NORWEGIAN MINISTRY OF
THE ENVIRONMENT

Meld. St. 10 (2010–2011) Report to the Storting (white paper)

First update of the Integrated Management Plan for the Marine Environment of the Barents Sea–Lofoten Area

Ørnulf Opdahl: Hav (Ocean) (watercolour)

Ørnulf Opdahl (b. 1944 in Ålesund) is one of Norway's most prominent artists. His fascination with the sea and coastal landscapes, and his striking ability to capture their changing moods, have caused him to be regarded as a new voice in Norwegian landscape painting.

Photo: Silje Gripsrud.

NORWEGIAN MINISTRY OF
THE ENVIRONMENT

Meld. St. 10 (2010–2011) Report to the Storting (white paper)

First update of the Integrated Management Plan for the Marine Environment of the Barents Sea–Lofoten Area

Translation from the Norwegian. For information only.

Contents

First update of the Integrated Management Plan for the Marine Environment of the Barents Sea–Lofoten Area

Meld. St. 10 (2010–2011) Report to the Storting (white paper)

Recommendation of 11 March 2011 from the Ministry of the Environment, approved in the Council of State the same day. (white paper from the Stoltenberg II Government)

1 Summary

Purpose of the management plan

The purpose of this management plan is to provide a framework for the sustainable use of natural resources and goods derived from the Barents Sea–Lofoten area and at the same time maintain the structure, functioning, productivity and diversity of the area's ecosystems. The management plan is thus a tool for both facilitating value creation and maintaining the high environmental value of the area.

Management plans for all Norwegian sea areas

The management plan for the Barents Sea–Lofoten area was first announced in the white paper *Protecting the Riches of the Sea* (Report No. 12 (2001–2002) to the Storting) and was submitted as the white paper *Integrated Management of the Marine Environment of the Barents Sea and the Sea Areas off the Lofoten Islands* (Report No. 8 (2005–2006) to the Storting). The white paper was discussed by the Storting in spring 2006, and was the first management plan for a Norwegian sea area.

The white paper *Integrated Management of the Marine Environment of the Norwegian Sea* (Report No. 37 (2008–2009) to the Storting) was submitted and debated by the Storting in spring 2009. The Government intends to present a management plan for the Norwegian part of the North Sea and the Skagerrak in 2013, thus establishing management plans as the basis for integrated ecosystem-based management of all Norwegian sea areas.

The management plans clarify the overall framework and encourage closer coordination and clear priorities for management of Norway's sea areas. They increase predictability and facilitate coexistence between industries that are based on the use of these sea areas and their natural resources.

First update of this management plan

In the 2006 management plan for the Barents Sea–Lofoten area, the Government decided that an updated plan was to be presented for the first time in 2010. The present update is based on the expansion of the knowledge base that has taken place since 2006. A report on the scientific basis for updating the management plan for the Barents Sea–Lofoten area was drawn up by 26 directorates and research institutes organised in three groups: the Management Forum (headed by the Norwegian Polar Institute), the Forum on Environmental Risk Management (headed by the Norwegian Coastal Administration) and the Advisory Group on Monitoring (headed by the Institute of Marine Research). They presented a joint report on 15 April 2010. On the following day, the Norwegian Petroleum Directorate presented its report on oil and gas resources in the waters off the Lofoten and Vesterålen Islands and Senja. Various supplementary studies have also been used as a basis for updating the management plan, including a review of spin-off effects and economic consequences of expanding oil and gas activities in the waters off the Lofoten and Vesterålen Islands and Senja, and an assessment of the Deepwater Horizon accident in the Gulf of Mexico in 2010 drawn up by the Forum on Environmental Risk Management. The scientific basis and supplementary studies were made available for public consultation. More than 80 responses were received, and these supplement the scientific basis on which the management plan is based.

The management plan has been updated on the basis of both existing and new knowledge about ecosystems, ecological goods and services and resources that are important as a basis for value creation in the management plan area, and about trends in environmental status, pressures and impacts on the environment, and environmental risk. The scientific basis has been supplemented with studies assessing commercial activities and social conditions and ecological goods and services, with a particular focus on the waters off the Lofoten and Vesterålen Islands and Senja.

New knowledge

Since the management plan was presented in 2006, the main thrust of efforts to meet needs for further knowledge has been mapping of the seabed, seabird populations and the geology of the area. The MAREANO programme for mapping of the seabed, the SEAPOP programme for seabirds, and the collection of seismic data on subsea petroleum resources have been particularly important in expanding the knowledge base. The work has focused on the waters off the Lofoten and Vesterålen Islands and Senja, and the Eggakanten area along the edge of the continental shelf. These areas were selected in 2006 because they were of interest for the oil and gas industry and had also been identified as particularly valuable and vulnerable. The SEAPOP programme has provided more information on the distribution of seabirds in the Barents Sea–Lofoten area. Information on inputs of hazardous substances to Norwegian sea areas has also been considerably improved through coordinated monitoring programmes. Furthermore, the knowledge base on the impacts, scale and pace of climate change and ocean acidification has been strengthened. There has been further development of the knowledge needed to carry out assessments of the risk of accidents and the impacts of acute pollution. The importance of the Barents Sea–Lofoten area in economic terms and the value of its ecosystem services now have a more prominent place in the knowledge base.

It is an important principle that all management of the natural environment must be knowledge-based. Since the establishment of a coordinated monitoring system, information on status and trends for species, habitats and ecosystems has been built up and more systematically adapted to a knowledge-based management regime. The monitoring system is still being developed.

Environmental status

New knowledge supports the conclusion that the state of the environment in the Barents Sea–Lofoten area is still generally good. New data, particularly on the benthic fauna and seabirds, confirms and strengthens the scientific basis for identification of the particularly valuable and vulnerable areas that were listed in the 2006 management plan. These are areas that on the basis of scientific assessments have been identified as being of great importance for biodiversity and for biological production in the entire Barents Sea–Lofoten area. These are areas with a combination of qualities; for example, they may have nutrient-rich seawater and high phytoplankton production, and function as spawning grounds or part of a spawning migration route for fish, or as breeding, moulting and wintering areas for seabirds. Other areas may be valuable because there are colonies, breeding areas or other concentrations of marine mammals such as grey seals, common seals, common porpoises and killer whales. Others again are classified as particularly valuable and vulnerable because there are sponge communities and coral reef complexes on the seabed, which in turn provide habitats for other species.

The different components of the ecosystem are dealt with in the scientific basis for the management plan, and this white paper gives a thorough account of the knowledge base and environmental status, with the emphasis on particularly valuable and vulnerable areas.

The most important conclusions on the environmental status of the Barents Sea–Lofoten area are as follows:

- The Barents Sea–Lofoten area is clean and rich in resources.
- The major fish stocks are in good condition.
- Pollution levels in the management plan area are generally low.
- The ocean climate is changing: acidification is increasing, the water temperature is rising and the extent of the sea ice is declining.
- Zooplankton biomass has decreased in the last three years, whereas phytoplankton shows no clear trend.
- Most seabird populations are declining.
- Populations of the ice-dependent seal species and certain fish stocks are showing negative trends.
- Knowledge of the seabed and the distribution of benthic species has been improved through the MAREANO programme, and new species have been registered. Knowledge of seabird populations has been improved by mapping and monitoring in the SEAPOP programme.
- Further studies have confirmed the environmental value of the areas identified as particularly valuable and vulnerable.

Activity trends, value creation and coexistence

The most important industries in the Barents Sea–Lofoten area today are fisheries, maritime transport and petroleum activities, but other industries such as travel and tourism, marine bioprospecting and possible future developments in offshore energy and prospecting for minerals on the seabed are also discussed in this white paper. The importance of marine ecosystem services for value creation and Norwegian society is also discussed.

Fisheries: In 2009, the direct commercial importance of fishing and aquaculture measured as its contribution to GDP was estimated at NOK 18 billion for Norway as a whole. In addition to the core activities (fishing, aquaculture, fish processing and wholesaling), fishing and aquaculture has spin-off effects in other sectors. These include employment in technological sectors, for example jobs in local shipbuilding companies or with suppliers of various types of technical equipment . The fishing and aquaculture industry had a total export value of NOK 44.7 billion in 2009 and 53.8 billion in 2010.

Maritime transport: In the period 2005–09, the volume of traffic of seismic survey vessels, offshore supply vessels and tankers has increased considerably more than for other vessel types, but from relatively low levels. There has also been an increase in tanker size. Fishing vessels accounted for the largest number of ship movements in 2008, and about 58 % of the total distance sailed in the management plan area.

More than 80 % of the total distance sailed in the management plan area is now within the areas covered by the traffic separation schemes between Vardø and Røst, and this includes nearly 100 % of all tanker traffic. The remaining traffic in the area is dominated by cargo vessels of gross tonnage 1 000–5 000, but there is also some traffic of other cargo vessels and offshore and other service vessels.

Transit traffic consists of large tankers and bulk carriers sailing to and from Russian ports. Up to 2008, the volume of traffic was relatively stable in terms of both cargo volume and the number of ships. The cargo volume was an estimated 10–12 million tonnes per year, carried on 200–240 fully loaded ships. However, in 2009, the volume rose considerably. There are many indications that there will be a continued rise in the transit cargo volume in the years ahead. The average size of oil tankers is also expected to rise.

Petroleum activities: From the start of petroleum activities in the southern Barents Sea in 1980 and up to the end of 2010, 79 exploration licences have been awarded and 85 exploration and appraisal wells have been drilled, 21 of which were started in 2005 or later. About half of these wells have shown the presence of hydrocarbon deposits. A number of small and medium-sized discoveries have been made, mainly of gas. Since 2006, additional exploration and appraisal wells have been drilled to investigate these discoveries further. Several of them are considered to be of interest, including Tornerose and Nucula.

The Goliat field 85 km north-west of Hammerfest is the first oil field to be developed in the Barents Sea. A plan for development and operation of the field was approved by the Storting in 2009, and production is expected to start in 2013. The operating company ENI is developing the field using a floating production, storage and offloading unit. Oil will be loaded on to oil tankers for transport to the markets. Total investments in the development project are expected to be almost NOK 30 billion.

The oil and gas sector includes oil companies, the supplier industry and petroleum-related research and education institutions. Together, they account for a substantial proportion of Norwegian value creation and provide employment in all parts of the country. In 2009, the petroleum sector accounted for 22 % of Norway's GDP, and in the same year the value of petroleum exports was almost NOK 480 billion.

Travel and tourism: The travel and tourism industry covers a wide range of activities and sectors, a large proportion of which involve sales to travellers. Accommodation, restaurant and transport services and travel and tour companies are all part of the tourist industry. The industry depends on and helps to maintain viable coastal communities along the Norwegian coastline. Few countries have as long and varied a coastline as Norway, and the coastal environment, the fjords and the open sea have great potential in terms of tourism. A growth in the number of tourists in a region has spin-off effects in addition to direct value creation in travel and tour companies, especially in the retail sector.

Statistics Norway has published a report on tourism and its economic importance, which shows that tourism accounts for a larger proportion of total production in the three northernmost counties than in the rest of the country. Total consumption by Norwegian and foreign visitors and tourists in North Norway in 2009 was estimated at NOK 19 billion. This is split as follows between the three counties: Nordland NOK 8.6 billion, Troms NOK 6.6 billion and Finnmark NOK 3.8 billion.

Marine bioprospecting: Marine bioprospecting can be described as a systematic and targeted search for components, bioactive compounds and genetic material in marine organisms. It is not an industry in the traditional sense of the word, but an approach to obtaining a variety of compounds that can be used in many different sectors, including the pharmaceutical industry, production of food and feedstuffs, the cosmetic industry, bioenergy production and the oil and gas industry.

The Government views marine bioprospecting as a means to innovative, sustainable value creation. The potential for value creation is substantial, and Norway is in a good position to make its mark in international competition. The Government considers that Norway's long coastline and extensive sea areas offer rich opportunities for access to resources and high species diversity. The infrastructure and research groups needed to collect and screen a wide variety of marine organisms are available in Norway. In combination with the national expertise that has already been built up in the marine sector and biotechnology, this gives Norway a good starting point for a national initiative for marine bioprospecting.

Coexistence between industries: Seismic surveys are carried out at all stages of oil and gas activities, from the early exploration phase and well into the production phase, when they are used for reservoir surveillance purposes. Seismic surveys have resulted in most conflict between the petroleum industry and the fisheries.

To reduce conflict, a working group with representatives from the Petroleum Directorate and the Directorate of Fisheries was appointed to review the legislation governing seismic surveys. In response to their report, amendments have been made to the legislation.

Ecosystem services: The benefits we obtain from ecosystems and our dependence on them can be described in the form of the wide range of ecosystem services we enjoy. The scientific basis for this white paper uses the classification of ecosystem services into four types.

– Supporting services such as maintenance of biodiversity and primary production, which are necessary for the production of all other ecosystem services.
– Regulating services, such as climate regulation and water purification.
– Provisioning services, which are the products obtained from ecosystems, such as fish, shellfish and energy sources, and genetic resources that provide a basis for the pharmaceutical and biotechnology industries.
– Cultural services, which provide non-material benefits in the form of recreation, aesthetic experience and a sense of place and identity.

It is possible to find market prices for some provisioning services, for example oil and gas or fish and shellfish. Other provisioning services have option values related to their possible future use. These include genetic resources and resources that may be useful for the pharmaceutical, chemical and biotechnological industries, but that cannot be assigned a specific value today.

Risk of acute pollution

The level of activity in the Barents Sea–Lofoten area is relatively low, and the probability of acute pollution from shipping and petroleum activities is still considered to be low. However, collation of data on acute pollution incidents involving the petroleum industry on the Norwegian continental shelf with various activity indicators shows that there is no direct linear relationship between activity level and the number or severity of acute pollution incidents. Thus, the influence of activity level on the level of risk should not be overestimated.

The scientific basis for this management plan includes oil spill scenarios that were drawn up for use in modelling the drift and spread of oil in the event of a spill, and environmental risk analyses of oil spills for selected discharge points off the Lofoten and Vesterålen Islands and Senja. Most of the scenarios are for oil spills from the petroleum industry (and petroleum-related shipping), but a scenario for a serious shipwreck southwest of the Røst archipelago was also modelled.

For shipping, the distance sailed is expected to increase for most types of ships, and markedly so for large oil and gas tankers. For fishing vessels, on the other hand, a decrease in distance sailed is expected. Since 2005, a number of steps have been taken to improve maritime safety. These have considerably reduced the probability of accidents. The most important measures – the traffic separation schemes between Vardø and Røst, the vessel traffic service centre in Vardø, and improvements in emergency tugboat services – considerably reduce the probability of two types of accidents, collisions and groundings.

The level of petroleum activity in the management plan area is currently low, with one gas field (Snøhvit) on stream and one oil field (Goliat) under development. At present, the risk of accidents and the probability of oil spills from the petroleum industry are low.

The Norwegian authorities are concerned about the accident in the Gulf of Mexico in 2010 and other similar accidents, particularly since the possibility of a major accident on the Norwegian continental shelf cannot be ruled out. The results and recommendations of investigations of the Deepwater Horizon accident are being followed up and evaluated by the different supervisory authorities in Norway, and also across administrative boundaries as regards the evaluation of environmental risk. The authorities are giving priority to studies of the causes of the accident and the course of events, and are making active use of lessons that can be learned from this accident in order to avoid similar incidents in Norway.

Assessment of cumulative environmental effects

An assessment of cumulative effects on the structure, functioning, productivity and diversity of the ecosystems of the area indicates that there have not been any changes at ecosystem level since 2006, nor would this be expected in such a short period of time.

According to the assessment, cumulative environmental effects are greatest for the following elements of the ecosystem: corals, sponges and sea pen communities, seabirds, ice-dependent seal species and those fish stocks that are in poor condition. The decline in guillemot and kittiwake populations as a result of the combined environmental pressures is particularly worrying.

In the years ahead, the cumulative effects of climate change, ocean acidification and long-range transport of pollutants will probably increase and have more serious implications for different types of activities in the Barents Sea–Lofoten area. A combination of several significant environmental pressures in the same area at the same time increases the risk of impacts on the ecosystem. For example, a permanent change in sea temperature and pH could result in change on such a scale that the ecosystem reaches a tipping point and there is a regime shift. This means that there are major, permanent changes in the structure, functioning and productivity of the ecosystem. The impacts are difficult to predict, but may be far-reaching.

Measures for the conservation and sustainable use of ecosystems

In the 2006 management plan, the Government stated that it considered the state of the environment in the Barents Sea–Lofoten area to be generally good, and this is still the case today. It is the Government's opinion, based on existing knowledge, that the main tasks in the period between now and 2020 will be related to long-range transboundary pollution, climate change and ocean acidification, the decline in seabird populations, the risk of acute oil pollution, and further development of the different elements of an ecosystem-based management regime.

The need to protect the seabed and seabirds is addressed by specific measures in this action plan.

A range of benthic fauna types have been registered during mapping of the seabed under the MAREANO programme; these include coral reefs, gorgonian forests, sponge communities and sea pen communities. The Government will give priority to further mapping of areas where there is a high probability of finding corals and certain other species. Furthermore, the Government will introduce general legislation for Norwegian sea areas requiring vessels that use bottom trawls and other gear that is towed along the seabed to leave the area where they are fishing if bycatches of sponges and corals exceed specified quantities, and will ensure that updated maps and other information on coral reefs and other vulnerable benthic animals is available.

Norway has a special responsibility for the management of several seabird species, because their Norwegian populations make up a substantial proportion of the European or North Atlantic populations. Further knowledge is needed on the reasons for the decline in seabird populations, and action must be taken if it is found that pressure from human activities is causing problems for seabirds. The Government will further develop systematic monitoring of the most important seabird populations and build up knowledge of the reasons for their decline.

In the first white paper on the management plan for the Barents Sea–Lofoten area, the Government established a framework for petroleum activities in the management plan area. The Government also announced that the framework would be re-evaluated on the basis of the information available each time the management plan was updated, from 2010 onwards. The Government's policy platform for the parliamentary period 2009–13 made it clear that the Government did not intend to open the waters off the Lofoten and Vesterålen Islands (Nordland VI and VII and Troms II) for petroleum activities during this period, but to decide whether an impact assessment of petroleum activities should be carried out in connection with this first update of the management plan. Moreover, the white paper on the management plan for the Norwegian Sea stated that the Government would consider whether to initiate opening of the northern part of the coastal zone for petroleum activities; this process would also include an environmental impact assessment. These assessments form part of the framework for petroleum activities set out in the present white paper. The new framework replaces the framework described in the 2006 management plan.

Delimitation treaty with Russia

The entry into force of the Treaty between Norway and Russia concerning Maritime Delimitation and Cooperation in the Barents Sea and the Arctic Ocean will establish the boundary for the Norwegian part of the Barents Sea. Until now, the whole of the previously disputed area has been included in the sections of the scientific basis for the management plan for the Barents Sea–Lofoten area that describe general environmental conditions, environmental pressures from human activity, etc, on the basis of existing knowledge. The knowledge base for this area does not differ greatly from that for other parts of the Barents Sea, except that information on the geology and petroleum resources is more limited, and the seabed has not been mapped in as much detail.

