundaries that were proposed for the region during the preparatory phase of GIWA to ensure that they are appropriate and that there are no important overlaps or gaps with neighbouring regions. When the proposed boundaries were found to be inadequate, the boundaries of the region were revised according to the recommendations of experts from both within the region and from adjacent regions so as to ensure that any changes did not result in the exclusion of areas from the GIWA. Once the regional boundary was defined, regional teams identified all the transboundary elements of the aquatic environment within the region and determined if these elements could be assessed as a single coherent aquatic system or if there were two or more independent systems that should be assessed separately.

Scoping – Assessing the GIWA concerns

Scoping is an assessment of the severity of environmental and socio-economic impacts caused by each of the five pre-defined GIWA concerns and their constituent issues (Table 1). It is not designed to provide an exhaustive review of water-related problems that exist within each region, but rather it is a mechanism to identify the most urgent problems in the region and prioritise those for remedial actions. The priorities determined by Scoping are therefore one of the main outputs of the GIWA project.

Focusing the assessment on pre-defined concerns and issues ensured the comparability of the results between different regions. In addition, to ensure the long-term applicability of the options that are developed to mitigate these problems, Scoping not only assesses the current impacts of these concerns and issues but also the probable future impacts according to the "most likely scenario" which considered demographic, economic, technological and other relevant changes that will potentially influence the aquatic environment within the region by 2020.

The magnitude of the impacts caused by each issue on the environment and socio-economic indicators was assessed over the entire region using the best available information from a wide range of sources and the knowledge and experience of the each of the experts comprising the regional team. In order to enhance the comparability of the assessment between different regions and remove biases in the assessment caused by different perceptions of and ways to communicate the severity of impacts caused by particular issues, the results were distilled and reported as standardised scores according to the following four point scale:

- 0 = no known impact
- 1 = slight impact
- 2 = moderate impact
- 3 = severe impact

The attributes of each score for each issue were described by a detailed set of pre-defined criteria that were used to guide experts in reporting the results of the assessment. For example, the criterion for assigning a score of 3 to the issue Loss of ecosystems or ecotones is: "*Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.*" The full list of criteria is presented at the end of the chapter, Table 5a-e. Although the scoring inevitably includes an arbitrary component, the use of predefined criteria facilitates comparison of impacts on a global scale and also encouraged consensus of opinion among experts.

The trade-off associated with assessing the impacts of each concern and their constituent issues at the scale of the entire region is that spatial resolution was sometimes low. Although the assessment provides a score indicating the severity of impacts of a particular issue or concern on the entire region, it does not mean that the entire region suffers the impacts of that problem. For example, eutrophication could be identified as a severe problem in a region, but this does not imply that all waters in the region suffer from severe eutrophication. It simply means that when the degree of eutrophication, the size of the area affected, the socio-economic impacts and the number of people affected is considered, the magnitude of the overall impacts meets the criteria defining a severe problem and that a regional action should be initiated in order to mitigate the impacts of the problem.

When each issue has been scored, it was weighted according to the relative contribution it made to the overall environmental impacts of the concern and a weighted average score for each of the five concerns was calculated (Table 2). Of course, if each issue was deemed to make equal contributions, then the score describing the overall impacts of the concern was simply the arithmetic mean of the scores allocated to each issue within the concern. In addition, the socio-economic impacts of each of the five major concerns were assessed for the entire region. The socio-economic impacts were grouped into three categories; Economic impacts, Health impacts and Other social and community impacts (Table 3). For each category, an evaluation of the size, degree and frequency of the impact was performed and, once completed, a weighted average score describing the overall socio-economic impacts of each concern was calculated in the same manner as the overall environmental score.

Table 2 Example of environmental impact assessment of Freshwater shortage.

Environmental issues	Score	Weight %	Environmental concerns	Weight averaged score
1. Modification of stream flow	1	20	Freshwater shortage	1.50
2. Pollution of existing supplies	2	50		
3. Changes in the water table	1	30		

Table 3 Example of Health impacts assessment linked to one of the GIWA concerns.