More knowledge needed

Although our general knowledge of the ecosystem of the Barents Sea–Lofoten area is fairly comprehensive, more knowledge is still needed in various fields. It is important to learn more about the pace and impacts of climate change and ocean acidification and about the factors that influence the resilience of the ecosystem to change. More knowledge is also needed on interactions between the impacts of ocean acidification and climate change, and between these and the impacts of human activities such as fisheries, petroleum activities and shipping.

2 Introduction

2.1 Integrated, ecosystem-based marine management

The purpose of this management plan is to provide a framework for the sustainable use of natural resources and ecosystem services derived from the Barents Sea–Lofoten area and at the same time maintain the structure, functioning, productivity and diversity of the area's ecosystems. The management plan is thus a tool for both facilitating value creation and maintaining the high environmental value of the area. This means that the overall framework for activities in these waters must be clarified in order to pave the way for the coexistence of different industries, particularly the fisheries industry, maritime transport and the petroleum industry. The management plan is also intended to be instrumental in ensuring that business interests, local, regional and central authorities, environmental organisations and other interest groups all have a common understanding of the goals for the management of the Barents Sea–Lofoten area.

The management plan for the Barents Sea–Lofoten area was the first management plan developed for a Norwegian sea area. The Government's proposal was presented in the white paper *Integrated Management of the Marine Environment of the Barents Sea and the Sea Areas off the Lofoten Islands* (Report No. 8 (2005–2006) to the Storting), and was debated in the Storting in spring 2006. Both the development process and the plan itself were later used as a model for the white paper *Integrated Management of the Marine Environment of the Norwegian Sea* (Report No. 37 (2008–2009) to the Storting), which was debated by the Storting in autumn 2009. The Government intends to present a similar management plan for the North Sea–Skagerrak area in 2013.

Figure 2.1 Fulmar (*Fulmarus glacialis*)

Photo: Cecilie von Quillfeldt.

Norway is a maritime nation. The Government's goal is for Norway to be a pioneer in developing an integrated, ecosystem-based management regime for marine areas. Our work on management plans for Norwegian sea areas has attracted considerable international attention.

2.2 Background and basis for this update of the management plan

The 2006 white paper states that the management plan will be a rolling plan and will be updated at regular intervals. In the white paper, the Government announced that it would:

- regularly assess the need to follow up and update the management plan;
- assess the overall need for new measures to achieve the goals of the plan, based on the status reports to be submitted from 2010 onwards.

This updated management plan does not include a full review of all the measures that were presented in 2006, but focuses on specific questions that were raised then and how these have been followed up. On the basis of the overall needs that are identified through assessments, a process will be started well before 2020 with a view to an overall revision of the management plan in 2020, with a time frame up to 2040.

In the 2006 management plan, the Government emphasised the importance of a cautious approach to the expansion of petroleum activities in the Barents Sea–Lofoten area. A framework for petroleum activities in the area was established taking into account the areas identified as particularly valuable and vulnerable and an assessment of the risk of acute oil pollution. The Government also announced that the framework would be re-evaluated on the basis of the information available each time the management plan was updated, from 2010 onwards. The management plan identified specific areas where there was a need to strengthen the knowledge base, particularly mapping of the seabed, seabirds and geology.

The coalition government's policy platform made it clear that it did not intend to open the waters off the Lofoten and Vesterålen Islands (Nordland VI and VII and Troms II) during the parliamentary term 2009–13, but that it would decide whether an impact assessment of petroleum activities should be carried out in connection with the review of the management plan in 2010. Furthermore, the 2006 white paper stated that the question of petroleum activities in the zone 35–50 km from the baseline off Troms and Finnmark would be considered in connection with the present update of the management plan.

Moreover, in the 2009 management plan for the Norwegian Sea, the Government announced that in connection with the update of the Barents Sea–Lofoten management plan, it would consider whether to initiate opening of the northern part of the coastal zone for petroleum activities; this process would also include an environmental impact assessment.

The present update of the management plan is based on both existing and new knowledge about ecosystems, ecological goods and services and resources that are important as a basis for value creation in the management plan area, and about trends in environmental status, pressures and impacts on the environment, and environmental risk. The scientific basis has been supplemented with studies assessing commercial activities and social conditions and ecological goods and services, with a particular focus on the waters off the Lofoten and Vesterålen Islands and Senja.

Certain thematic and policy areas, such as issues relating to international law and climate, security and business policy, are briefly discussed here but not considered in depth.

Main geographical focus

The scientific basis, descriptions and assessments in this white paper deal with the entire management plan area. However, there is a special emphasis on descriptions and assessments of the waters off the Lofoten and Vesterålen Islands and Senja. This is because special efforts have been made to build up knowledge of these areas, and the framework for petroleum activities is being reconsidered.

The boundary between the management plan areas for the Barents Sea–Lofoten area and the Norwegian Sea was adjusted in the Norwegian Sea management plan so that it follows a natural boundary between ecosystems. The present white paper is based on the new boundary.

Treaty on Maritime Delimitation and Cooperation in the Barents Sea and the Arctic Ocean

Norway and Russia signed the Treaty on Maritime Delimitation and Cooperation in the Barents Sea and the Arctic Ocean in Murmansk on 15 September 2010. The treaty clarifies the exact boundary of the Norwegian and Russian zones and con-

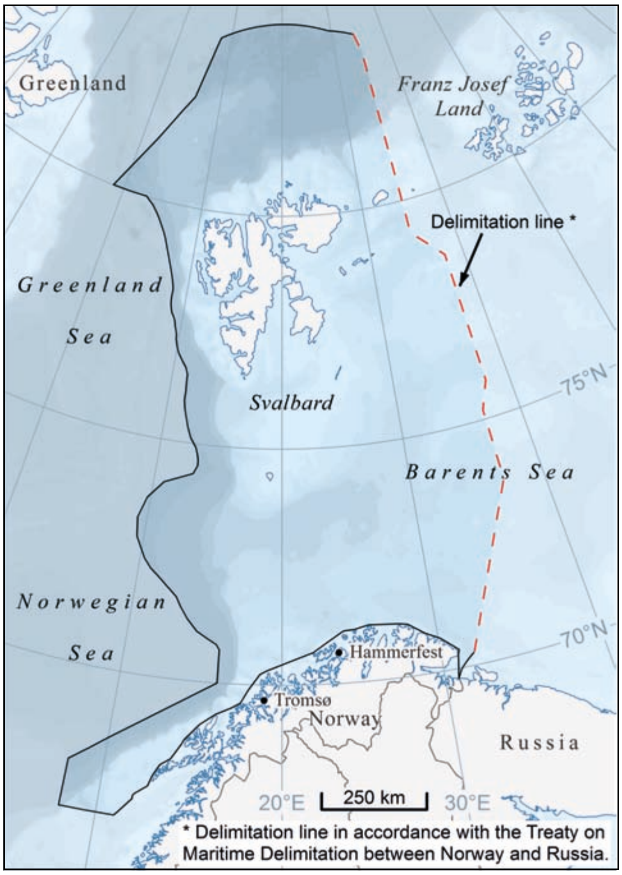

Figure 2.2 The Barents Sea–Lofoten management plan area

Map data: Norwegian Polar Institute 2011
Depth data: IBCAO

tinental shelves in the Barents Sea and Arctic Ocean, and creates clarity, predictability and stability as regards the exercise of authority, control and jurisdiction over resources in this area. It also contains provisions on the continuation of the extensive and fruitful Norwegian-Russian fisheries cooperation, as well as provisions concerning cooperation on the exploitation of any petroleum deposits in these waters that extend across the delimitation line.

The Storting gave its consent to ratification of the treaty on 8 February 2011. In mid-February, the Russian President submitted the treaty to the Duma for approval. At the time of publication of this white paper, it was not known when the Duma would consider the question of ratification, but it was hoped that this would take place in the near future so that the treaty could be ratified and enter into force.[1]

Under the treaty, the previously disputed area of about 175 000 km^2 is divided into two parts of approximately the same size. Chapter 3.2 gives an account of the state of the environment and current activity in the previously disputed area.

2.3 Overall framework and key processes

The management regime for the marine environment is constantly being developed, and progress in the past two years is briefly discussed here. For further details, the reader is referred to the 2006 management plan for the Barents Sea–Lofoten area and the 2009 management plan for the Norwegian Sea.

International developments

The 1982 United Nations Convention on the Law of the Sea constitutes the basic international legal framework for all maritime activity, and thus also provides the overall legal framework for activity in and management of the Barents Sea–Lofoten area. It establishes rights and duties that apply to Norway as a coastal state regarding jurisdiction over maritime transport, utilisation of living resources and petroleum resources, and environmental protection. The Convention also provides the international legal basis for the establishment of Norway's 12-nautical-mile territorial limit and the 200-nautical-mile zones off the mainland and around Svalbard and Jan Mayen, and for determining the extent of the Norwegian continental shelf.

In November 2006, Norway submitted documentation on the outer limits of the continental shelf beyond 200 nautical miles in the Barents Sea, the Norwegian Sea and the Arctic Ocean to the Commission on the Limits of the Continental Shelf. In its recommendations for these areas in March 2009, the Commission agreed in all essential points with the Norwegian documentation. The recommendations cover a total area of continental shelf outside the 200-nautical-mile limit of about 235 000 km^2, which corresponds to almost three-quarters of the area of the Norwegian mainland.

The 1995 Agreement on implementation of the provisions of the Convention on the Law of the Sea (UNCLOS) relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (Fish Stocks Agreement) implements and further specifies the provisions of the convention. The 2006 UN resolution on sustainable fisheries (A/RES/61/105) calls

[1] The treaty entered into force on 7 July 2011.

upon states and regional fisheries management organisations to protect vulnerable marine ecosystems from destructive fishing practices, including bottom fishing, in accordance with the precautionary principle and within the framework of ecosystem-based management. This was reiterated in a new resolution in 2009 (A/RES/64/72), which reviewed states' implementation of the 2006 resolution. In 2008, the Food and Agriculture Organization of the United Nations (FAO) adopted guidelines for the management of deep-sea fisheries in the high seas, and these have provided a tool for the development of legislation by regional fisheries management organisations.

The Convention on Biological Diversity is a framework convention whose objectives include both the conservation and sustainable use of biological diversity and the equitable sharing of the benefits arising out of the utilisation of genetic resources. In October 2010, the Conference of the Parties under the Convention in Nagoya, Japan, adopted a number of goals, and agreed among other things:

- to take action to halt the loss of biodiversity in order to ensure that by 2020 ecosystems are resilient;
- to conserve 10 % of coastal and marine areas by 2020 through effective management;
- to minimise anthropogenic pressures on coral reefs and other ecosystems that are vulnerable to the impacts of climate change by 2015;
- to manage living marine resources sustainably.

The Convention for the Protection of the Marine Environment in the North-East Atlantic (the OSPAR Convention) provides a comprehensive framework for protection of the marine environment against pollution and other environmental pressures. The convention sets out obligations for the parties to apply the precautionary and polluter pays principles, and the best available techniques and environmental practice. The September 2010 Ministerial Meeting in Bergen, Norway, adopted decisions and recommendations in a number of fields. For the first time, decisions were adopted to establish marine protected areas in areas beyond national jurisdiction. Six such areas were included in the OSPAR network of marine protected areas, which also includes about 160 areas within the parties' national jurisdiction. Recommendations were also adopted on the reduction of marine litter, and, in response to the Deepwater Horizon accident, on the prevention of oil pollution.

The North East Atlantic Fisheries Commission (NEAFC) has promoted the development of good regional control and enforcement schemes and a more ecosystem-based approach to management of sea areas beyond the 200-nautical-mile limit, in line with what the UN General Assembly has called for. In 2009, the NEAFC closed several areas, covering a total of 355 000 km^2, to bottom fisheries, including bottom trawling, and banned discards of many of the most important commercial species in the NEAFC area (the EU entered an objection, and is not bound by this decision). OSPAR and the NEAFC have signed a memorandum of understanding on cooperation, including on the protection of marine areas.

The Northwest Atlantic Fisheries Organization (NAFO) has also, like the NEAFC and in line with the UN General Assembly resolutions, adopted wide-ranging procedures and rules for protection against damaging bottom fishing activities.

The longest-running fisheries cooperation arrangement in which Norway is involved is the Joint Norwegian-Russian Fisheries Commission, which details with the Barents Sea and is important focal point for institutional cooperation between Norway and Russia. The most important fish stocks in the Barents Sea range through both Norwegian and Russian waters, and quotas are set in accordance with scientific recommendations and well within sustainable limits. The fisheries cooperation also includes extensive long-term research cooperation between the parties. As a result of cooperation on resource control and management strategies, the state of the Barents Sea fish stocks is now very good by international standards. In addition, the Norwegian-Russian fisheries cooperation includes steps to harmonise technical control measures for the fisheries, including agreement on the same mesh sizes and the same minimum sizes for certain species, and on criteria for opening and closing fishing grounds.

Cooperation under the Joint Norwegian-Russian Commission on Environmental Protection involves extensive cooperation on the marine environment. This is intended to develop the knowledge base needed for sound management of the Barents Sea, and an integrated and as far as possible joint approach to its management. A milestone was reached in 2009, when a joint Norwegian-Russian environmental status report for the Barents Sea was published. The report was based partly on the annual ecosystem status reports drawn up by Norway's Institute of Marine Research and the

Russian marine research institute PINRO under the Joint Norwegian-Russian Fisheries Commission. The plan is to follow up the environmental status report with the development of a joint environmental monitoring system for the Barents Sea. This will also be valuable for Russia in its efforts to develop an integrated management plan for its part of the Barents Sea. Moreover, the expanding economic activity in the High North, especially oil and gas activities, fisheries and maritime transport, make it even more important to establish a joint environmental monitoring system and management plans based on the same principles. Issues related to oil and gas are altracting growing attention in the cooperation on the marine environment. These include a comparison of Norwegian and Russian legislation on oil and gas activities in the High North, exchange of experience on inspection and enforcement, and harmonisation of environmental monitoring methods.

Extensive international cooperation is organised within the framework of the Arctic Council. The main focus of the Ministerial Meeting in Tromsø in April 2009 was climate change in the Arctic. The Working Group on Protection of the Arctic Marine Environment (PAME) has published the Arctic Marine Shipping Assessment 2009 Report, which reviews Arctic shipping activity and what action needs to be taken. The report is being followed up within the framework of the International Maritime Organization (IMO), which has decided to develop a mandatory code, known as the «Polar Code», to improve maritime safety and safeguard the marine environment in polar waters. IMO started work on the code in spring 2010, and aims to complete it in 2012 so that it can enter into force in 2015.

The 2009 Ministerial Meeting of the Arctic Council also established a task force to develop a binding international instrument on cooperation on search and rescue operations in the Arctic. The aim is to improve regional organisation of search and rescue services in the Arctic, and to divide the region into national search and rescue areas in order to clarify the responsibility of the individual Arctic states.

In autumn 2010, the International Hydrographic Organization (IHO) established the Arctic Regional Hydrographic Commission. So far, less than 10 % of Arctic waters have been surveyed using modern technology, and given the retreat of the sea ice, it is considered extremely important to develop maritime infrastructure and reliable nautical charts to ensure safe navigation and sustainable management of these areas.

One of the agreements concluded under the Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention) is the Agreement on the Conservation of African-Eurasian Migratory Waterbirds. This agreement entered into force in 1999, and Norway ratified it in 2008. It applies to a total of 255 species of birds that are ecologically dependent on wetlands, including many of Norway's seabirds. These include various species found in the Barents Sea–Lofoten area – great cormorant, common gull, glaucous gull, herring gull, lesser black-backed gull, black-legged kittiwake, little auk, common guillemot, Brünnich's guillemot, razorbill, black guillemot and Atlantic puffin. The purpose of the agreement is to maintain migratory waterbird species in a favourable conservation status or to restore them to such a status, giving special attention to endangered species and those with an unfavourable conservation status.

The EU

In the last few years, the EU has adopted policy instruments to promote an integrated marine environmental policy in EU member states. Norway is cooperating closely with the EU in this field, and the 2008 EU Marine Strategy Framework Directive is largely based on the same model as the integrated management plans for Norwegian sea areas. Most of the EU member states have now transposed the directive into national law, which has entailed extensive new legislation in a number of countries. There is at present extensive cooperation, both within the EU system and in the regional marine environment conventions (including OSPAR) on the implementation of the directive. The directive has not been incorporated into the EEA Agreement, but Norwegian experts are sharing experience and providing expert input to the process.

The Nature Diversity Act

Norway's Nature Diversity Act entered into force in 2009, and applies to all decisions that will have an impact on biological, geological or landscape diversity.

The Act generally applies to Norwegian land territory and territorial waters (to a distance of 12 nautical miles from the baselines). However, the objects clause and certain of the general provisions on sustainable use in Chapter II have also been made applicable in the Economic Zone of Norway and on the continental shelf. The objects

Box 2.1 Key provisions of Chapters I and II of the Nature Diversity Act

Section 2 (geographical scope of the Act)

The Act applies to Norwegian land territory, including river systems, and to Norwegian territorial waters.

Chapter VII of the Act applies to Svalbard and Jan Mayen. The King may decide that other provisions also apply to Svalbard and Jan Mayen. The Act of 15 June 2001 No. 79 relating to the protection of the environment in Svalbard and the Act of 27 February 1930 No. 2 relating to Jan Mayen otherwise apply instead of this Act.

On the continental shelf and in the areas of jurisdiction established under the Act of 17 December 1976 No. 91 relating to the economic zone of Norway, sections 1, 3 to 5, 7 to 10, 14 to 16, 57 and 58 apply to the extent they are appropriate.

Section 4 (management objectives for habitat types and ecosystems)

The objective is to maintain the diversity of habitat types within their natural range and the species diversity and ecological processes that are characteristic of each habitat type. The objective is also to maintain ecosystem structure, functioning and productivity to the extent this is considered to be reasonable.

According to the legislative history of the Act, the provisions of this section do not establish specific obligations for the public administration or the private sector, but will be important in interpreting the Act, exercising discretionary powers under this or other statutes, and drawing up legislation. The objective of section 4 and objectives under other legislation will have equal importance.

Section 5 (management objectives for species)

The objective is to maintain species and their genetic diversity for the long term and to ensure that species occur in viable populations in their natural ranges. To the extent necessary to achieve this objective, areas with specific ecological functions for different species and other ecological conditions on which they are dependent are also to be maintained.

The management objective under the first paragraph does not apply to alien organisms.

The genetic diversity of domesticated species shall be managed in such a way that it helps to secure the future resource base.

According to the legislative history of the Act, the provisions of this section do not establish specific obligations for the public administration or the private sector, but will be important in interpreting the Act, exercising discretionary powers under this or other statutes, and drawing up legislation. The objective of section 5 and objectives under other legislation will have equal importance.

Section 7 (the principles for official decision-making set out in sections 8 to 12)

The principles set out in sections 8 to 12 shall serve as guidelines for the exercise of public authority, including when an administrative agency allocates grants, and for the management of real property. Decisions shall state how these principles have been applied in an assessment under the first sentence.

According to the legislative history, the use of the word «guidelines» in section 7 means that the principles set out in sections 8–12 need not necessarily be decisive in every case. Other considerations may apply, for example guidelines for the use of discretionary powers under another act, which have greater weight in a specific case. However, the overall management of biological, geological and landscape diversity must be in accordance with the guidelines. It follows from this that the principles of the Nature Diversity Act do not apply directly. The operative provisions that apply to sea areas in other legislation together with these principles determine the specific responsibilities of a particular body.

Section 8 (knowledge base)

Official decisions that affect biological, geological and landscape diversity shall, as far as is reasonable, be based on scientific knowledge of the population status of species, the range and ecological status of habitat types, and the impacts of environmental pressures. The knowledge required shall be in reasonable proportion to the nature of the case and the risk of damage to biological, geological and landscape diversity.

Box 2.1 cont.

Furthermore, the authorities shall attach importance to knowledge that is based on many generations of experience acquired through the use of and interaction with the natural environment, including traditional Sami use, and that can promote the conservation and sustainable use of biological, geological and landscape diversity.

According to the legislative history, the term «knowledge base» as used in section 8 generally refers to knowledge that is already available. However, it may also refer to knowledge that still needs to be obtained. Obtaining knowledge may involve either obtaining existing knowledge that is not readily accessible or not known to the administrative authority, or obtaining new knowledge. The knowledge required must be in reasonable proportion to the nature and scope of the case. This must be assessed on the basis of the knowledge base it is reasonable to require taking into account the costs of obtaining the knowledge, the nature of the case and the possible environmental impacts.

Section 9 (precautionary principle)

When a decision is made in the absence of adequate information on the impacts it may have on the natural environment, the aim shall be to avoid possible significant damage to biological, geological or landscape diversity. If there is a risk of serious or irreversible damage to biological, geological or landscape diversity, lack of knowledge shall not be used as a reason for postponing or not introducing management measures.

According to the legislative history, the basis for decisions that may have an impact on biological, geological or landscape diversity must be as sound as possible, see section 8. Nevertheless, in some cases there may be doubt about the environmental impacts, and the precautionary principle provides guidelines for the authorities when dealing with such cases. Thus, the principle is applicable in situations where adequate information is not available, and applies both to administrative decisions and to evaluation of measures initiated by an administrative authority. Inadequate information may mean that it is uncertain which species, ecosystems or ecosystem services will be affected, for example which species occur in an area, or uncertainty about what the impacts will be.

Section 10 (ecosystem approach and cumulative environmental effects)

Any pressure on an ecosystem shall be assessed on the basis of the cumulative environmental effects on the ecosystem now or in the future.

According to the legislative history, the provision of section 10, like the other principles set out in this chapter of the Act, is intended as a guideline for the exercise of public authority. In applying this provision, account can thus be taken of what overall assessments may reasonably be required relating to projects and sustainable use. This section is intended to ensure that an overall assessment is made of the pressures on an ecosystem if there are plans that will involve new pressures. This means that specific environmental pressures are not to be assessed in isolation, but in relation to the impacts that have already been caused by other environmental pressures, and taking into consideration other pressures of the same or a different type that may arise later, and that together with the pressure being assessed may have unwanted impacts on biological, geological or landscape diversity.

Section 14 (other important public interests and Sami interests)

Measures under this Act shall be weighed against other important public interests.

When decisions are made under the Act that directly affect Sami interests, due importance shall be attached, within the framework that applies for the individual provision, to the natural resource base for Sami culture.

clause (section 1) states that the purpose of the Act is to protect nature through conservation and sustainable use. Sustainability has three main pillars: economic, social and environmental. The Act's provisions on management objectives for habitat types, ecosystems and species (sections 4 and 5) and some key principles for official decision-making – on the knowledge base (section 8), the precautionary principle (section 9), the ecosystem approach and cumulative environmental effects (section 10) – also apply in the Economic Zone and on the continental shelf to the extent they are appropriate.

Together with relevant sectoral legislation, the Nature Diversity Act is intended to ensure that Norway uses its resources sustainably and that the natural environment and ecological processes are protected through conservation and sustainable use.

According to the Act, the general provisions on sustainable use must be used as guidelines when exercising public authority, and decisions must make it clear how these principles have been taken into account and applied (section 7). The Act does not transfer any authority to the environmental authorities from administrative agencies that have responsibilities under other legislation. Instead, authorities in other sectors will apply the principles, objectives and guidelines for sustainable use set out in the Nature Diversity Act when making decisions under their sectoral legislation. As regards sea areas, this means that the principles set out in the Nature Diversity Act will supplement requirements of other legislation regulating the activities of various sectors, such as the Marine Resources Act, the Pollution Control Act, the Petroleum Act and the Marine Energy Act. When the relevant sectoral authorities make decisions under such legislation, they will also make use of the principles set out in the Nature Diversity Act during preparatory work and when exercising discretionary powers. In other words, when decisions will have an impact on biological, geological or landscape diversity, the Nature Diversity Act will together with sectoral legislation determine the framework for activities and protection of the marine environment.

The Nature Diversity Act also states that measures under the Act (for example relating to marine protected areas, see section 39, priority species, see section 23, and selected habitat types, see section 52) must be weighed against other important public interests and Sami interests.

Rights to harvest or otherwise utilise wild living marine resources follow from the Marine Resources Act, which entered into force in 2009. A key element of this Act is the principle for management of wild living marine resources (section 7, first paragraph), according to which the management authorities must evaluate which types of management measures are necessary to ensure sustainable management of these resources. This requires a sound knowledge base. Further efforts to gather knowledge about resources that are harvested and their environment will be important for their management. Furthermore, a precautionary approach together with an ecosystem approach that takes into account habitats and biodiversity are fundamental considerations, as set out in the second paragraph of section 7. The Marine Resources Act also provides the legal authority to protect vulnerable areas against fisheries activities, and it applies to the entire Economic Zone of Norway.

The Petroleum Act regulates the management of petroleum resources, and its basic principle is that resource management must take a long-term approach for the benefit of Norwegian society as a whole. Before any activity is started, an area must be formally opened for petroleum activities (Section 3–1). Proposals to open new areas are put before the Storting. The Ministry of Petroleum

Box 2.2 Key provisions of the Marine Resources Act

Section 7 Principle for management of wild living marine resources and fundamental considerations

The Ministry shall evaluate which types of management measures are necessary to ensure sustainable management of wild living marine resources.

Importance shall be attached to the following in the management of wild living marine resources and genetic material derived from them:

a. a precautionary approach, in accordance with international agreements and guidelines,
b. an ecosystem approach that takes into account habitats and biodiversity,
c. effective control of harvesting and other forms of utilisation of resources,
d. appropriate allocation of resources, which among other things can help to ensure employment and maintain settlement in coastal communities,
e. optimal utilisation of resources, adapted to marine value creation, markets and industries,
f. ensuring that harvesting methods and the way gear is used take into account the need to reduce possible negative impacts on living marine resources,
g. ensuring that management measures help to maintain the material basis for Sami culture.

and Energy carries out a broad-based environmental impact assessment to provide a basis for the Storting's decision.

A new Act relating to offshore renewable energy production (the Offshore Energy Act) entered into force in 2010. A strategy for offshore renewable energy was put forward together with the bill (in Proposition No. 107 (2008–2009 to the Storting). The Offshore Energy Act provides a framework for regulating offshore renewable energy production, and as a general rule applies outside the baselines and on the continental shelf, although it may also be made applicable inside the baselines. The Act requires an environmental impact assessment to be carried out before an area is opened for licence applications. Chapter 4.6 discusses the Act in more detail. The Pollution Control Act applies to offshore activities, which in many cases require a permit under section 11 of the Act. Specific conditions for activities are laid down when such permits are issued. An environmental impact assessment may also be required (section 13) as a basis for the evaluations made in connection with permits under the Pollution Control Act. In such cases, the Pollution Control Act and the relevant sectoral legislation apply together.

The Act relating to ports and navigable waters entered into force in 2010. It is intended to facilitate safe and unimpeded passage and sound use and management of navigable waters in accordance with the public interest, fisheries interests and other commercial interests. It is also intended to facilitate safe, secure and efficient port activities as part of maritime transport and intermodal transport, and to facilitate effective and competitive maritime transport of persons and goods within national and international transport networks.

Comprehensive legislation also applies to shipping. New regulations on the prevention of the spread of alien organisms via ballast water and sediments from ships entered into force in 2010.

There is separate legislation for Svalbard and Jan Mayen in several of the areas discussed above. For example, as a general rule the Svalbard Environmental Protection Act and the Act relating to Jan Mayen apply instead of the Nature Diversity Act and the Pollution Control Act.

Knowledge requirements

The general requirement for knowledge-based management set out in section 8 of the Nature Diversity Act serves as a guideline for decision-making by the authorities. The provision requires the authorities to make use of scientific and empirical knowledge when making decisions that may affect biological, geological and landscape diversity. This generally refers to knowledge that is already available. The knowledge required must be in reasonable proportion to the nature and scope of the case. The provision does not require the authorities to make general surveys of biological, geological and landscape diversity.

Section 8 of the Nature Diversity Act specifies that the knowledge requirement concerns the population status of species, the range and ecological status of habitat types, and the impacts of environmental pressures on species, habitat types and ecosystems. This will supplement the basis for assessments and decision-making under sectoral legislation that applies on the continental shelf and in Norway's economic zone. The knowledge requirement must also be considered in conjunction with the requirement to use an ecosystem approach and consider cumulative environmental effects when assessing pressure on an ecosystem. This means that different environmental pressures should not be assessed in isolation. They must also be assessed on the basis of the overall pressure on an ecosystem, including habitats and species, now or in the future.

In the absence of adequate information, application of the precautionary principle as set out in the Nature Diversity Act and the Marine Resources Act means that the aim should be to avoid significant damage to biological, geological or landscape diversity.

The scientific basis has been updated for this white paper, with new information on biodiversity, pressures and impacts, and human activity, and the white paper focuses on new information and changes in the knowledge base used for the 2006 white paper. Chapters 3–5 describe the updated knowledge base, in line with the knowledge requirements of legislation including the Nature Diversity Act and the Marine Resources Act.

The cumulative environmental effects on the ecosystems of the Barents Sea are described, compared and assessed in Chapter 6, in line with the principle of assessing cumulative environmental effects set out in the Nature Diversity Act and the Marine Resources Act. This makes it possible to gain an overview of the cumulative environmental effects of activities in different sectors on the Barents Sea ecosystems, including habitat types and species, and provides a better basis for evaluating targeted measures for the conservation and sustainable use of ecosystems.

2.4 Organisation of the work

Work on the management plans for Norway's sea areas is coordinated by an interministerial Steering Committee headed by the Ministry of the Environment. Three advisory groups have been established to implement the management plan for the Barents Sea–Lofoten area: the Management Forum (headed by the Norwegian Polar Institute), the Advisory Group on Monitoring (headed by the Institute of Marine Research), and the Forum on Environmental Risk Management (headed by the Norwegian Coastal Administration) (see Figure 2.3).

A Reference Group has also been established for the advisory groups, which represents the various interests involved. After an evaluation of its work so far, the possibility of replacing the Reference Group with improved arrangements for ensuring the participation and engagement of interested parties will be considered. On 15 April 2010, the three advisory groups presented their joint report, containing the scientific basis for the management plan update. The report was based on published scientific and other documented knowledge available in March 2010, and reflects the consensus arrived at by the twenty-six institutions involved in its preparation. The scientific basis forms the core of the knowledge base used for the evaluations in this management plan update and for finding a balance between conservation and sustainable use. Supplementary reports have been drawn up for evaluating whether the waters off the Lofoten and Vesterålen Islands and Senja should be opened for oil and gas activities. These include an analysis of population and industrial structure in North Norway, an economic analysis and a report on the possible spin-off effects of expanding oil and gas activities, and a report on the importance of marine ecosystem services. In addition, an overall evaluation of lessons learned from the Gulf of Mexico oil spill has been drawn up. New information from the Nature Index for Norway and the 2010 Norwegian Red List for Species has also been incorporated during the preparation of the white paper. All the studies and reports have been made available on the Internet, and a list of all the background documents can be found in Annex 1.

Figure 2.3 Administrative structure for the work on the management plans for Norway's sea areas

Source: Ministry of the Environment

A public consultation process was held to enable other groups whose interests are affected by the management plan to participate. About 80 responses were received, and a conference on the scientific basis for updating the plan was held in Svolvær on 8 June 2010 and attended by about 300 people. The responses have been categorised and assessed scientifically, and where appropriate, the advisory groups for the management plan have commented on the responses. The results of the consultation process have been used in the preparation of the white paper.

3 State of the environment – status and trends

A monitoring system has been established as part of the work on the management plans. This uses a set of indicators selected to give information on environmental status and trends (see Appendix 2). Through monitoring of the indicators, the management authorities will be warned of changes that require a response. Reference values and action thresholds have been established for a number of the indicators to identify the degree of change that calls for action to be taken.

This chapter gives an account of existing knowledge about the ecosystems, including species and habitat types, and the state of the environment in the Barents Sea–Lofoten area, using information from the scientific basis described in Chapter 2.4. It discusses the population status of species and the distribution and ecological status of habitat types. Environmental pressures and impacts are largely discussed in Chapter 4, and Chapter 6 gives an account of the cumulative environmental effects on the ecosystems.

The state of the ecosystems in the Barents Sea–Lofoten area is determined by a combination of external pressures such as ocean acidification and climate change, interactions between species in the ecosystems, and human activities in the area.

Box 3.1 Most important conclusions on the state of the environment and knowledge development

- The Barents Sea is clean and rich in resources.
- The major fish stocks are in good condition.
- Pollution levels in the management plan area are generally low.
- The ocean climate is changing: acidification is increasing, the water temperature is rising and the extent of the sea ice is declining.
- Zooplankton biomass has decreased in the last three years, whereas phytoplankton shows no clear trend.
- Most seabird populations are declining.
- Populations of the ice-dependent seal species and certain fish stocks are showing negative trends.
- Knowledge of the seabed and the distribution of benthic species has been improved through the MAREANO programme, and new species have been registered. Knowledge of seabird populations has been improved by mapping and monitoring in the SEAPOP programme.
- Further studies have confirmed the environmental value of the areas identified as particularly valuable and vulnerable.

The knowledge base

It is an important principle that all management of the natural environment must be knowledge-based. This means using knowledge about the state of the environment and environmental trends and how they are related to environmental pressures and their impacts. The 2006 management plan documented a considerable body of knowledge about the sea area, including knowledge of the marine environment and living marine resources in general, and of the most important commercial fish stocks in particular. Nevertheless, important gaps in our knowledge were identified, particularly as regards the benthic fauna (for example the distribution of coral reefs and sponge communities) and the distribution of seabirds. More knowledge was also needed about the distribution of certain fish species, where and how the benthic fauna may be damaged, and about bycatches of seabirds. Other areas where more knowledge was needed included inputs of long-range transboundary pollution, the impacts of hazardous substances, the impacts of climate change, and the cumulative environmental effects of activities in various sectors on different ecosystem components. It also became apparent that more knowledge was needed as a basis for risk assessments. Monitoring of elements such as seabirds, pollutants and fish stocks was not sufficiently coordinated and targeted to the authorities' needs. The knowledge base available in 2006 was thus of very variable quality, and in many cases did not provide an adequate basis for decision-making.

Since the 2006 management plan was presented, the main thrust of efforts to meet knowledge needs has been mapping of the seabed, seabird populations and the geology of the area. The MAREANO programme for mapping of the seabed, the SEAPOP programme for seabirds, and the collection of seismic data on subsea petroleum resources have been particularly important in expanding the knowledge base. Mapping of the seabed and seabird populations is discussed further in section 3.3, and geological surveys in Chapter 4.3. In line with the 2006 management plan, the work has focused mainly on the area from the Lofoten Islands to the Tromsøflaket, the Tromsøflaket bank area, and the Eggakanten area along the edge of the continental shelf. These areas were selected in 2006 because they were of interest for the oil and gas industry and had also been identified as particularly valuable and vulnerable. A corridor of the seabed stretching northwards from the North Cape has also been mapped, but not other areas of the Barents Sea away from the coast or eastwards towards the delimitation line with Russia. The SEAPOP programme has provided more information on the distribution of seabirds in the Barents Sea.

The establishment of the Advisory Group on Monitoring for the management plans has helped to improve the coordination of monitoring activities in the Barents Sea–Lofoten area. Information on inputs of hazardous substances to Norwegian sea areas has also been considerably improved through the Marine Pollution Monitoring Programme, and knowledge about the impacts, scale and pace of climate change and ocean acidification has been substantially expanded since 2006. There has been further development of the knowledge needed to carry out assessments of the risk of accidents and the impacts of acute pollution. The importance of the Barents Sea–Lofoten area in economic terms and the value of its ecosystem services now have a more prominent place in the knowledge base (see Chapter 4).

We now have a thorough knowledge of those geographical areas where the distribution and status of fish stocks is known, and where mapping of the seabed and seabirds has also been carried out. In the areas that have been mapped, we also have information on the impacts of certain important environmental pressures.

Since the coordinated monitoring system was established, information on status and trends for species, habitats and ecosystems has been built up and more systematically adapted to a knowledge-based management regime. However, the monitoring system is still being developed, and certain of the state indicators have not yet been established. In large parts of the sea areas, baseline surveys such as mapping of the seabed have not yet been carried out. In cases where insufficient knowledge is available to evaluate new projects that will have an impact on the seabed, for example under the Petroleum Act, the precautionary principle must be applied as an integrated part of the decision-making process. This principle is set out in the legislation such as the Nature Diversity Act, see Chapter 2 for further details.

The knowledge base is being steadily developed and revised. Identifying areas where more knowledge is needed is therefore still an important task (see section 3.4).

3.1 Particularly valuable and vulnerable areas

The 2006 management plan identified particularly valuable and vulnerable areas within the management plan area (see Figure 3.1). These are areas that on the basis of scientific assessments were identified as being of great importance for biodiversity and for biological production in the entire Barents Sea–Lofoten area. Adverse impacts in these areas, especially as a result of climate change, might be long-lasting or irreversible. Special caution will be required in these areas.

The Barents Sea is a nursery area for important fish stocks such as cod and haddock, which spawn along the coast from the Lofoten Islands to Troms. The relatively narrow continental shelf off the Lofoten and Vesterålen Islands is especially rich and productive, and also functions as a conveyor belt for fish eggs and larvae. It is therefore particularly vulnerable to pollution.