Criteria for Health impacts	Raw score	Score	Weight %
Number of people affected	Very small – Very large (0 1 2 3)	2	50
Degree of severity	Minimum – Severe (0 1 2 3)	2	30
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	2	20
Weight average score for Health impacts		**2**	

After all 22 issues and associated socio-economic impacts have been scored, weighted and averaged, the magnitude of likely future changes in the environmental and socio-economic impacts of each of the five concerns on the entire region is assessed according to the most likely scenario which describes the demographic, economic, technological and other relevant changes that might influence the aquatic environment within the region by 2020.

In order to prioritise among GIWA concerns within the region and identify those that will be subjected to causal chain and policy options analysis in the subsequent stages of the GIWA, the present and future scores of the environmental and socio-economic impacts of each concern are tabulated and an overall score calculated. In the example presented in Table 4, the scoping assessment indicated that concern III, Habitat and community modification, was the priority concern in this region. The outcome of this mathematic process was reconciled against the knowledge of experts and the best available information in order to ensure the validity of the conclusion.

In some cases however, this process and the subsequent participatory discussion did not yield consensus among the regional experts regarding the ranking of priorities. As a consequence, further analysis was required. In such cases, expert teams continued by assessing the relative importance of present and potential future impacts and assign weights to each. Afterwards, the teams assign weights indicating the relative contribution made by environmental and socio-economic factors to the overall impacts of the concern. The weighted average score for each concern is then recalculated taking into account

Table 4 Example of comparative environmental and socio-economic impacts of each major concern, presently and likely in year 2020.

Concern	Types of impacts: Environmental score		Economic score		Human health score		Social and community score		Overall score
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)	
Freshwater shortage	1.3	2.3	2.7	2.8	2.6	3.0	1.8	2.2	**2.3**
Pollution	1.5	2.0	2.0	2.3	1.8	2.3	2.0	2.3	**2.0**
Habitat and community modification	2.0	3.0	2.4	3.0	2.4	2.8	2.3	2.7	**2.6**
Unsustainable exploitation of fish and other living resources	1.8	2.2	2.0	2.1	2.0	2.1	2.4	2.5	**2.1**
Global change	0.8	1.0	1.5	1.7	1.5	1.5	1.0	1.0	**1.2**

the relative contributions of both present and future impacts and environmental and socio-economic factors. The outcome of these additional analyses was subjected to further discussion to identify overall priorities for the region.

Finally, the assessment recognises that each of the five GIWA concerns are not discrete but often interact. For example, pollution can destroy aquatic habitats that are essential for fish reproduction which, in turn, can cause declines in fish stocks and subsequent overexploitation. Once teams have ranked each of the concerns and determined the priorities for the region, the links between the concerns are highlighted in order to identify places where strategic interventions could be applied to yield the greatest benefits for the environment and human societies in the region.

Causal chain analysis

Causal Chain Analysis (CCA) traces the cause-effect pathways from the socio-economic and environmental impacts back to their root causes. The GIWA CCA aims to identify the most important causes of each concern prioritised during the scoping assessment in order to direct policy measures at the most appropriate target in order to prevent further degradation of the regional aquatic environment.

Root causes are not always easy to identify because they are often spatially or temporally separated from the actual problems they cause. The GIWA CCA was developed to help identify and understand the root causes of environmental and socio-economic problems in international waters and is conducted by identifying the human activities that cause the problem and then the factors that determine the ways in which these activities are undertaken. However, because there is no universal theory describing how root causes interact to create natural resource management problems and due to the great variation of local circumstances under which the methodology will be applied, the GIWA CCA is not a rigidly structured assessment but should be regarded as a framework to guide the analysis, rather than as a set of detailed instructions. Secondly, in an ideal setting, a causal chain would be produced by a multidisciplinary group of specialists that would statistically examine each successive cause and study its links to the problem and to other causes. However, this approach (even if feasible) would use far more resources and time than those available to GIWA[1]. For this reason, it has been necessary to develop a relatively simple and practical analytical model for gathering information to assemble meaningful causal chains.