The areas identified as particularly valuable and vulnerable have a combination of qualities; for example, they may have nutrient-rich seawater and high phytoplankton production, and function as spawning grounds or part of a spawning migration route for fish, or as breeding, moulting and wintering areas for seabirds. Other areas may be valuable because there are colonies, breeding areas or other concentrations of marine mammals such as grey seals, common seals, common porpoises and killer whales. Others again are classi-

Figure 3.1 Particularly valuable and vulnerable areas in the Barents Sea–Lofoten area (shown in green)

Map data: Norwegian Polar Institute 2011
Depth data: IBCAO

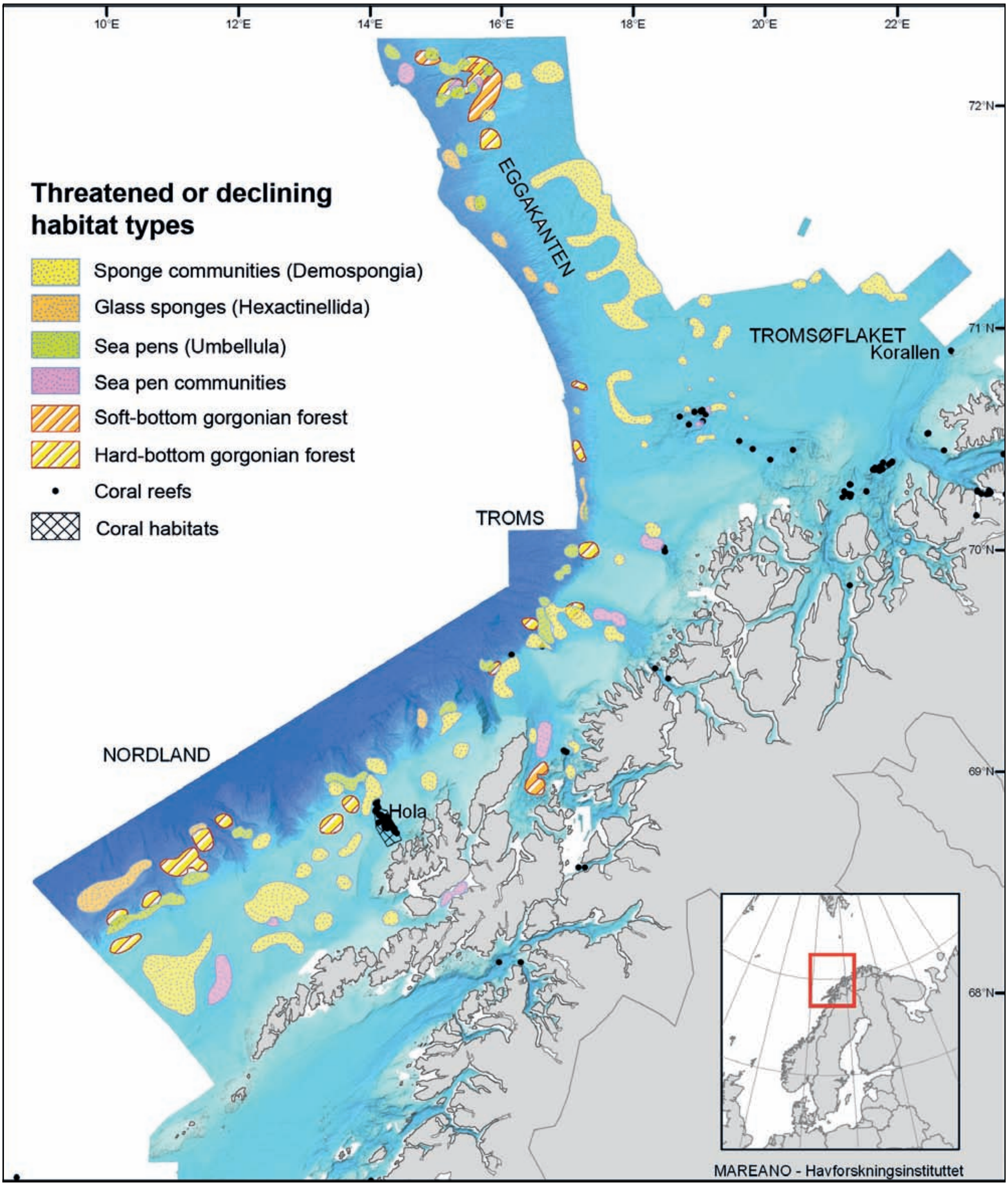

Figure 3.2 Parts of the Eggakanten area, the Tromsøflaket bank area and the area from the Lofoten Islands to the Tromsøflaket where there are habitat types listed as threatened and/or declining by OSPAR

Source: MAREANO/Institute of Marine Research

fied as particularly valuable and vulnerable because there are sponge communities and coral reef complexes on the seabed, which in turn provide habitats for other species.

New knowledge has confirmed the environmental value of the areas identified as particularly valuable and vulnerable. These include the area from the Lofoten Islands to the Tromsøflaket, the Tromsøflaket bank area, and the Eggakanten

Box 3.2 Vulnerability

Vulnerability can be defined as a measure of how liable a species or habitat is to be negatively affected by external, often anthropogenic pressures.

An assessment of the vulnerability of an area is generally based on which species and habitats occur naturally in the area and their reproductive capacity. Factors such as seasonal variations, distribution patterns, age/stage of the life cycle, behaviour and biological characteristics are used to determine the vulnerability of a particular species. Vulnerability to environmental pressures is assessed on the basis of the likely impacts of different pressures on the development and survival of a species or population. Some species are particularly vulnerable at times of the year when most of the population is concentrated in a limited area (for example fish during spawning and seabirds during the breeding season). The vulnerability of habitats depends on factors such as the substrate type (for example sand or rock), whether it contains sessile or motile species, and whether the habitat type is rare. Certain areas dominated by long-lived, habitat-forming species such as corals and sponges may be particularly vulnerable to certain environmental pressures because habitat formation can be such a slow process. Areas where biological production is high may be particularly vulnerable at certain times of year (for example when eggs and larvae (the early stages of fish) are present). Vulnerability can be measured at individual, population, community and ecosystem level. For management purposes, impacts at population, community and ecosystem level are most important.

area. Surveys have shown wide variation in habitat types and seabed landscapes, and observations include many new coral reefs, several habitat types that have provisionally been identified as new and several species that may be designated as species for which Norway has special responsibility. The presence of habitat types that are listed as threatened and/or declining by OSPAR has also been documented, see Figure 3.2. Most seabird species in many of the valuable and vulnerable areas are declining, particularly along the mainland coast. There is no new information indicating that the status of any of the areas identified as particularly valuable and vulnerable in 2006 should be changed.

Mapping of the seabed has shown trawl tracks and damage to certain coral reefs and sponge and sea pen communities in particularly valuable and vulnerable areas, but little is known about the implications of this for the ecological functioning and/or biodiversity of such areas. In other sea areas, it has been shown that sponge communities and coral reefs can be very important for the biodiversity and ecological functioning of the areas where they are found. This has not been specifically investigated in the Barents Sea–Lofoten area.

Existing knowledge does not provide an adequate basis for assessing whether more areas than those already identified should be designated as particularly valuable. New knowledge from mapping programmes may result in new assessments of which areas are particularly valuable and vulnerable.

3.2 State of the environment in the previously disputed area of the Barents Sea

When the Treaty between Norway and Russia concerning Maritime Delimitation and Cooperation in the Barents Sea and the Arctic Ocean enters into force, it will have implications for the management plan area as a whole. A larger area of the Barents Sea and Arctic Ocean will be under undisputed Norwegian jurisdiction. Together with the recommendations of the Commission on the Limits of the Continental Shelf, the Treaty means that all of the seabed west of the delimitation line will be part of the Norwegian continental shelf. As regards the water column in the previously disputed area, almost all the area west of the delimitation line will form part of Norway's 200-mile zones, while a smaller area in the southwestern part of the Loophole will still be designated as international waters. The areas that will now come under Norwegian jurisdiction include parts of the relatively shallow bank areas Sentralbanken and Storbanken, but also a smaller area north of Svalbard where the water depth reaches 3 000–4 000 m. Until now, the whole of the previously disputed area has been included in the sections of the scientific basis for the management plan for the Barents Sea–Lofoten area that describe general environmental conditions, environmental pressures from human activity, etc, on the basis of existing knowledge. The joint Norwegian-Russian environmental status report also covers the whole of the

Figure 3.3 The Norwegian part of the previously disputed area

Map data: Norwegian Polar Institute 2011
Depth data: IBCAO

previously disputed area. The knowledge base for this area does not differ greatly from that for other parts of the Barents Sea, except perhaps for the progress made in geological surveying of the petroleum potential.

The previously disputed area includes important nursery and feeding areas for fish, seabirds and marine mammals. A number of species also winter in this area, for example polar cod in the north and Northeast Arctic cod in the south. In the southern Barents Sea, the 50-km zone outside the baseline along the coast of Finnmark has been identified as a particularly valuable and vulnerable area. Central parts of the Barents Sea are also important wintering areas for a number of seabirds, including the common guillemot, which is critically endangered. The numbers of wintering common guillemots vary widely from year to year, but the reason for this is not known. There are particularly large concentrations of guillemots from the Russian breeding population in the area. In the shallow Storbanken and Sentralbanken areas, anticyclonic eddies form that prolong the residence time of the water masses in the area and therefore also concentrate organisms such as plankton that drift more or less passively with the currents. This phenomenon is exploited by animals at higher trophic levels in the food web, which are attracted to these areas. The current system, together with other physical factors that maintain high phytoplankton production, also results in an abundant benthic fauna in the shallow bank areas. The density of sea urchins is particularly high in the Sentralbanken area, and there are also concentrations of sea cucumbers in certain areas. The polar front also extends into the previously disputed area. This is an area of elevated biological production, and therefore an important feeding area for various groups of organisms; it is also a natural and dynamic biogeographical boundary, and therefore supports relatively high biodiversity. However, the eastern part of the polar front is broader and less clearly defined than it is further west. Sea ice covers part of the previously disputed area for periods of the year. The maximum extent of the sea ice varies from year to year, with wider variations further east. As the marginal ice zone moves northwards in spring, it is accompanied by fairly short-lived but intensive biological production. This makes it an important feeding area, where many groups of organisms may be present at high individual densities. However, the controlling factors and the intensity of biological production vary from the south to the deeper waters in the north. Both the polar front and the marginal ice zone have already been identified as particularly valuable and vulnerable areas in the management plan.

Since the 1980s, the previously disputed area has been closed for oil and gas activities, including seismic surveys, under a moratorium agreed by the Norwegian and Russian authorities. The incomplete information available on possible petroleum reserves in this area is therefore based on old data and very uncertain. The moratorium will lapse when the maritime delimitation treaty enters into force. In the 1970s, a few seismic surveys were carried out in the Norwegian part of the Barents Sea, mainly in the southern part. A number of seismic surveys carried out in the 1980s in the Russian sector of the Barents Sea (including the previously disputed area), together with information from exploration wells drilled near the delimitation line, suggest that there are promising petroleum structures in the area. The maritime delimitation treaty includes provisions on unitisation (meaning that any transboundary hydrocarbon deposit discovered will be exploited as a unit).

3.3 Specific ecosystem components

The following assessments of pressures and impacts on different ecosystem components focus mainly on changes since 2006. They also include a brief discussion of expected developments, with projections for 2025.

3.3.1 Physical/chemical environment

Climate change is expected to result in considerable changes in the Barents Sea ecosystem. Ice-dependent species will be under increasing pressure. Southerly species are expected to shift northwards, and there will be a similar displacement northwards of the southern distribution limits of Arctic cold-water species. Research since 2006 indicates that the first signs of such effects are becoming apparent in the Barents Sea.

Ocean acidification is expected to have major impacts on marine ecosystems, which will first become apparent in polar and subpolar regions. A large proportion of CO_2 of anthropogenic origin ends up in the oceans, where it reacts with water to form carbonic acid, making the seawater more acidic (lowering the pH). This can have a range of impacts, particularly on organisms that build calcium carbonate shells and skeletons (see Box 3.3).

Although there is already a measurable increase in the acidity of seawater, no damage to biodiversity has been shown as yet.

The ocean climate of the Barents Sea shows relatively wide variability. However, in the past 30 years the water temperature has shown a rising trend, and the extent of the sea ice has been shrinking. Continued warming of the Barents Sea–Lofoten area may result in major ecosystem changes. If the rising temperature allows adult herring to become established in the Barents Sea, for example, the capelin stock may remain at a permanently low level. This could have major impacts on other parts of the ecosystem. A combination of ocean acidification and higher temperatures could cause fundamental and irreversible changes. The impacts are difficult to predict, but may be far-reaching.

The extent of the sea ice has declined more rapidly than expected. Calculations made before the publication of the 2006 white paper indicated that the Arctic Ocean might be ice-free in summer for the first time in 60–80 years, but this is now expected to happen much sooner. Some recent models predict that the Arctic may be practically ice-free in summer before 2040.

In addition to long-term climate trends in the Barents Sea, there are short-term fluctuations

Box 3.3 Ocean acidification and its impacts on calcifying organisms

An equilibrium always forms between CO_2 in surface sea water and atmospheric CO_2. When CO_2 dissolves in water, it forms carbonic acid, which makes the seawater less basic. Acidity is expressed as pH. A pH of 7 is neutral, solutions with a pH less than 7 are acidic and solutions with a pH greater than 7 are basic or alkaline. Since the industrial revolution, global surface ocean acidity has increased by 30 %. This means that the concentration of positive, acidic hydrogen ions (H^+) ions has risen by 30 %, and that average pH has dropped from 8.2 to 8.1. The water is still on the basic side of neutral, but has become more acidic. In the decades ahead, a further reduction of 0.1–0.2 pH units is expected. Calcium carbonate forms when calcium and carbonate ions precipitate out of seawater. As the concentration of hydrogen ions rises, the concentration of carbonate ions decreases. If it falls below a critical level, the seawater becomes undersaturated in carbonate, and solid calcium carbonate can gradually dissolve.

Calcifying organisms mainly use calcium carbonate in the form of calcite or aragonite to build their shells and skeletons, and require a certain degree of supersaturation of these compounds in seawater for the process to function properly. Measurements show that there has already been some decline in the degree of calcite and aragonite saturation. Coldwater corals and a number of bivalves contain aragonite, the most soluble form of calcium carbonate. So does *Limacina helicina*, a sea snail that plays an important role in the marine food web. Crustaceans and echinoderms with calcium carbonate skeletons contain calcite, which is less soluble than aragonite, as do many groups of planktonic organisms. Ocean acidification may also have negative effects on sensitive biological processes such as reproduction, and on early life stages such as eggs and larvae.

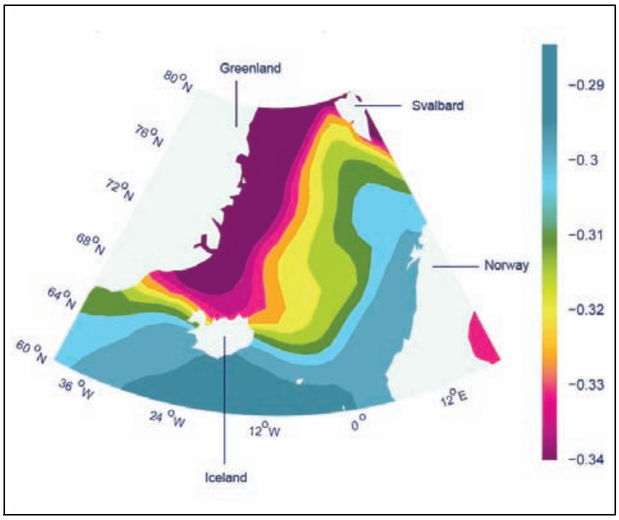

Figure 3.4 Projected changes in the acidity of surface seawater up to 2100

Source: Bellerby et al 2005

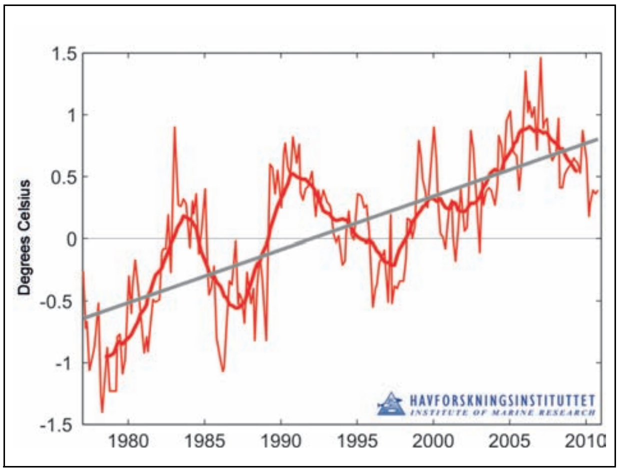

Figure 3.5 Temperature anomaly in the core of the Atlantic water flowing into the Barents Sea in the period 1977–2010. The figure shows measured values (thin red line), the 3-year moving average (thick red line), the linear trend for the whole period (bold grey line) and the long-term mean (horizontal grey line).

Source: Institute of Marine Research

from year to year. In 2006, the water temperature reached a maximum, and then declined, so that in 2010 it was a little below the trend line but above the long-term mean, as shown in Figure 3.5.

In 2006, the extent of the sea ice in winter in the Barents Sea reached a minimum, and has increased somewhat since then. On the other hand, there have been several ice-free summer seasons since 2000. The high water temperatures and shrinking sea ice have made larger parts of

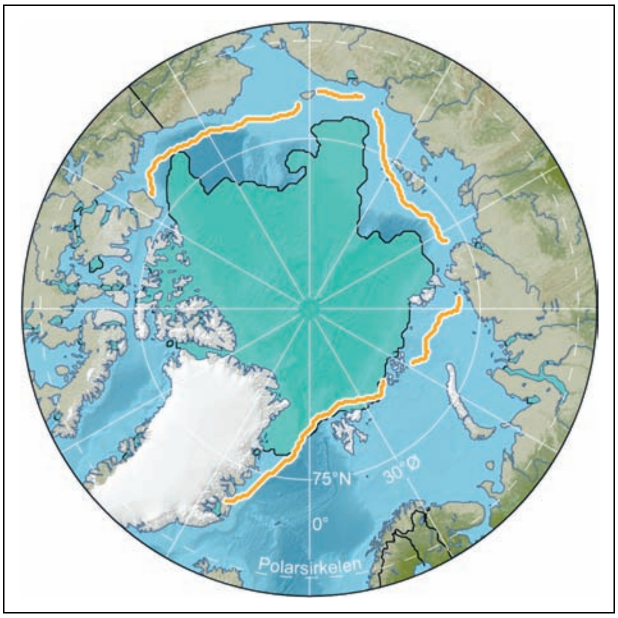

Figure 3.6 Extent of the sea ice in September 2010 (green shading) and average sea ice extent in September for the period 1979–2000 (orange line)

Map data: Norwegian Polar Institute, 2011.
Source: Data sources: IBCAO, LP DAAC, NSIDC

the Barents Sea accessible to cod and other species in recent years. This is probably one of the factors behind the recent growth in the cod stock. The inflow of water from the Atlantic Ocean is another factor that varies from year to year and is important for changes in water temperature and ice cover. The Atlantic water also transports large quantities of eggs, larvae and zooplankton into the Barents Sea. The inflow has declined somewhat in recent years from a previously high level.