Conceptual model

A causal chain is a series of statements that link the causes of a problem with its effects. Recognising the great diversity of local settings and the resulting difficulty in developing broadly applicable policy strategies, the GIWA CCA focuses on a particular system and then only on those issues that were prioritised during the scoping assessment. The starting point of a particular causal chain is one of the issues selected during the Scaling and Scoping stages and its related environmental and socio-economic impacts. The next element in the GIWA chain is the immediate cause; defined as the physical, biological or chemical variable that produces the GIWA issue. For example, for the issue of eutrophication the immediate causes may be, inter alia:

- Enhanced nutrient inputs;
- Increased recycling/mobilisation;
- Trapping of nutrients (e.g. in river impoundments);
- Run-off and stormwaters

Once the relevant immediate cause(s) for the particular system has (have) been identified, the sectors of human activity that contribute most significantly to the immediate cause have to be determined. Assuming that the most important immediate cause in our example had been increased nutrient concentrations, then it is logical that the most likely sources of those nutrients would be the agricultural, urban or industrial sectors. After identifying the sectors that are primarily

[1] This does not mean that the methodology ignores statistical or quantitative studies; as has already been pointed out, the available evidence that justifies the assumption of causal links should be provided in the assessment.

responsible for the immediate causes, the root causes acting on those sectors must be determined. For example, if agriculture was found to be primarily responsible for the increased nutrient concentrations, the root causes could potentially be:

- Economic (e.g. subsidies to fertilisers and agricultural products);
- Legal (e.g. inadequate regulation);
- Failures in governance (e.g. poor enforcement); or
- Technology or knowledge related (e.g. lack of affordable substitutes for fertilisers or lack of knowledge as to their application).

Once the most relevant root causes have been identified, an explanation, which includes available data and information, of how they are responsible for the primary environmental and socio-economic problems in the region should be provided.

Policy option analysis

Despite considerable effort of many Governments and other organisations to address transboundary water problems, the evidence indicates that there is still much to be done in this endeavour. An important characteristic of GIWA's Policy Option Analysis (POA) is that its recommendations are firmly based on a better understanding of the root causes of the problems. Freshwater scarcity, water pollution, overexploitation of living resources and habitat destruction are very complex phenomena. Policy options that are grounded on a better understanding of these phenomena will contribute to create more effective societal responses to the extremely complex water related transboundary problems. The core of POA in the assessment consists of two tasks:

Construct policy options

Policy options are simply different courses of action, which are not always mutually exclusive, to solve or mitigate environmental and socio-economic problems in the region. Although a multitude of different policy options could be constructed to address each root cause identified in the CCA, only those few policy options that have the greatest likelihood of success were analysed in the GIWA.

Select and apply the criteria on which the policy options will be evaluated

Although there are many criteria that could be used to evaluate any policy option, GIWA focuses on:

- Effectiveness (certainty of result)
- Efficiency (maximisation of net benefits)
- Equity (fairness of distributional impacts)
- Practical criteria (political acceptability, implementation feasibility).

The policy options recommended by the GIWA are only contributions to the larger policy process and, as such, the GIWA methodology developed to test the performance of various options under the different circumstances has been kept simple and broadly applicable.