It is difficult to say with any certainty how large a proportion of the already observed temperature change is a result of natural fluctuations and how much is a result of the rise in the CO_2 content of the atmosphere. In several of the recent summer seasons, the ice cover in the Arctic has retreated further than previously. At the same time, as a result of the ice-melt far larger areas of the Arctic Ocean are covered in thin first-year ice.

The extent of the sea ice in the Barents Sea is now showing a tendency to increase after a number of years when the marginal ice zone has been retreating further and further north both in winter and in summer. The annual variations in nutrient concentrations are small, but show a weakly declining trend throughout the 15-year observation period. Atlantic water has replaced Arctic water on the northern part of the continental shelf west of Spitsbergen, possibly because there is little drift ice in the coastal current in this area. This has had far-reaching effects on the species composition of plankton and fish in the area. Changes in the diet of seabirds have also been observed. Climate change is expected to have a considerable effect on transport routes for hazardous substances to the management plan area and their spread within it. However, on the basis of current knowledge it is not possible to predict what the impacts will be.

Our knowledge of climate change, ocean acidification and sea ice indicates that these factors will be of considerable importance for ecosystem status and trends in the years ahead, and that the pace of change will be more rapid than previously expected. There are significant gaps in our knowledge of physical and biological processes in the marginal ice zone, the polar front and other productive areas. More knowledge is also needed on topics such as the inflow of Atlantic water in the future and the impacts of climate change on different ecosystem components. Inadequate knowledge of such key processes means that any assessment of cumulative effects on the ecosystems today and in the future is very uncertain. In cases where there is a lack of information for decision-making, the precautionary principle must be applied. Climate change, ocean acidification and shrinking sea ice cover are expected to be responsible for a substantial proportion of cumulative effects on ecosystems and species in the years ahead.

Projections for 2025

Projections for 2025 are uncertain, but climate change models indicate that there will be a rise in temperature, a reduction in ice cover and further ocean acidification. Such changes are expected to have impacts on the ecosystems of the Barents Sea–Lofoten area.

3.3.2 Phyto- and zooplankton

Phytoplankton production (primary production) is governed by light, the availability of nutrients and the layered temperature structure of the ocean. Changes in plankton distribution are also governed by such natural factors.

There are relatively small variations from year to year in the quantity of *zooplankton* observed in the Barents Sea. However, after 2006, when observed plankton quantities were higher than for the previous eight years, there was a weak decline until 2010, when the quantity increased again.

Because the quantity of zooplankton is so important, particularly for pelagic fish species, it is an important parameter to monitor so that indications of any changes that may have affected fish stocks and other species that are dependent on zooplankton are identified as soon as possible. Grazing by the large fish stocks influences the species composition and size of plankton populations. Thus, harvesting fish stocks has some indirect influence on the composition of the zooplankton.

It is difficult to identify any trend in *phytoplankton* production in the Barents Sea in the last 10–15 years, but biomass production varies considerably between cold and warm years. This is mainly explained by the variation in the area that remains ice-free in winter. A prolonged period of higher water temperatures has resulted in changes in the distribution of recycled nutrients in the Barents Sea, which in turn is influencing the distribution of the phytoplankton. The higher temperatures are closely linked to an increase in the inflow of nutrient-rich Atlantic water. Phytoplankton production in the polar front is limited to a relatively short season, but results in large concentrations of feeding fish and crustaceans in this zone.

Our knowledge of phyto- and zooplankton in the management plan area and the relationships between plankton and commercial plankton-feeding fish stocks has been considerably improved. Nevertheless, we do not have a good enough understanding of how variations in primary and secondary production affect other ecosystem components. At present, there is no adequate explanation of why there are still large fish stocks despite a reduction in the quantity of plankton.

3.3.3 The seabed and benthic fauna

In the areas off the Lofoten and Vesterålen Islands, the Eggakanten area and coastal areas off Troms, seabed mapping has shown wide variation in habitats and seabed landscapes, including many new coral reefs, several habitat types that have been provisionally identified as new, and new species. It has also shown that there is more damage to fragile benthic communities such as coral reefs, sponge communities and sea pen communities than has previously been documented.

Examples of new habitat types include «shallow shelf areas with moraines, iceberg plough marks and sponge habitats», «deep shelf areas with level sand and gravel bottom», and «lower continental slope with canyons». In general, biodi-

Figure 3.7 Coral reef with gorgonian corals and sponges

Source: MAREANO/Institute of Marine Research

versity is highest in the shallowest hard-bottom areas. In the areas that have been mapped, the highest biodiversity has been found in the more southerly areas with a varied underwater landscape and wide variation in bottom types, for example off the Lofoten and Vesterålen Islands and the coast of Troms, while areas further north (the Tromsøflaket bank area and the transect northwards from the North Cape) are more uniform. Mapping in parts of two areas (Andfjorden transect and Lopphavet) that have been proposed for inclusion in Norway's national marine protection plan has also revealed important and vulnerable species and habitats, including coral reefs and sponge communities.

It is known from areas other than the Barents Sea that sponges grow slowly and that colonies function as habitat-building organisms. Highly specialised benthic communities develop in such habitats, which are stable over time, and these are dependent on the ecological functions provided by the sponge colonies. Sponges are also known to play an important role as shelter for larvae of various organisms during this vulnerable stage of their lives. At present, we have only limited knowledge about the ecological functions of different types of benthic organisms in the Barents Sea, but in areas where benthic communities have been studied, they have been shown to have important ecological functions. Knowledge of the impacts on benthic organisms in the Barents Sea is also limited. The MAREANO project has registered more than 1 400 different species and faunal groups in the management plan area. Many of these have been registered here for the first time, and some have not previously been found on the Norwegian continental shelf. About 100 species have been found further north than the previously known distribution limit. Several habitat types that have provisionally been identified as new have been described, including «gravelly bottom with basket stars» and «muddy bottom with sea lilies», and it has been suggested that certain species should be designated as species for which Norway has a special responsibility, including the sea pen *Umbellula*, the soft coral *Radicipes a*nd the bamboo coral *Isidella*. *Radicipes* has only been found in a landslide area (Bjørnøyaraset) at the northern end of Eggakanten, where there is a stand that has been characterised as unique and vulnerable. The results of MAREANO's analyses of the relationships between marine landscapes and the fauna will be important in further development of the system of habitat types.

Areas mapped by the MAREANO programme

The Tromsøflaket is a large, relative flat, shallow bank area dominated by sand and mud. There are large sponge communities, and many iceberg

Box 3.4 The MAREANO programme

The MAREANO programme is systematically mapping depth and topography, sediment conditions, habitats and pollutants on the seabed. So far, the areas off the Lofoten and Vesterålen Islands and the coast of Troms, parts of the Tromsøflaket bank area, parts of the edge of the continental shelf and a transect northwards from the North Cape have been mapped. By 2010, a total area of 67 600 km^2 had been mapped. This has provided valuable new knowledge, including maps of the underwater landscape, bottom types, trawl tracks, levels of pollutants in sediments and the distribution of habitat types, including vulnerable habitat types.

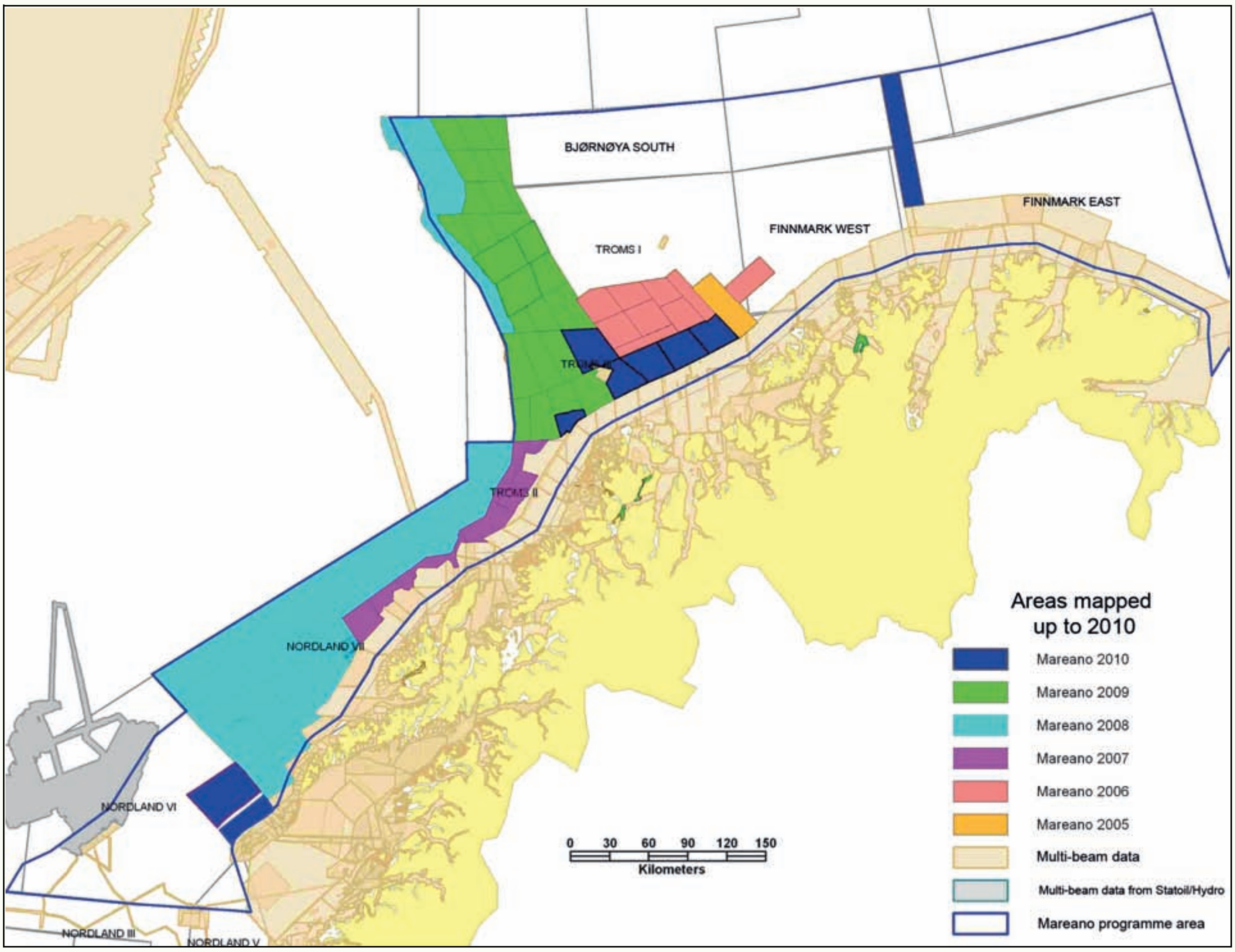

Figure 3.8 Areas where depth surveys have been carried out as part of the MAREANO programme

Source: MAREANO/ Institute of Marine Research

Data from the MAREANO surveys are made available on the programme's website and through the Norway Digital programme. The data are also being used by the Norwegian Biodiversity Information Centre in developing a new classification system for Norwegian habitat types, to map species distribution and in evaluation of the status of different habitat types. Data from other sources, for example the oil and gas sector and the Norwegian Defence Research Establishment, has also been made available to MAREANO and is included in the maps and databases.

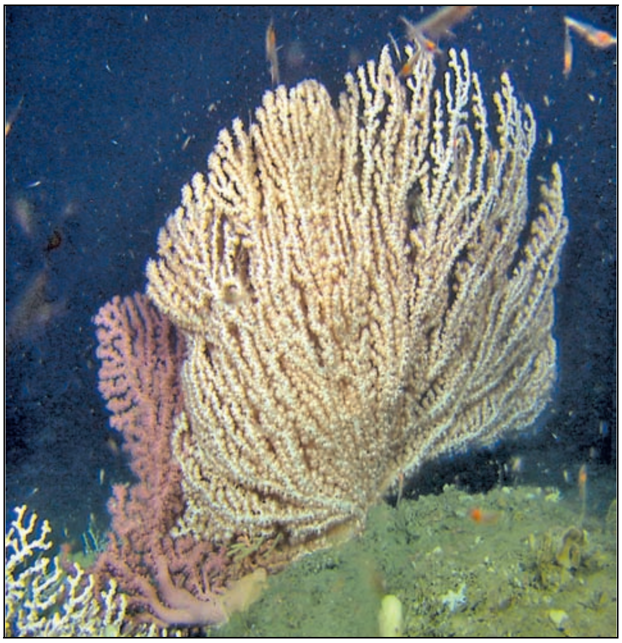

Figure 3.9 Part of a gorgonian forest

Source: MAREANO/ Institute of Marine Research

ploughmarks and moraine ridges on the seabed. East of the Tromsøflaket, in the deeper water of Ingøydypet, thousands of pockmarks have been observed on the seabed, which may indicate gas seepage. In the Eggakanten area, the continental shelf is dominated by sand and gravel, with sea anemones and sponges. The upper part of the continental slope is dominated by sea anemones and soft corals (*Cladiella*), and the lower part by tube-building polychaetes and small crustaceans in soft-bottom areas, and the Gorgon's head (a sea star) and sponges in hard-bottom areas. Another feature of the Eggakanten area is a large area of rocks from an old landslide (Bjørnøyraset). The Håkon Mosby mud volcano lies in the western part of this area.

West of the Tromsøflaket, mud diapirs have been found. These are intrusions of clay that have been forced up through geological layers below the seabed.

Off the coast of Troms, there are two shallow, species-rich areas called Malangsgrunnen and Sveinsgrunnen, consisting of boulders covered with coralline algae, sponges and other sessile animals. There are also coral reefs, species-poor areas with large sand waves on the seabed, and soft-bottom areas where the fauna includes sea cucumbers and sea pens. This area also includes shallow bank areas near the coast with a strong current, where the sediments are coarser and there is more hard bottom than further west and north.

The most varied underwater landscape is found off the Lofoten and Vesterålen Islands, where shallow bank areas lie in close proximity to steep ravines that descend to a depth of up to 3 700 m. There is a rich fauna in the shallow areas, and the Norway lobster reaches the northern limit of its distribution here. There are 330 small, intact coral reefs, surrounded by sand, in an area called Hola. In deeper water, there is an Arctic fauna dominated by sea cucumbers, sea lilies, crustaceans and sea urchins. Geological structures and a bacterial film indicate that there are cold seeps at a depth of 1 200 m.

We do not have adequate knowledge of the benthic fauna and habitats for the whole management plan area, but this is being built up as part of the activities of various research institutes and as part of the monitoring system under the management plan. Several of the coral reefs in areas that have been mapped by the MAREANO programme have been found to be damaged. This means that the management objective for endangered and vulnerable habitat types (see Chapter 6.4.1) has not been achieved in the areas where the seabed has been mapped.

Several studies have been made of the scale of damage to coral reefs in the Barents Sea–Lofoten area. Their results do not provide a basis for concluding that damage from bottom trawling has increased. Much of the damage that has been observed is several years old. In the areas that have been mapped, approximately 20 % of the coral reefs are damaged to some extent, and about 6 % of all reefs that have been inspected in the entire management plan area have been destroyed.

An area called «Korallen» northwest of Sørøya island in Finnmark was protected against bottom trawling in autumn 2009.

Projections for 2025

The situation for the benthic fauna and benthic communities in 2025 will depend primarily on activity levels and the management measures that are implemented. In the past 10 years, the fisheries management authorities have focused increasingly on impacts on benthic communities, and a number of measures have been introduced. Although oil and gas activities can have limited local impacts on benthic communities, the industry must meet strict requirements to map and avoid damage to coral reefs and other valuable benthic communities. Temperature changes may result in a northward shift in the distribution of benthic species.

Many benthic species will be vulnerable to ocean acidification, but the scale of the direct and indirect impacts is uncertain.

3.3.4 Fish stocks

There are wide natural variations in the size of fish stocks. In recent years, natural conditions together with a sound management regime have resulted in historically high levels of key fish stocks such as cod, haddock and saithe.

Capelin, herring and cod play a key role in ecosystem dynamics in the Barents Sea, and together with Greenland halibut, golden and beaked redfish and blue whiting, they are used as indicator species in the monitoring system for the Barents Sea–Lofoten area.

Northeast Arctic cod: The spawning stock is at the highest level observed since 1947, and was estimated at over 1.14 million tonnes in 2010. In 2005, the spawning stock was 700 000 tonnes.

Herring and capelin: In 2010, the abundance of juvenile herring in the Barents Sea was low, while capelin abundance was high. This gives favourable conditions for many other species in the ecosystem. The large quantity of capelin is probably an important reason why the Northeast Arctic cod stock has been growing for several years, to the extent that the spawning stock is now as high as it was immediately after the Second World War.

To prevent harvesting from reducing the weak spawning stock of capelin, zero quotas were set for commercial fishing for capelin in the Barents Sea in the period 2004–08. In 2009 and 2010, the spawning stock was large enough to allow for a directed fishery during the winter, while at the same time it was calculated that there was sufficient capelin for the cod stock to feed on. Cod and capelin are included in a separate multi-species model which is used to calculate quotas. The quotas set by Norway and Russia are in accordance with harvesting rules approved by the International Council for the Exploration of the Sea (ICES).

Norwegian spring-spawning herring: The stock of Norwegian spring-spawning herring has been very strong in recent years, and the spawning stock has reached levels comparable to those observed in the 1950s. However, recruitment has been somewhat weaker in the last couple of years, and as a result the stock declined somewhat in 2010 from a peak in 2009.

The Barents Sea is an important nursery area for spring-spawning herring, but there is no fishery for juvenile herring in this area. Since 1999, the herring stock as a whole has been managed in accordance with a management plan adopted by the coastal states. The plan involves keeping the harvest below the precautionary level recommended by ICES, which is important in maintain-

Figure 3.10 The clam *Acesta excavata* and a gorgonian coral, Tromsøflaket

Source: MAREANO/ Institute of Marine Research

Figure 3.11 Saithe feeding on krill and other zooplankton

Source: MAREANO/ Institute of Marine Research

Box 3.5 Capelin as a key species in the Barents Sea

The *capelin* stock shows wide natural variations. The species is an important predator on zooplankton, and grazing pressure from capelin is so great that the quantity of zooplankton tends to decrease as the capelin stock increases, and vice versa. Capelin feed to a large extent in the marginal ice zone and migrate to Norway's northern coast to spawn. They thus transport energy from biological production in the marginal ice zone to more southerly parts of the Barents Sea. Juvenile herring feed on capelin larvae, and this predation pressure can cause the capelin stock to collapse when the abundance of juvenile herring in the Barents Sea is high.

This became particularly clear when the capelin stock collapsed in the mid-1980s, the first of three occasions when this has happened since monitoring began in the early 1970s. The collapse of the capelin also resulted in the collapse of the common guillemot population and a decline in body condition in minke whales; it triggered mass migrations of harp seals, and the cod stock came under pressure, with poorer food supplies and high juvenile mortality as a result of cannibalism. The effects on species that feed on capelin were less dramatic in the two later periods when the capelin stock collapsed (1993–97 and 2003–06), partly because of greater availability of alternative prey. Capelin is an important prey for cod, seabirds and marine mammals.

ing a stock with a high biomass. Adult herring do not live in the Barents Sea, but larvae drift into the area from the spawning grounds along the Norwegian coast. They remain in the Barents Sea for three to four years before migrating back to the Norwegian Sea, where they spawn. The three occasions when the capelin stock has collapsed since 1970 have all coincided with the migration of large year classes of juvenile herring into the Barents Sea. Nevertheless, there have been cases when capelin recruitment has been good even when the abundance of juvenile herring in the Barents Sea is high, probably because in certain years the two species use different parts of the area.