Global International Waters Assessment

Table 5a: Scoring criteria for environmental impacts of Freshwater shortage

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 1: Modification of stream flow "An increase or decrease in the discharge of streams and rivers as a result of human interventions on a local/ regional scale (see Issue 19 for flow alterations resulting from global change) over the last 3-4 decades."	■ No evidence of modification of stream flow.	■ There is a measurably changing trend in annual river discharge at gauging stations in a major river or tributary (basin > 40 000 km^2); or ■ There is a measurable decrease in the area of wetlands (other than as a consequence of conversion or embankment construction); or ■ There is a measurable change in the interannual mean salinity of estuaries or coastal lagoons and/or change in the mean position of estuarine salt wedge or mixing zone; or ■ Change in the occurrence of exceptional discharges (e.g. due to upstream damming.	■ Significant downward or upward trend (more than 20% of the long term mean) in annual discharges in a major river or tributary draining a basin of >250 000 km^2; or ■ Loss of >20% of flood plain or deltaic wetlands through causes other than conversion or artificial embankments; or ■ Significant loss of riparian vegetation (e.g. trees, flood plain vegetation); or ■ Significant saline intrusion into previously freshwater rivers or lagoons.	■ Annual discharge of a river altered by more than 50% of long term mean; or ■ Loss of >50% of riparian or deltaic wetlands over a period of not less than 40 years (through causes other than conversion or artificial embankment); or ■ Significant increased siltation or erosion due to changing in flow regime (other than normal fluctuations in flood plain rivers); or ■ Loss of one or more anadromous or catadromous fish species for reasons other than physical barriers to migration, pollution or overfishing.
Issue 2: Pollution of existing supplies "Pollution of surface and ground fresh waters supplies as a result of point or diffuse sources"	■ No evidence of pollution of surface and ground waters.	■ Any monitored water in the region does not meet WHO or national drinking water criteria, other than for natural reasons; or ■ There have been reports of one or more fish kills in the system due to pollution within the past five years.	■ Water supplies does not meet WHO or national drinking water standards in more than 30% of the region; or ■ There are one or more reports of fish kills due to pollution in any river draining a basin of >250 000 km^2 .	■ River draining more than 10% of the basin have suffered polysaprobic conditions, no longer support fish, or have suffered severe oxygen depletion ■ Severe pollution of other sources of freshwater (e.g. groundwater)
Issue 3: Changes in the water table "Changes in aquifers as a direct or indirect consequence of human activity"	■ No evidence that abstraction of water from aquifers exceeds natural replenishment.	■ Several wells have been deepened because of excessive aquifer draw-down; or ■ Several springs have dried up; or ■ Several wells show some salinisation.	■ Clear evidence of declining base flow in rivers in semi-arid areas; or ■ Loss of plant species in the past decade, that depend on the presence of ground water; or ■ Wells have been deepened over areas of hundreds of km^2;or ■ Salinisation over significant areas of the region.	■ Aquifers are suffering salinisation over regional scale; or ■ Perennial springs have dried up over regionally significant areas; or ■ Some aquifers have become exhausted

Table 5b: Scoring criteria for environmental impacts of Pollution

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 4: Microbiological pollution "The adverse effects of microbial constituents of human sewage released to water bodies."	■ Normal incidence of bacterial related gastroenteric disorders in fisheries product consumers and no fisheries closures or advisories.	■ There is minor increase in incidence of bacterial related gastroenteric disorders in fisheries product consumers but no fisheries closures or advisories.	■ Public health authorities aware of marked increase in the incidence of bacterial related gastroenteric disorders in fisheries product consumers; or ■ There are limited area closures or advisories reducing the exploitation or marketability of fisheries products.	■ There are large closure areas or very restrictive advisories affecting the marketability of fisheries products; or ■ There exists widespread public or tourist awareness of hazards resulting in major reductions in the exploitation or marketability of fisheries products.
Issue 5: Eutrophication "Artificially enhanced primary productivity in receiving water basins related to the increased availability or supply of nutrients, including cultural eutrophication in lakes."	■ No visible effects on the abundance and distributions of natural living resource distributions in the area; and ■ No increased frequency of hypoxia[1] or fish mortality events or harmful algal blooms associated with enhanced primary production; and ■ No evidence of periodically reduced dissolved oxygen or fish and zoobenthos mortality; and ■ No evident abnormality in the frequency of algal blooms.	■ Increased abundance of epiphytic algae; or ■ A statistically significant trend in decreased water transparency associated with algal production as compared with long-term (>20 year) data sets; or ■ Measurable shallowing of the depth range of macrophytes.	■ Increased filamentous algal production resulting in algal mats; or ■ Medium frequency (up to once per year) of large-scale hypoxia and/or fish and zoobenthos mortality events and/or harmful algal blooms.	■ High frequency (>1 event per year), or intensity, or large areas of periodic hypoxic conditions, or high frequencies of fish and zoobenthos mortality events or harmful algal blooms; or ■ Significant changes in the littoral community; or ■ Presence of hydrogen sulphide in historically well oxygenated areas.

Issue 6: Chemical pollution "The adverse effects of chemical contaminants released to standing or marine water bodies as a result of human activities. Chemical contaminants are here defined as compounds that are toxic or persistent or bioaccumulating."	■ No known or historical levels of chemical contaminants except background levels of naturally occurring substances; and ■ No fisheries closures or advisories due to chemical pollution; and ■ No incidence of fisheries product tainting; and ■ No unusual fish mortality events. If there is no available data use the following criteria: ■ No use of pesticides; and ■ No sources of dioxins and furans; and ■ No regional use of PCBs; and ■ No bleached kraft pulp mills using chlorine bleaching; and ■ No use or sources of other contaminants.	■ Some chemical contaminants are detectable but below threshold limits defined for the country or region; or ■ Restricted area advisories regarding chemical contamination of fisheries products. If there is no available data use the following criteria: ■ Some use of pesticides in small areas; or ■ Presence of small sources of dioxins or furans (e.g., small incineration plants or bleached kraft/pulp mills using chlorine); or ■ Some previous and existing use of PCBs and limited amounts of PCB-containing wastes but not in amounts invoking local concerns; or ■ Presence of other contaminants.	■ Some chemical contaminants are above threshold limits defined for the country or region; or ■ Large area advisories by public health authorities concerning fisheries product contamination but without associated catch restrictions or closures; or ■ High mortalities of aquatic species near outfalls. If there is no available data use the following criteria: ■ Large-scale use of pesticides in agriculture and forestry; or ■ Presence of major sources of dioxins or furans such as large municipal or industrial incinerators or large bleached kraft pulp mills; or ■ Considerable quantities of waste PCBs in the area with inadequate regulation or has invoked some public concerns; or ■ Presence of considerable quantities of other contaminants.	■ Chemical contaminants are above threshold limits defined for the country or region; and ■ Public health and public awareness of fisheries contamination problems with associated reductions in the marketability of such products either through the imposition of limited advisories or by area closures of fisheries; or ■ Large-scale mortalities of aquatic species. If there is no available data use the following criteria: ■ Indications of health effects resulting from use of pesticides; or ■ Known emissions of dioxins or furans from incinerators or chlorine bleaching of pulp; or ■ Known contamination of the environment or foodstuffs by PCBs; or ■ Known contamination of the environment or foodstuffs by other contaminants.
Issue 7: Suspended solids "The adverse effects of modified rates of release of suspended particulate matter to water bodies resulting from human activities"	■ No visible reduction in water transparency; and ■ No evidence of turbidity plumes or increased siltation; and ■ No evidence of progressive riverbank, beach, other coastal or deltaic erosion.	■ Evidently increased or reduced turbidity in streams and/or receiving riverine and marine environments but without major changes in associated sedimentation or erosion rates, mortality or diversity of flora and fauna; or ■ Some evidence of changes in benthic or pelagic biodiversity in some areas due to sediment blanketing or increased turbidity.	■ Markedly increased or reduced turbidity in small areas of streams and/or receiving riverine and marine environments; or ■ Extensive evidence of changes in sedimentation or erosion rates; or ■ Changes in benthic or pelagic biodiversity in areas due to sediment blanketing or increased turbidity.	■ Major changes in turbidity over wide or ecologically significant areas resulting in markedly changed biodiversity or mortality in benthic species due to excessive sedimentation with or without concomitant changes in the nature of deposited sediments (i.e., grain-size composition/redox); or ■ Major change in pelagic biodiversity or mortality due to excessive turbidity.