Coastal cod: Cod in coastal waters and the fjords is known as Norwegian coastal cod. There are several stocks from Stad at about 62°N to the border with Russia. The proportion of coastal cod relative to Northeast Arctic cod rises from north to south, whereas the quantity of coastal cod (number and biomass) rises from south to north, and about 75 % of the overall stock is found north of 67°N. Coastal cod are found from the kelp zone down to about 500 m. They spawn in the inner parts of most fjords and in tributary fjord arms of the larger fjord systems, but also in the same areas as Northeast Arctic cod. The larvae of coastal cod settle in very shallow water, and rarely move to deeper water before they are two years old. They reach sexual maturity earlier than Northeast Arctic cod, grow more rapidly and are less migratory. A plan for rebuilding the stock was adopted in spring 2010.

Figure 3.12 A redfish on a coral reef

Source: MAREANO/Institute of Marine Research

Greenland halibut: The spawning stock has been low for many years, but has shown weak growth in the past ten years. It is classified as of «least concern» on the 2010 Norwegian Red List. From 2010, Norway and Russia introduced a joint management regime for Greenland halibut. The ban on a directed fishery has been repealed, and a three-year quota of 15 000 tonnes has been set. This was possible because a joint research effort has provided better knowledge of the biology and distribution of the stock.

Golden and beaked redfish: In 2005, ICES considered that both species had reduced reproductive capacity. Surveys showed a clear reduction in abundance, and indicated that both stocks were near a historical low. The year classes for the previous 10 years had been very low, and were declining. ICES recommended a ban on all directed fisheries, an expansion of area closures and stricter regulation of bycatches. The fisheries have been limited by close seasons, bycatch rules and gear restrictions, and this is still the case. These factors have helped to protect redfish larvae. There are now signs of better recruitment to the beaked redfish stock in nursery areas in the Barents Sea. However, in 2010, ICES still considered that both species had reduced reproductive capacity. The golden redfish stock is very weak, and this situation is expected to persist for many years. ICES therefore recommends stricter restrictions on the fisheries. The golden redfish is classified as endangered on the 2010 Norwegian Red List, while the beaked redfish is classified as vulnerable.

Blue whiting: The Barents Sea is at the edge of the distribution area for blue whiting, and there is no blue whiting fishery in this area. In 2006, the species was included in the monitoring system as an indicator of climate change. The quantity of juvenile blue whiting in the Barents Sea has declined over the past six years.

There are also various fish stocks of minor commercial importance in the Barents Sea. Some of these, for example several species of skate, are in poor condition. The blue skate is classified as critically endangered on the 2010 Norwegian Red List. The basking shark and blue ling are now listed as endangered, while the porbeagle is still listed as vulnerable. There is no directed fishery for any of these species.

Knowledge about commercial fish stocks is generally satisfactory. Knowledge about non-commercial fish species, including sharks, is more variable and should be strengthened. Monitoring of the commercial stocks is well established and provides a good overview of the state of the various stocks. The annual ecosystem surveys in the Barents Sea carried out by the Institute of Marine Research also provide a good basis for monitoring non-commercial species.

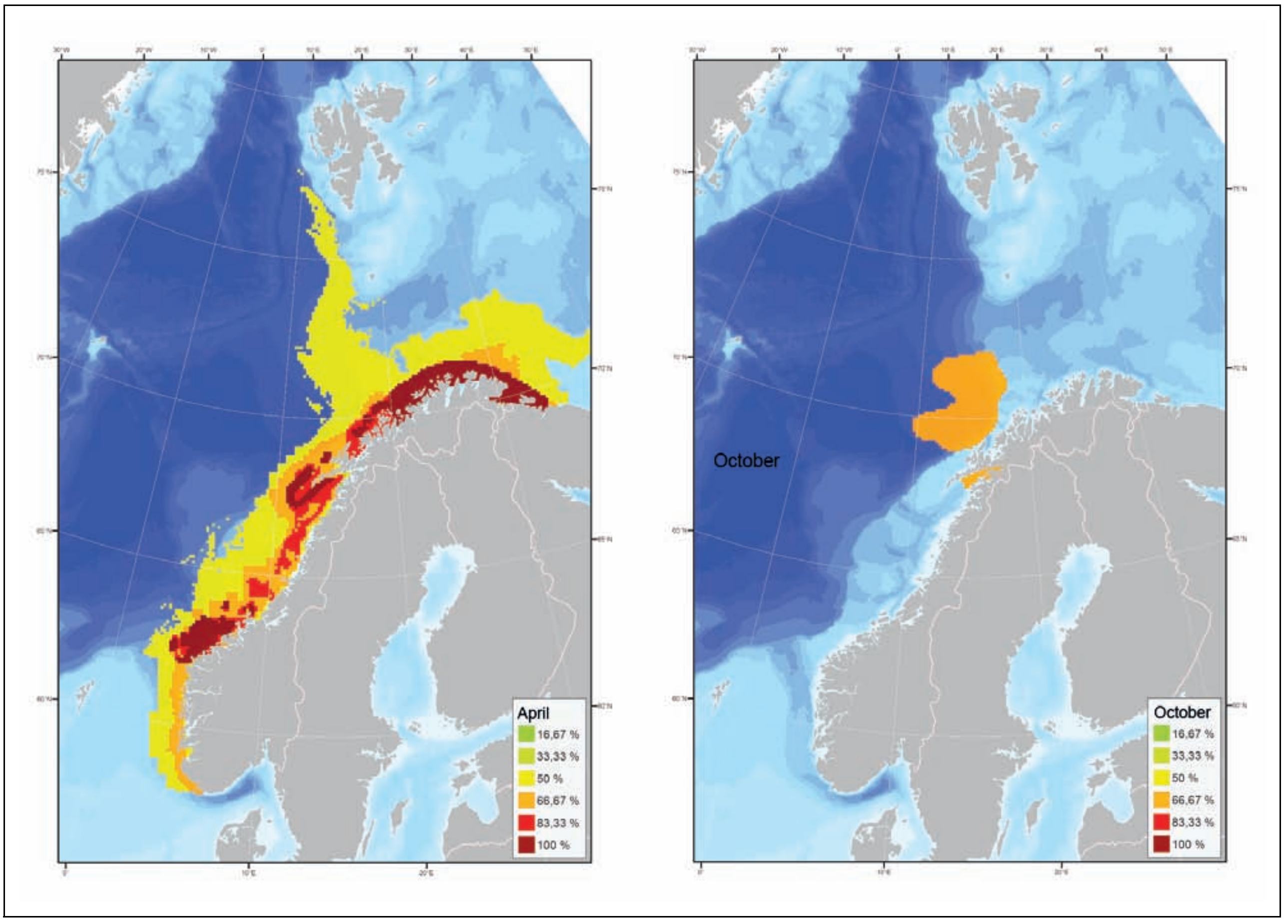

Figure 3.13 Internationally important areas for capelin, Norwegian spring-spawning herring and Northeast Arctic cod. The value of different areas for these species is expressed as percentages (the maximum value, designated as 100 %, is only assigned to spawning grounds). The maps show the situation in spring and autumn. The pattern for October is dominated by the wintering stock of Norwegian spring-spawning herring.

Source: Institute of Marine Research/Directorate for Nature Management/DNVeritas

Projections for 2025

It is not possible to make reliable projections for fish stocks over such a long period, but there are many indications that management of the large commercial stocks will ensure that they are healthy and at full reproductive capacity. The main focus in the years ahead will therefore be on rebuilding smaller but important stocks, such as the two redfish species and Greenland halibut. In the short to medium term, rising temperatures are expected to result in rising quantities of fish in the Barents Sea, particularly in northern and northeastern parts. Climate change may cause changes in physical conditions and ice cover, which will have a considerable impact on the distribution of fish species. In addition, any harvesting of zooplankton may have an impact on fish stocks. Ocean acidification will have impacts on lower trophic levels in the food web and indirect effects on other ecosystem components, including fish.

As the marginal ice zone retreats northwards, new areas can be opened up for fisheries nearer the North Pole. However, it is uncertain whether the productivity of the Arctic Ocean and its peripheral seas will increase as the ice retreats and to what extent primary production will be channelled to fish species that are of commercial interest. In the Barents Sea itself, it is already possible to observe how fish species that have traditionally been found further south have moved northwards. However, various factors make it uncertain how ecosystems will respond to a warmer climate, and thus to draw a clear picture of which fish species can be expected to dominate and the size of stocks in the future.

3.3.5 Seabird populations

Status

In the past 10 years, many seabird populations in the Barents Sea–Lofoten area have shown a serious decline. This has affected a number of species, but the problems are greatest for the most abundant species, which typically breed in colonies and feed out at sea. In the more southerly and westerly parts of the management plan area, problems have also been registered for certain coastal species.

The common guillemot and black-legged kittiwake have shown a particularly severe decline, especially in the southwestern part of the management plan area. The situation for the common guillemot is so serious that it may only be a question of time before it is lost as a breeding species from many colonies along the Norwegian coast. The situation has been better further north in the Barents Sea, but the Brünnich's guillemot population is now showing clear signs of a decline on both Bjørnøya and Spitsbergen. There are signs of a decline in the kittiwake population in this area as well. The glaucous gull population on Bjørnøya has been declining for the past 20 years, and the population has dropped by 65 % since 1986. Several of the large Atlantic puffin colonies have shown a negative trend in the past five years. Breeding success in the past four years has been below the action threshold defined in the monitoring system. A similar decline in kittiwake numbers has been observed across much of the North Atlantic, which indicates that the species' problems may be linked to large-scale environmental change throughout the area. Climate change is therefore now being discussed as an important factor behind the decline in seabird populations, primarily through its effects on food supplies.

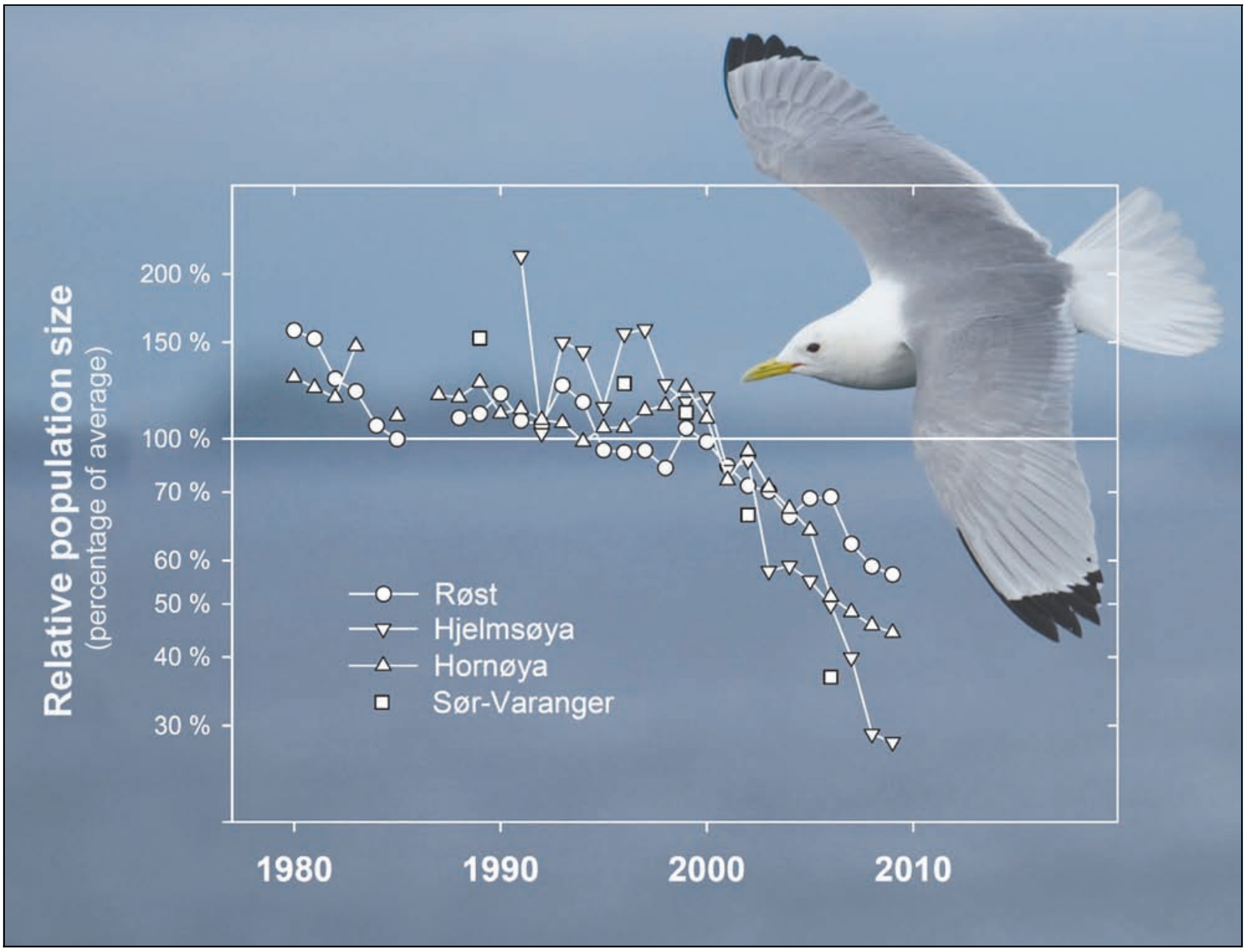

Figure 3.14 The breeding population of black-legged kittiwakes at the key localities monitored by the SEAPOP programme in the Barents Sea–Lofoten area has declined considerably in only a few years (data from the national monitoring programme for seabirds, Norwegian Institute for Nature Research

Photo: T. Anker-Nilssen

Source: Management Forum for the Barents Sea–Lofoten area, 2010.

On the Norwegian mainland, populations of kittiwake, puffin, razorbill and common guillemot have been declining for many years. The common guillemot population here has dropped to only about 1 % of the 1980 level, while the kittiwake population is declining by 5–14 % per year, and is only 15–35 % of what it was 20–30 years ago. A substantial proportion of the Norwegian population of some of the seabirds listed as threatened on the 2010 Norwegian Red List (see section 3.3.7) is found within the management plan area; this applies to the common guillemot, Brünnich's guillemot, black guillemot, puffin, razorbill, kittiwake, ivory gull and Sabine's gull. The Steller's eider, which breeds on the Russian tundra, winters on the coast of Finnmark. Other typical seabird species are placed in the «near threatened» category in the 2010 Red List: northern fulmar, white-billed diver, common gull, Leach's storm petrel, Arctic skua, and (in Svalbard) king eider, brent goose and glaucous gull.

Almost all the seabird indicators show some degree of decline, both over the last ten years and for the entire period over which monitoring has been carried out.

Seabirds are considered to be good indicators of change in marine ecosystems. They are easily visible elements in an environment where most animals and plants live below the water surface, they are easy to count, and they often concentrate in large numbers in productive marine «hotspots». Indicators for seabirds have two functions. Their numbers can be used both to indicate the availability of biomass in the upper water layers and as a basis for management of the seabird populations themselves. The role of seabirds in marine ecosystems means that they are one of the most vulnerable groups of marine organisms. At the same time, they are adapted to a constantly changing, unstable environment, where there are natural variations in food supplies. Seabirds are long-lived, which makes it difficult to identify environmental pressures and their impacts within a short time frame.

Food supplies

Changes in food supplies have been suggested as one of the main explanations for the severe decline in a number of seabird populations. A reduction in the amounts of important prey available is believed to be the key factor. The reasons for these changes are complex and only partly understood, but may include climate-related changes in marine ecosystems, lower production of prey (plankton and fish), changes in larval migration patterns, and variable recruitment to populations that are important prey for seabirds.

Many seabird species are particularly sensitive to the supply of pelagic, schooling fish species such as capelin and herring. From 2002 to 2005, there were very healthy year classes of juvenile herring, followed by a sharp rise in the capelin stock in the Barents Sea. The rise in the availability of capelin is one important reason why several of the seabird populations in eastern Finnmark and on Bjørnøya have not shown the same drop in breeding success as many populations of the same species further south. Along the coast of mainland Norway southwards from western Finnmark, breeding success and the status of breeding populations are considerably poorer. Off the Lofoten Islands, herring larvae drifting northwards are important food for many seabirds, but all the year classes of herring from 2004 onwards have been weak.

A lack of food at critical stages of the life cycle can partly explain the decline in certain seabird populations. Food shortages can be linked both to climate change and to the direct and indirect impact of the fisheries on populations of prey species. The most important factors altering food availability for seabirds are probably changes in the size of fish stocks and the balance between different species. Given that these complex relationships are also being influenced by large-scale climate change, it is difficult to identify the causes of the observed trends precisely. Through the SEAPOP programme, the authorities have initiated systematic mapping and monitoring of seabirds in all Norwegian sea areas. The objective of the programme is to obtain the necessary knowledge base for seabird management, including identifying general population trends and assessing the most likely causes of these trends.

Knowledge about seabirds

Better knowledge of how seabird reproduction and survival (and diet) are affected by interactions between herring, capelin and cod seems to be a key to understanding the development of the largest seabird populations in the Barents Sea–Lofoten area. The SEAPOP programme has considerably improved the knowledge base in most areas, with the exception of bycatches of seabirds. Information on populations, their distribution, food choices, relationships with the distribution of food species, migratory paths and wintering areas has been considerably improved in recent years.

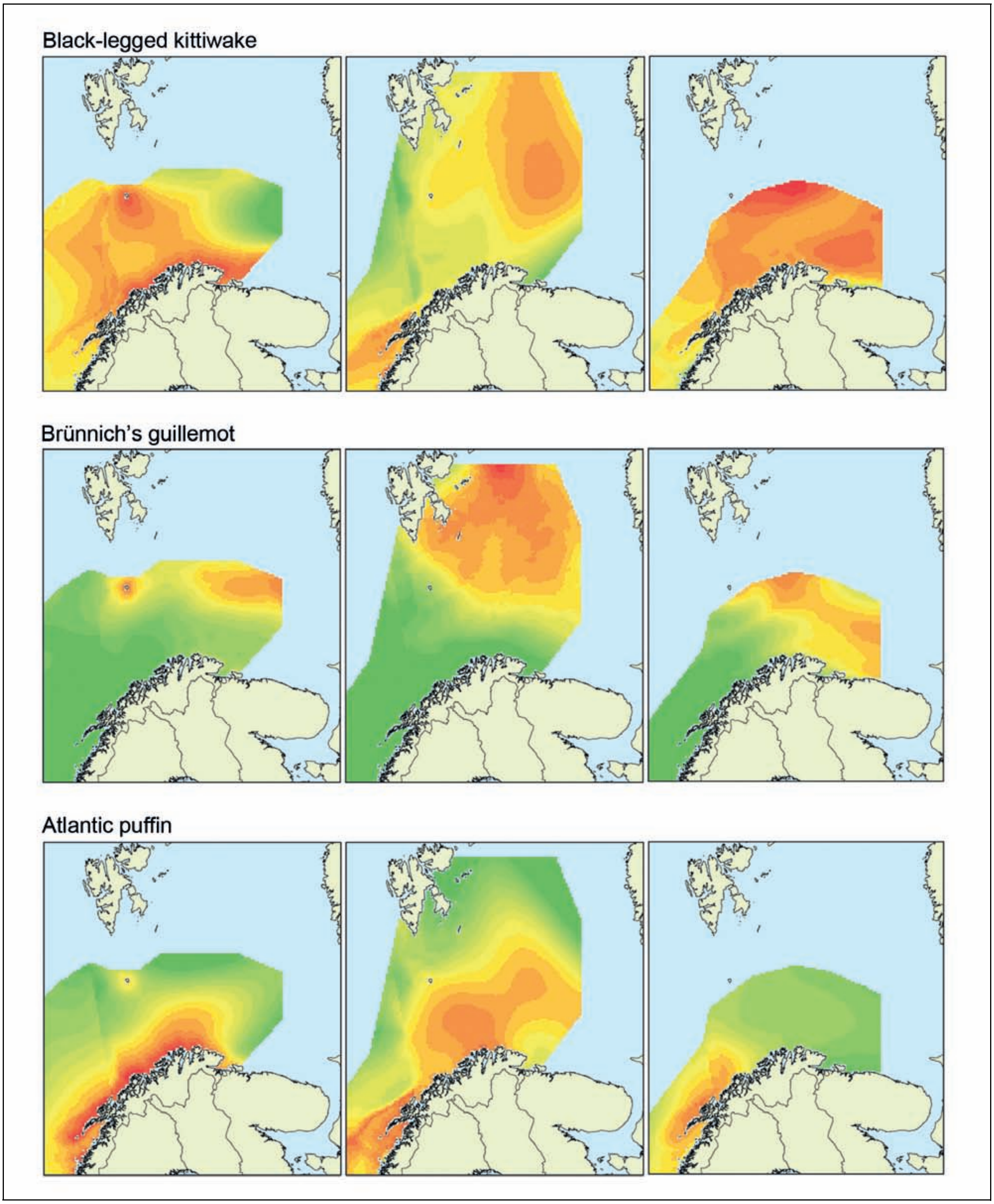

Figure 3.15 Distribution of seabirds (black-legged kittiwake, Brünnich's guillemot and Atlantic puffin) in the open sea at different times of year. The maps show the situation in summer, autumn and winter. Green: low density. Red: high density

Source: SEAPOP programme/Norwegian Institute for Nature Research

One of the remaining areas where more knowledge is needed is what impacts the management of the largest commercial fish stocks (including herring, capelin, sandeels, cod and saithe) have on seabirds. Marine ecosystems are highly complex, and an integrated ecosystem approach to management requires thorough knowledge of the different species and how they interact. However, ICES is already taking all components of natural mortality into account in today's models when calculating recommended fish mortality levels and using these to calculate quotas. Predation by other species, including seabirds, is included in calculations of natural mortality. Natural mortality varies widely, but ICES takes this into account by basing its recommendations on a precautionary approach, so that the probability that stocks will be maintained at productive levels and thus continue to be available as a source of food for predators is as high as possible. A large spawning stock does not automatically provide good food supplies for seabirds. Seabirds feed largely on fish at earlier stages of their life cycle, and the models used by ICES do not estimate the abundance of these stages near the birds' breeding grounds. No fishing for juvenile fish is permitted today. Moreover, a healthy spawning stock is no guarantee that all year classes of fish will be strong. Natural factors can result in poor recruitment even to stocks that are not fished at all, with resulting food shortages for seabirds. Fishing pressure on herring and capelin in the management plan area has not increased significantly in recent years. It is important to continue efforts to improve knowledge and understanding of the food needs of seabirds and the food available to them.

Information on bycatches of seabirds is incomplete and difficult to quantify, but work is in progress on this. More systematic mapping of the areas used by seabirds at different times of year and at different stages of their life cycle is also considered to be important.

3.3.6 Marine mammals and polar bears

Common porpoises are found all along the Norwegian coast and up to the polar front in the Barents Sea. Only a minimum estimate of population size is available for parts of this area, and we have no information on population trends. Monitoring by the Institute of Marine Research has shown that bycatches of porpoises are relatively large, but there is no sign that they are increasing. Locally, particularly in areas very close to the coast where there is an intensive gill net fishery, the bycatch mortality may be above the sustainable level for the local porpoise population. However, until the population structure has been clarified, it is not possible to judge whether the porpoise bycatch in the management plan area is reducing biodiversity, and whether the management objective set out in the Nature Diversity Act is being achieved for this species.

Surveys outside the management plan area suggest that the porpoise population is stable.

Every six years, the Scientific Committee of the International Whaling Commission (IWC) makes a scientific assessment of the minke whale stock, and the results of the assessment are used as a basis for the Norwegian management regime in the subsequent six-year period. For the management period beginning in 2009, the Scientific Committee estimated the total abundance of minke whale in the Northeast Atlantic and the Jan Mayen area at 103 000 animals. Norway's annual catch of minke whales in recent years has been 400–600 animals.

A survey of the hooded seal population shows a steep decline in pup production since 1997. The observed reduction is probably not due to hunting. Climatic conditions have resulted in changes in the extent and quality of the drift ice in the West Ice, and we cannot rule out the possibility that a proportion of the hooded seal population have responded by moving to other areas for whelping. Another possible cause of the drop in pup production may be epidemic diseases such as phocine distemper virus (PDV) or bacterial diseases such as brucellosis (caused by *Brucella*) which has been recorded in seals in the North Atlantic. Because of the low pup production, no harvest of hooded seals has been permitted since 2007.

The ringed seal is one of several species that live on the sea ice and are dependent on good ice conditions to raise their pups. There has been a reduction in the area of sea ice of suitable quality, resulting in widespread reproductive failure among ringed seals along the west coast of Spitsbergen in recent years (2006, 2007 and 2008). Similar reproductive failure has also been observed in the traditional breeding areas for other ice-dependent species in areas bordering on the Barents Sea. In the White Sea, which lies south of the Russian sector of the Barents Sea, there has been a considerable drop in harp seal pup production in recent years, probably as a result of poor ice conditions. In the Norwegian Sea, the hooded seal has suffered a substantial reduction in pup production and a population decline, which have been linked to the reduction in ice cover in this area. Until larger geographical areas can be surveyed, it is not possible to decide whether this is a real population decline or whether there has been a change in the whelping areas the species are using

Figure 3.16 Ringed seal

Source: Norwegian Polar Institute

in response to shrinking ice cover and poorer ice quality.

There has been no new survey of polar bear numbers in the management plan area since 2004. Information on population size and biology is generally satisfactory for marine mammal species that are or have until recently been commercially harvested (harp seal, hooded seal and minke whale), and the uncertainty in the stock estimates has been reduced. There are also satisfactory data on population trends for other whale species that are included in the annual sighting surveys. However, there is a lack of information on population sizes for the Arctic species ringed seal, bearded seal, walrus, narwhal and bowhead whale. It is important to monitor these species as well, and better data should also be obtained on common porpoise and beluga whale in the management plan area. Our knowledge of long-term changes in marine mammal populations as a result of climate change is limited. This information is particularly important for ice-dependent species.

Projections for 2025

Pressure from fishing and hunting is expected to remain unchanged or decline. Climate change will have a direct impact on the availability of suitable habitat for ice-dependent species (Arctic seals, ringed seal, polar bear). For other species, it may result in changes in the availability of prey. The impacts of climate change on marine mammals are expected to become more marked towards 2025. A growing volume of shipping and rising oil and gas activity may also have impacts on marine mammals, for example through increasing noise levels or collisions with ships.

3.3.7 Threatened species

If evidence indicates that a species is or may be at risk of extinction if a negative population trend continues, it is listed as critically endangered (CR), endangered (EN) or vulnerable (VU) on the national red list. These three categories together are referred to by the generic term «threatened species».

Species are placed in the different categories on the basis of an evaluation of the risk of extinction. The threat level is assessed on the basis of a set of five criteria developed by the International Union for Conservation of Nature (IUCN). The three most important elements of these criteria are:

Box 3.6 From the 2010 Norwegian Red List

Species	*Category in the Red List*
European eel	Critically endangered
Blue skate	Critically endangered
Spiny dogfish	Critically endangered
Basking shark	Endangered
Blue ling	Endangered
Golden redfish	Endangered
Porbeagle	Vulnerable
Beaked redfish	Vulnerable
Common guillemot	Critically endangered
Black-legged kittiwake	Endangered
Razorbill (Svalbard)	Endangered
Razorbill (mainland Norway)	Vulnerable
Black guillemot	Vulnerable
Atlantic puffin	Vulnerable
Steller's eider	Vulnerable
Common tern	Vulnerable
Brünnich's guillemot	Vulnerable
Ivory gull (Svalbard)	Vulnerable
Sabine's gull (Svalbard)	Endangered
Common guillemot (Svalbard)	Vulnerable
North Atlantic Right whale	Regionally extinct
Bowhead whale	Critically endangered
Hooded seal	Endangered
Narwhal	Endangered
Common seal	Vulnerable
Walrus (Svalbard)	Vulnerable
Common seal (Svalbard)	Vulnerable
Polar bear (Svalbard)	Vulnerable

Figure 3.17 Red-listed species in the management plan area. Walrus (vulnerable), polar bear (vulnerable), common guillemot (critically endangered), golden redfish (endangered)

Photos: Kit M. Kovacs and Christian Lydersen (walrus, polar bear), Hallvard Strøm (common guillemot), Institute of Marine Research (redfish).

1. A reduction in the population (meaning the number of reproductive/mature individuals) of the species.
2. The geographical range of the species consists of a few or small areas, is declining or is severely fragmented, or there is a known threat.
3. The species is very rare (population of less than 1 000).

The significance of the red list categories is the same for all species groups. However, differences in the generation length may have an impact, since in the final analysis this is what determines how long it takes before a species becomes extinct.

The information on threatened species in the 2006 white paper was based on the 1998 Norwegian Red List, which did not include marine fish. A new Red List including marine fish was drawn up in 2006. The Red List was updated again in 2010, and some adjustments were made to the criteria. The Red List status of a number of species that occur in the management plan area has been changed from 2006 to 2010. In some cases a change in category reflects a real population change, whereas in others it reflects better knowledge of the population.

The 2006 Norwegian Red List categorised 27 species that occur in the Barents Sea–Lofoten area as threatened. In the 2010 Red List, this has increased to 36 species.

The indicator for threatened species in the Barents Sea–Lofoten area is still being developed. Work on vulnerable and endangered species has been stepped up, and this has improved the knowledge base.

Projections for 2025

See the text on each species group.

3.3.8 Alien species

The spread and introduction of alien organisms can have impacts on important elements of the ecosystem. In the management plan area, the

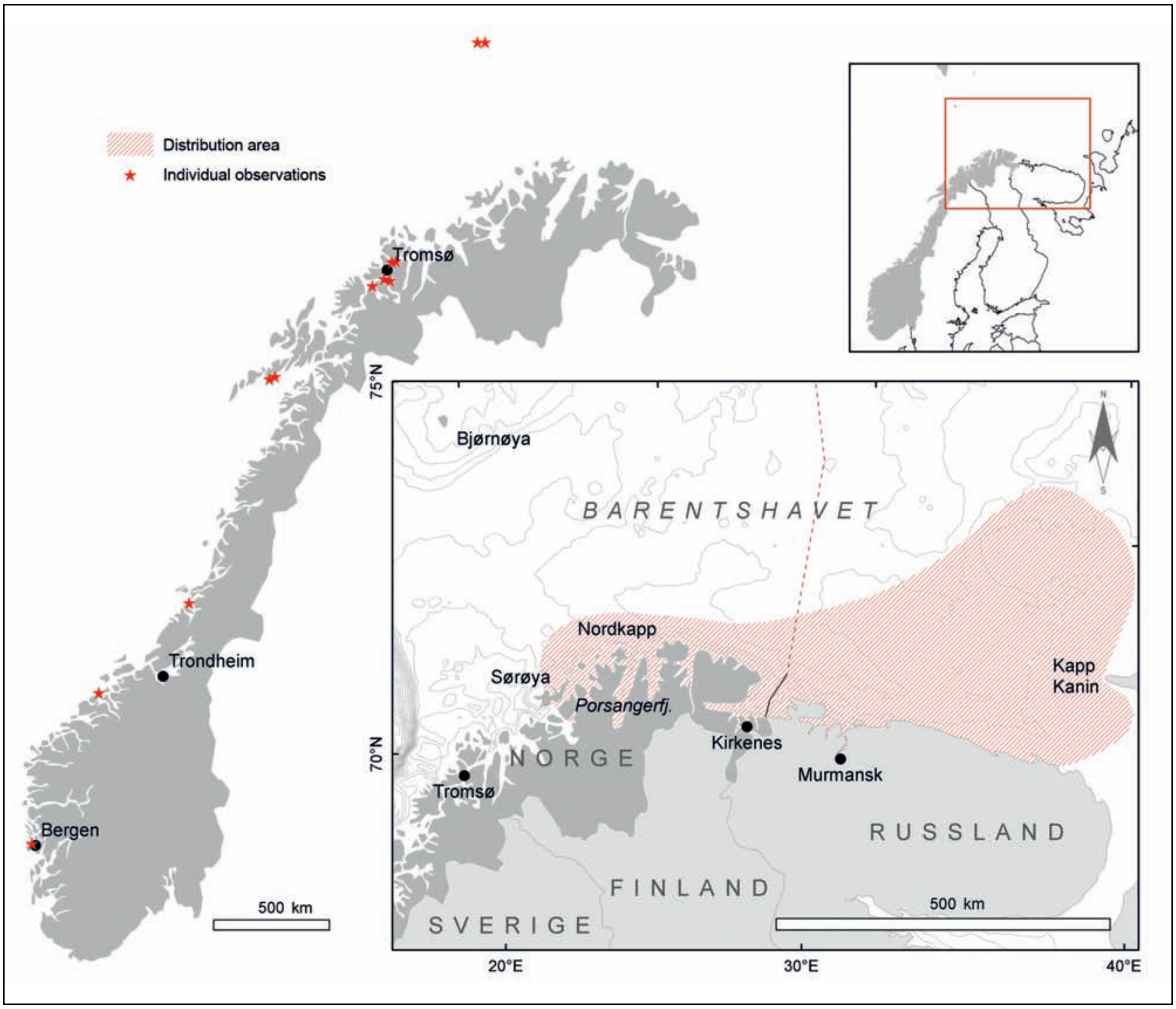

Figure 3.18 Approximate distribution of red king crab in the Barents Sea (red hatching) and individual observations of the species (red stars). Individuals found around the Lofoten Islands and further south are most likely to have been released. Those observed further north may have spread to these areas or have been released. Individual observations were registered in the period 2002–11

Source: Institute of Marine Research

alien species with the largest population and widest distribution is the red king crab. The species is also used as a harvestable resource in the fisheries. The red king crab is an invasive species that may damage important elements of the ecosystem, as further discussed below. In recent years, the combination of the commercial fishery east of 26°E (North Cape) and harvesting of all sizes of crabs in an effort to control the species west of 26°E has had a considerable effect, and the king crab population in Norwegian waters has been substantially reduced. However, it is a problem that Russia, where most of the population is found, manages the species solely as a resource. The king crab is protected in a large area along the coast adjoining the Norwegian border. As a result, there is a steady influx of crabs along the coast of Finnmark.

Monitoring alien species

The indicator for alien species in the monitoring system is still being developed. So far, it is recommended that two species, red king crab and snow crab, should be closely monitored. There are strong indications that the snow crab is developing a more northerly distribution in the Barents Sea than the red king crab. The westerly distribution of the latter has changed since 2006. In 2010, a substantial amount of red king crab was har-

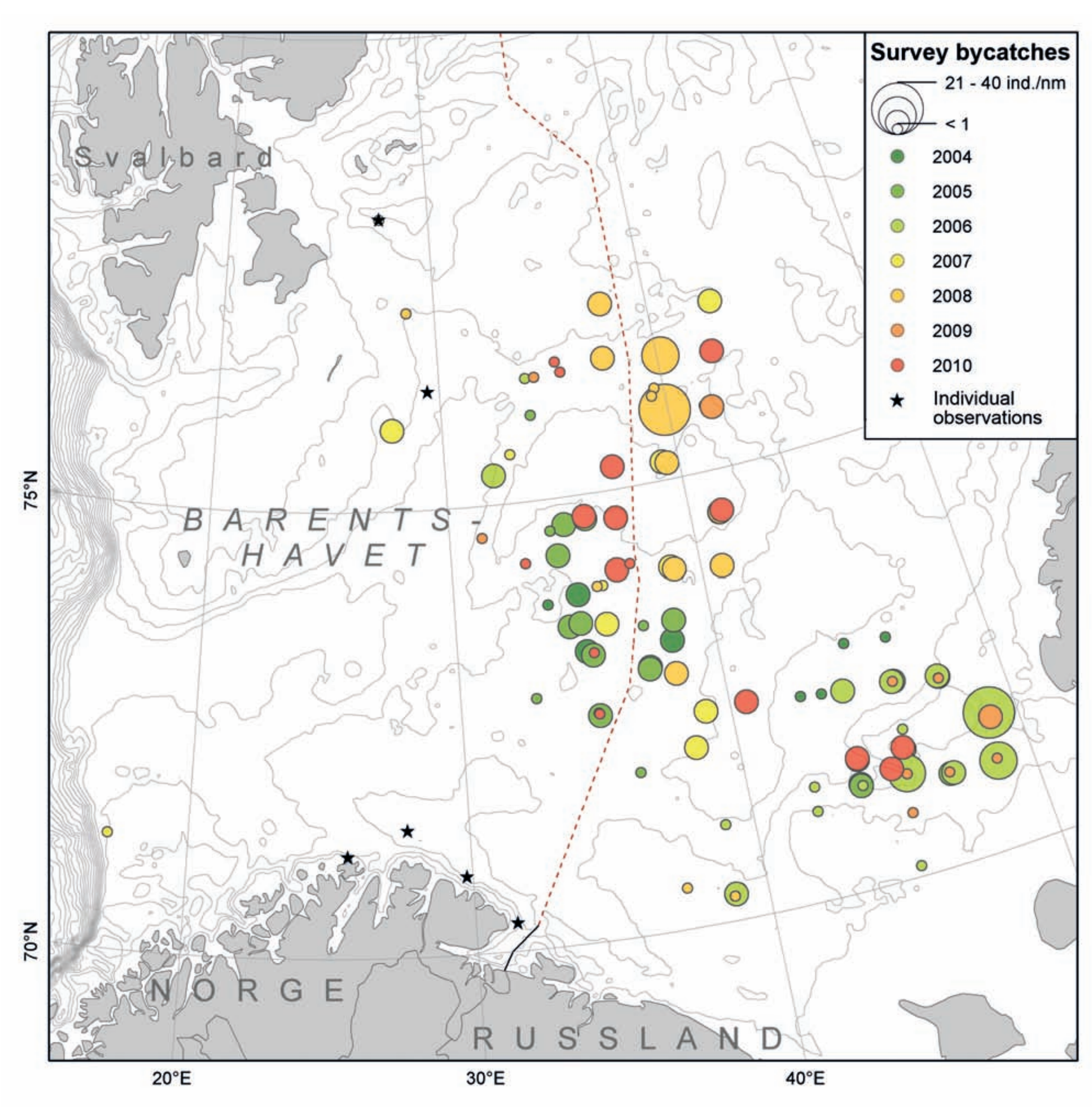

Figure 3.19 Bycatches of snow crabs by fishing vessels (black stars) and during surveys by the Institute of Marine Research (circles) in the period 2004–10. The size of the circles indicates the relative number of crabs caught at each position

Source: Institute of Marine Research

vested near Sørøya (west of Hammerfest), which is further west than previously.