Issue 8: Solid wastes "Adverse effects associated with the introduction of solid waste materials into water bodies or their environs."	■ No noticeable interference with trawling activities; and ■ No noticeable interference with the recreational use of beaches due to litter; and ■ No reported entanglement of aquatic organisms with debris.	■ Some evidence of marine-derived litter on beaches; or ■ Occasional recovery of solid wastes through trawling activities; but ■ Without noticeable interference with trawling and recreational activities in coastal areas.	■ Widespread litter on beaches giving rise to public concerns regarding the recreational use of beaches; or ■ High frequencies of benthic litter recovery and interference with trawling activities; or ■ Frequent reports of entanglement/suffocation of species by litter.	■ Incidence of litter on beaches sufficient to deter the public from recreational activities; or ■ Trawling activities untenable because of benthic litter and gear entanglement; or ■ Widespread entanglement and/or suffocation of aquatic species by litter.
Issue 9: Thermal "The adverse effects of the release of aqueous effluents at temperatures exceeding ambient temperature in the receiving water body."	■ No thermal discharges or evidence of thermal effluent effects.	■ Presence of thermal discharges but without noticeable effects beyond the mixing zone and no significant interference with migration of species.	■ Presence of thermal discharges with large mixing zones having reduced productivity or altered biodiversity; or ■ Evidence of reduced migration of species due to thermal plume.	■ Presence of thermal discharges with large mixing zones with associated mortalities, substantially reduced productivity or noticeable changes in biodiversity; or ■ Marked reduction in the migration of species due to thermal plumes.
Issue 10: Radionuclide "The adverse effects of the release of radioactive contaminants and wastes into the aquatic environment from human activities."	■ No radionuclide discharges or nuclear activities in the region.	■ Minor releases or fallout of radionuclides but with well regulated or well-managed conditions complying with the Basic Safety Standards.	■ Minor releases or fallout of radionuclides under poorly regulated conditions that do not provide an adequate basis for public health assurance or the protection of aquatic organisms but without situations or levels likely to warrant large scale intervention by a national or international authority.	■ Substantial releases or fallout of radionuclides resulting in excessive exposures to humans or animals in relation to those recommended under the Basic Safety Standards; or ■ Some indication of situations or exposures warranting intervention by a national or international authority.
Issue 11: Spills "The adverse effects of accidental episodic releases of contaminants and materials to the aquatic environment as a result of human activities."	■ No evidence of present or previous spills of hazardous material; or ■ No evidence of increased aquatic or avian species mortality due to spills.	■ Some evidence of minor spills of hazardous materials in small areas with insignificant small-scale adverse effects one aquatic or avian species.	■ Evidence of widespread contamination by hazardous or aesthetically displeasing materials assumed to be from spillage (e.g. oil slicks) but with limited evidence of widespread adverse effects on resources or amenities; or ■ Some evidence of aquatic or avian species mortality through increased presence of contaminated or poisoned carcasses on beaches.	■ Widespread contamination by hazardous or aesthetically displeasing materials from frequent spills resulting in major interference with aquatic resource exploitation or coastal recreational amenities; or ■ Significant mortality of aquatic or avian species as evidenced by large numbers of contaminated carcasses on beaches.

Table 5c: Scoring criteria for environmental impacts of Habitat and community modification

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 12: Loss of ecosystems or ecotones "The complete destruction of aquatic habitats. For the purpose of GIWA methodology, recent loss will be measured as a loss of pre-defined habitats over the last 2-3 decades."	■ There is no evidence of loss of ecosystems or habitats.	■ There are indications of fragmentation of at least one of the habitats.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by up to 30 % during the last 2-3 decades.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.
Issue 13: Modification of ecosystems or ecotones, including community structure and/or species composition "Modification of pre-defined habitats in terms of extinction of native species, occurrence of introduced species and changing in ecosystem function and services over the last 2-3 decades."	■ No evidence of change in species complement due to species extinction or introduction; and ■ No changing in ecosystem function and services.	■ Evidence of change in species complement due to species extinction or introduction	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure; and ■ Evidence of change in ecosystem services[2].

[2] Constanza, R. et al. (1997). The value of the world ecosystem services and natural capital, Nature 387:253-260.

Table 5d: Scoring criteria for environmental impacts of Unsustainable exploitation of fish and other living resources

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 14: Overexploitation "The capture of fish, shellfish or marine invertebrates at a level that exceeds the maximum sustainable yield of the stock."	■ No harvesting exists catching fish (with commercial gear for sale or subsistence).	■ Commercial harvesting exists but there is no evidence of over-exploitation.	■ One stock is exploited beyond MSY (maximum sustainable yield) or is outside safe biological limits.	■ More than one stock is exploited beyond MSY or is outside safe biological limits.
Issue 15: Excessive by-catch and discards "By-catch refers to the incidental capture of fish or other animals that are not the target of the fisheries. Discards refers to dead fish or other animals that are returned to the sea."	■ Current harvesting practices show no evidence of excessive by-catch and/or discards.	■ Up to 30% of the fisheries yield (by weight) consists of by-catch and/or discards.	■ 30-60% of the fisheries yield consists of by-catch and/or discards.	■ Over 60% of the fisheries yield is by-catch and/or discards; or ■ Noticeable incidence of capture of endangered species.
Issue 16: Destructive fishing practices "Fishing practices that are deemed to produce significant harm to marine, lacustrine or coastal habitats and communities."	■ No evidence of habitat destruction due to fisheries practices.	■ Habitat destruction resulting in changes in distribution of fish or shellfish stocks; or ■ Trawling of any one area of the seabed is occurring less than once per year.	■ Habitat destruction resulting in moderate reduction of stocks or moderate changes of the environment; or ■ Trawling of any one area of the seabed is occurring 1-10 times per year; or ■ Incidental use of explosives or poisons for fishing.	■ Habitat destruction resulting in complete collapse of a stock or far reaching changes in the environment; or ■ Trawling of any one area of the seabed is occurring more than 10 times per year; or ■ Widespread use of explosives or poisons for fishing.
Issue 17: Decreased viability of stocks through contamination and disease "Contamination or diseases of feral (wild) stocks of fish or invertebrates that are a direct or indirect consequence of human action."	■ No evidence of increased incidence of fish or shellfish diseases.	■ Increased reports of diseases without major impacts on the stock.	■ Declining populations of one or more species as a result of diseases or contamination.	■ Collapse of stocks as a result of diseases or contamination.
Issue 18: Impact on biological and genetic diversity "Changes in genetic and species diversity of aquatic environments resulting from the introduction of alien or genetically modified species as an intentional or unintentional result of human activities including aquaculture and restocking."	■ No evidence of deliberate or accidental introductions of alien species; and ■ No evidence of deliberate or accidental introductions of alien stocks; and ■ No evidence of deliberate or accidental introductions of genetically modified species.	■ Alien species introduced intentionally or accidentally without major changes in the community structure; or ■ Alien stocks introduced intentionally or accidentally without major changes in the community structure; or ■ Genetically modified species introduced intentionally or accidentally without major changes in the community structure.	■ Measurable decline in the population of native species or local stocks as a result of introductions (intentional or accidental); or ■ Some changes in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).	■ Extinction of native species or local stocks as a result of introductions (intentional or accidental); or ■ Major changes (>20%) in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).

Table 5e: Scoring criteria for environmental impacts of Global change

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 19: Changes in hydrological cycle and ocean circulation "Changes in the local/regional water balance and changes in ocean and coastal circulation or current regime over the last 2-3 decades arising from the wider problem of global change including ENSO."	■ No evidence of changes in hydrological cycle and ocean/coastal current due to global change.	■ Change in hydrological cycles due to global change causing changes in the distribution and density of riparian terrestrial or aquatic plants without influencing overall levels of productivity; or ■ Some evidence of changes in ocean or coastal currents due to global change but without a strong effect on ecosystem diversity or productivity.	■ Significant trend in changing terrestrial or sea ice cover (by comparison with a long-term time series) without major downstream effects on river/ocean circulation or biological diversity; or ■ Extreme events such as flood and drought are increasing; or ■ Aquatic productivity has been altered as a result of global phenomena such as ENSO events.	■ Loss of an entire habitat through desiccation or submergence as a result of global change; or ■ Change in the tree or lichen lines; or ■ Major impacts on habitats or biodiversity as the result of increasing frequency of extreme events; or ■ Changing in ocean or coastal currents or upwelling regimes such that plant or animal populations are unable to recover to their historical or stable levels; or ■ Significant changes in thermohaline circulation.
Issue 20: Sea level change "Changes in the last 2-3 decades in the annual/seasonal mean sea level as a result of global change."	■ No evidence of sea level change.	■ Some evidences of sea level change without major loss of populations of organisms.	■ Changed pattern of coastal erosion due to sea level rise has became evident; or ■ Increase in coastal flooding events partly attributed to sea-level rise or changing prevailing atmospheric forcing such as atmospheric pressure or wind field (other than storm surges).	■ Major loss of coastal land areas due to sea-level change or sea-level induced erosion; or ■ Major loss of coastal or intertidal populations due to sea-level change or sea level induced erosion.
Issue 21: Increased UV-B radiation as a result of ozone depletion "Increased UV-B flux as a result polar ozone depletion over the last 2-3 decades."	■ No evidence of increasing effects of UV/B radiation on marine or freshwater organisms.	■ Some measurable effects of UV/B radiation on behavior or appearance of some aquatic species without affecting the viability of the population.	■ Aquatic community structure is measurably altered as a consequence of UV/B radiation; or ■ One or more aquatic populations are declining.	■ Measured/assessed effects of UV/B irradiation are leading to massive loss of aquatic communities or a significant change in biological diversity.
Issue 22: Changes in ocean CO_2 source/sink function "Changes in the capacity of aquatic systems, ocean as well as freshwater, to generate or absorb atmospheric CO_2 as a direct or indirect consequence of global change over the last 2-3 decades."	■ No measurable or assessed changes in CO_2 source/sink function of aquatic system.	■ Some reasonable suspicions that current global change is impacting the aquatic system sufficiently to alter its source/sink function for CO_2.	■ Some evidences that the impacts of global change have altered the source/sink function for CO_2 of aquatic systems in the region by at least 10%.	■ Evidences that the changes in source/sink function of the aquatic systems in the region are sufficient to cause measurable change in global CO_2 balance.

The Global International Waters Assessment (GIWA) is a holistic, globally comparable assessment of all the world's transboundary waters that recognises the inextricable links between freshwater and coastal marine environment and integrates environmental and socio-economic information to determine the impacts of a broad suite of influences on the world's aquatic environment.

Broad Transboundary Approach

The GIWA not only assesses the problems caused by human activities manifested by the physical movement of transboundary waters, but also the impacts of other non-hydrological influences that determine how humans use transboundary waters.

Regional Assessment - Global Perspective

The GIWA provides a global perspective of the world's transboundary waters by assessing 66 regions that encompass all major drainage basins and adjacent large marine ecosystems. The GIWA Assessment of each region incorporates information and expertise from all countries sharing the transboundary water resources.

Global Comparability

In each region, the assessment focuses on 5 broad concerns that are comprised of 22 specific water related issues.

Integration of Information and Ecosystems

The GIWA recognises the inextricable links between freshwater and coastal marine environment and assesses them together as one integrated unit.

The GIWA recognises that the integration of socio-economic and environmental information and expertise is essential to obtain a holistic picture of the interactions between the environmental and societal aspects of transboundary waters.

Priorities, Root Causes and Options for the Future

The GIWA indicates priority concerns in each region, determines their societal root causes and develops options to mitigate the impacts of those concerns in the future.

This Report

This report presents the results of the GIWA assessment of the Barents Sea region – one of the largest shallow continental shelf seas in the world and the most productive sea within the Arctic Ocean. Overexploitation of fish stocks and modification of the ecosystem caused by the invading Red king crab and other alien species have severely affected Barents Sea habitats. Policy options addressing the root causes of these problems are presented along with a discussion of the management of the large quantities of nuclear wastes stored in the area.

UNEP

GEF

HÖGSKOLAN KALMAR UNIVERSITY