Estimates of the total population of red king crab (individuals of carapace length more than 70 mm) for 2010 are somewhat lower than for 2009. On the other hand, bycatches of snow crab in gill-net and longline fisheries in eastern Finnmark were higher in 2009 than in previous years.

Impacts of red king crab and snow crab on the ecosystem

The red king crab has impacts on the benthic fauna that we were not aware of in 2005. More recent investigations in the Varangerfjorden (2008/09) have shown the species is causing substantial changes in soft-bottom benthic communities. A comparison with the situation before the red king crab became abundant in the areas studied (1995) shows a dramatic decline both in the number of species and in biomass. In addition, the investigations confirm that large individuals of bivalves, echinoderms and polychaetes are more or less absent. It is unclear whether these are permanent effects. The Varangerfjorden studies indicate that when the crabs remove the dominant benthic organisms, oxygenation in the sediments is reduced. Research in the Russian part of the Barents Sea has yielded similar results, but the reduction in species diversity and biomass is considerably less marked than that found in Norwegian waters in the Varangerfjorden.

Increasing numbers of snow crabs are being found in the Barents Sea. The original range of the species was the Bering Sea, northeastern Canada and west of Greenland. It is not known whether larvae have been introduced with ballast water or whether the species has spread into the management plan area itself. Genetic studies are being carried out to determine the origin of the crabs in the area. So far, no research has been carried out on the effects of snow crab on the ecosystem. The crabs feed on benthic animals, and it is expected that any impact will be primarily on benthic communities.

Projections for 2025

The risk of the spread of alien species via ballast water is expected to be considerably reduced when the Ballast Water Convention enters into force and strict requirements for ballast water treatment are introduced. If the convention is not yet in force in 2025, the outlook is uncertain, but a rising volume of shipping, particularly tankers, will increase the risk that alien species will be spread with discharges of ballast water and on ships' hulls. A warmer climate may increase the likelihood that species introduced from further south will be able to establish themselves in Norwegian waters. Traffic through the Northeast Passage would increase the risk of introductions from distant areas with a similar marine climate, particularly from the species-rich Pacific Ocean to the Barents Sea. A rising temperature may also affect the distribution of the red king crab and snow crab. It is uncertain how much impact these two species will have in 2025.

3.3.9 Pollution

Long-range transport of pollutants with air and ocean currents is the main source of pollution in the management plan area. More intensive monitoring since 2006 has given us more insight into the state of the environment, and the results show that pollution levels in the Barents Sea–Lofoten area are low. Seafood from the area is generally safe, and the Arctic areas are considered relatively unpolluted at present. However, the Arctic is more vulnerable to pollution than other regions. Animals at the upper trophic levels of Arctic food chains accumulate considerable concentrations of fat-soluble pollutants, probably mainly because Arctic animals rely on fat for survival, both as an energy reserve and as insulation. New pollutants are constantly being detected in the region through regular screening studies.

Monitoring system strengthened since 2006

In the 2006 management plan, it was decided to introduce a more integrated monitoring system, with indicators, reference values and action thresholds, for the Barents Sea–Lofoten area, including closer monitoring of pollution levels in the marine ecosystems. A set of pollution indicators was chosen to cover inputs of pollutants via different routes (atmospheric inputs, inputs via rivers, marine beached litter) and environmental pollution (in sediments, benthic animals, fish, birds, seals and polar bears).

Monitoring and mapping activities have been scaled up considerably since the 2006 management plan was published, particularly as regards the selected indicators. The indicators have also been further developed. Even though it has not been possible to start satisfactory monitoring of all the indicators, we have developed more insight and knowledge about the pollution status of the management plan area. Appendix 2 provides an overview of the different pollution indicators and the data available.

Long-range transport the main source of pollution

Concentrations of organic pollutants in the atmosphere and precipitation have been monitored in Svalbard since the early 1980s. The results show a downward trend for most of the «classical» persistent organic pollutants (POPs), but in the last two to six years (varying from one substance to another), this positive trend has stagnated for DDT, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and hexachlorobenzene (HCB). There are several possible explanations for this: continued use of DDT in other parts of the world, the release of these pollutants from environmental sinks as a result of cli-

Box 3.7 The Marine Pollution Monitoring Programme

The Marine Pollution Monitoring Programme was started in 2009 in direct response to the 2006 management plan for the Barents Sea–Lofoten area, which had identified serious gaps in our knowledge of pollution in open sea areas. It is a broad-based monitoring programme that in the longer term is intended to provide an overall picture of the pollution status of Norwegian sea areas. It has the following goals:

– to identify the most important sources of pollutants (oil and environmentally hazardous substances, including radioactivity);
– to provide an overview of inputs of pollutants and transport routes to sea areas;
– to document the status of selected indicators of pollution;
– to monitor changes in sources, pressures and status over time;
– to provide an overview of the pollution status of Norwegian sea areas.

The programme brings together expertise on a wide variety of areas from a number of leading Norwegian research institutions.

The programme covers all routes for inputs of pollutants to the sea, including ocean currents, the atmosphere, runoff from land, leaching from bedrock and marine sediments, and releases from shipping and oil and gas activities in Norwegian sea areas.

The programme focuses on one sea area each year: the Barents Sea in 2009, the North Sea in 2010 and the Norwegian Sea in 2011. To give a more representative picture of inputs via air and ocean currents in the Barents Sea–Lofoten area, a new measuring station was established on Andøya (Vesterålen Islands) in 2010, and passive samplers were deployed on Bjørnøya and Jan Mayen.

The programme makes use of and supplements other monitoring programmes run by agencies including the Climate and Pollution Agency, the Institute of Marine Research, the National Institute of Nutrition and Seafood Research, the Norwegian Institute for Water Research, the Norwegian Institute for Air Research, the Bjerknes Centre for Climate Research and the Norwegian Radiation Protection Authority.

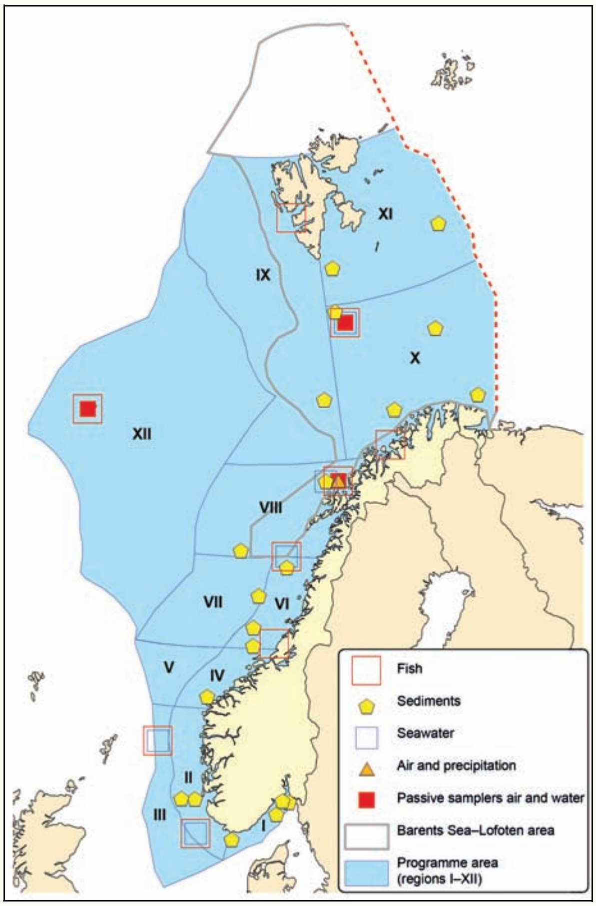

Figure 3.20 Measuring stations for the Marine Pollution Monitoring Programme in Norwegian waters in 2010

Source: Institute of Marine Research, Norwegian Institute for Water Research, Norwegian Institute for Air Research, National Institute of Nutrition and Seafood Research, Norwegian Radiation Protection Authority, Climate and Pollution Agency

mate change, an increase in the evaporation of previously deposited HCB and PCBs with an increase in the number of forest fires, the reduction in ice cover, and larger inputs of relatively warm Atlantic water.

Knowledge about the presence of new organic pollutants and time trends for their concentrations is more limited because the measurement series are shorter, but levels of polybrominated diphenyl ethers (PBDEs) are showing a tendency to decline, while levels of perfluoroalkyl substances (PFAS) are rising.

The 2006 white paper indicated that a continued rise in mercury levels was expected up to 2020, whereas a decline was expected for other metals. However, mercury levels in air have now

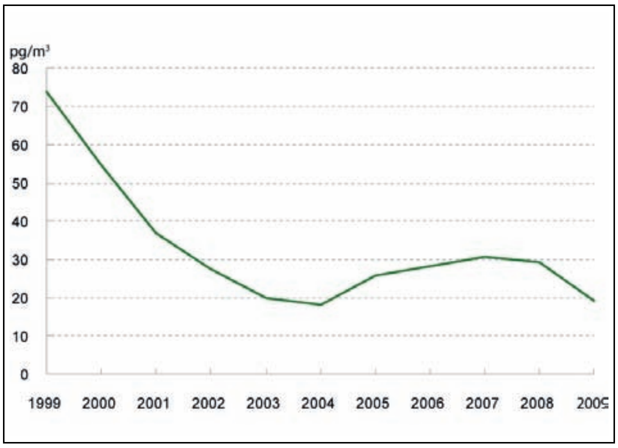

Figure 3.21 Annual mean concentrations of sum PCB in air at the Zeppelin station in Svalbard, 1999–2009

Source: Norwegian Institute for Air Research

been stable for a number of years, and the expected decline in atmospheric inputs of other heavy metals has not been observed, with the exception of nickel.

Radioactive substances carried with the coastal current

Radioactive pollution is largely transported to the management plan area in the Norwegian coastal current. There are low levels of radioactive substances in the Barents Sea, and levels in the Arctic are generally declining. Caesium-137 from the Baltic Sea, which originates from Chernobyl, is the most important source of inputs of this substance to the management plan area. Releases of technetium-99 from the reprocessing plant for spent nuclear fuel at Sellafield on the west coast of England have been reduced since 2003/2004, as a result of the introduction of a new method of waste treatment.

Inputs from neighbouring areas less important

There are still only a few large onshore or coastal sources of pollution near the management plan area. Sediments in several ports are contaminated by pollutants released from ships and shipyards. Other routes for inputs of pollutants – transport with ice, runoff from land and inputs via rivers – are assumed to be less important in the management plan area, but may be of local significance. There are appreciable levels of nickel and copper pollution in the Pasvikelva river in eastern Finnmark, along the border with Russia, largely transported by air from the Pechenganikel nickel works. Otherwise, the levels of pollutants measured in rivers (Altaelva, Barduelva, Tanaelva and Pasvikelva) are low. The impacts of pollution from mining and quarrying in northern areas will be largely local and not affect the management plan area itself.

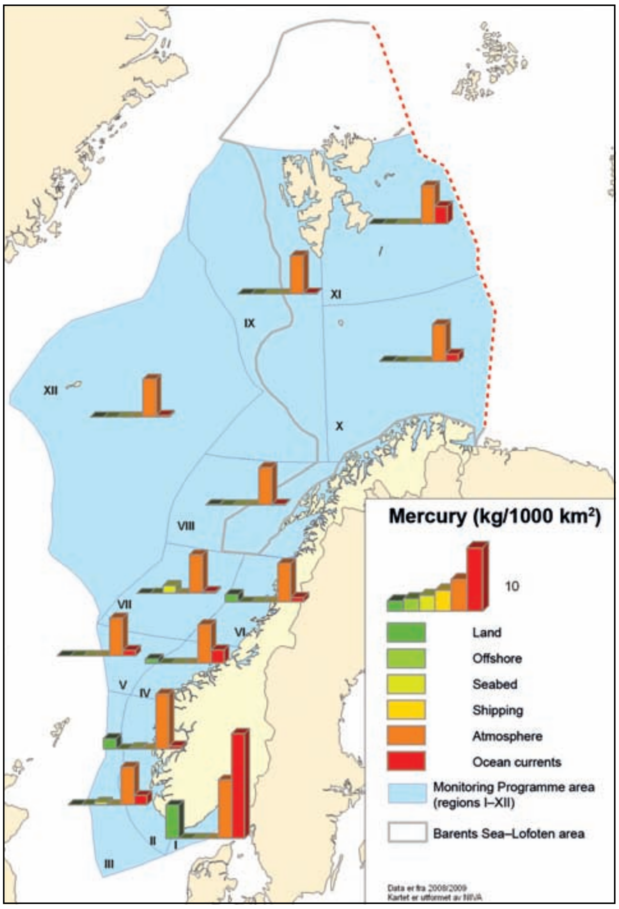

Figure 3.22 Inputs of mercury by source and area, 2008/2009

Source: Marine Pollution Monitoring Programme/Norwegian Institute for Water Research

Pollution status for the seabed

A great deal of work has been done on mapping and monitoring levels of pollutants, particularly concentrations of oil and metals, in the seabed sediments of the Barents Sea in the period 2003–09. Many hazardous substances bind to particulate matter and organic material, and therefore end up in sediments. Levels of hazardous substances and radioactive substances in sediments will therefore reflect the pollution status of the area. Pollutants can spread from the sediments to the water column and organisms.

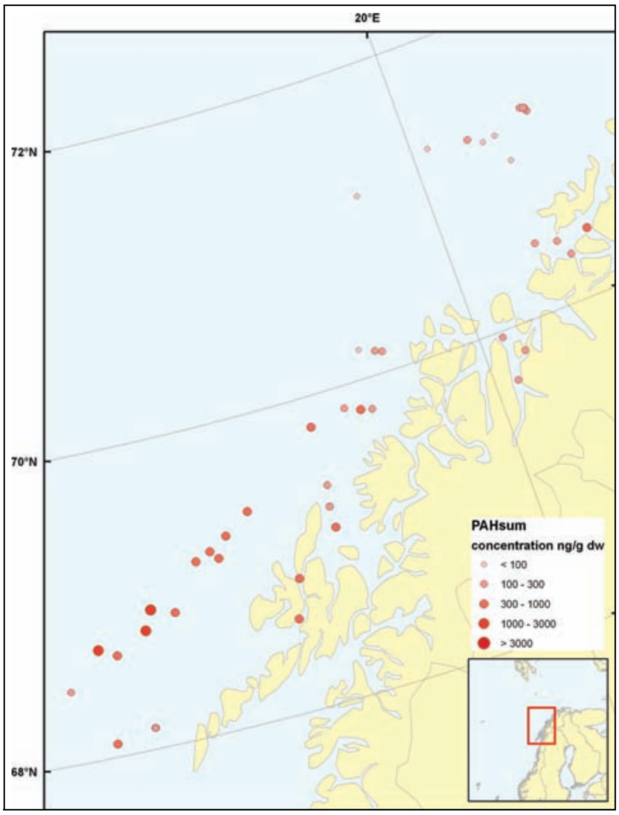

Figure 3.23 PAH levels in surface sediments

Source: Institute of Marine Research

The results show that levels of PAHs and total hydrocarbon content (THC), which are used as indicators of oil pollution, are relatively low, but there is a good deal of variation in hydrocarbon levels in sediments in different parts of the management plan area. This variation can be explained by the geochemical origin of the sediments, including natural leaching and erosion of fossil fuels (coal/oil). In addition, a small proportion of these substances may originate from inputs of oil and other fossil fuels from various human activities.

Analyses of surface samples from the seabed show that levels of heavy metals, organochlorine compounds and man-made radioactive substances are generally low. Time trend analyses of samples from deeper areas (Malangsdjupet and Ingøydjupet) indicate a weak rise in inputs, particularly of the heavy metals lead and mercury, over a period of 50–70 years. Thus, although pollution levels are still low, human activity is having a detectable effect in the management plan area as a result of long-rang transport of pollutants. Low concentrations of organic pollutants have been found in sediments throughout the management plan area, and are also a result of human activity.

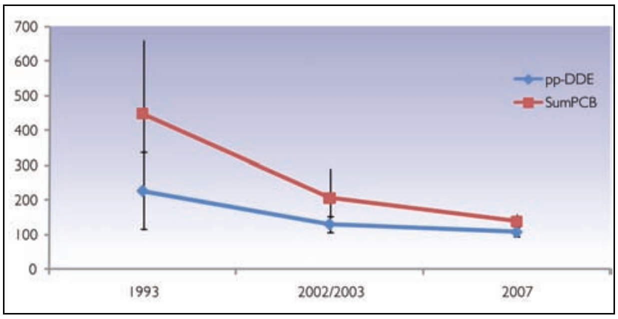

Figure 3.24 Levels of PCBs and DDE in Brünnich's guillemot eggs from Kongsfjorden (Svalbard) and Bjørnøya

Source: Institute of Marine Research

Levels of radioactive substances in sediments in the management plan area are low. The annual monitoring programme for radioactivity in sediments around the wreck of the nuclear submarine *Komsomolets*, which lies on the seabed at a depth of 1 700 m south-west of Bjørnøya, shows that caesium levels in the sediments are no higher than in the surrounding waters, but small releases of radioactivity to the environment have been registered.

Pollution levels in organisms

Studies of POPs in seabirds and marine mammals show that international regulation of several substances, such as PCBs and organochlorine pesticides, is having a positive effect.

A study of ringed seals from Svalbard in the period 1996–2004 showed a reduction of 50–80 % in levels of PCBs and organochlorine pesticides. Glaucous gulls have been monitored for 35 years, and the results show that levels of most PCBs and organochlorines have declined. The insecticides DDT and DDE are an exception to this: there has been no decline in levels in polar bears and glaucous gulls in the past 10 years. This indicates that DDT is still being transported to the area or is being released from environmental sinks as a result of climate change.

There are indications that the downward trend in PCB concentrations in polar bears is continuing (based on data from Svalbard up to 2008), and that there may be less pressure on polar bears as a result. However, despite the decline in levels of certain pollutants in polar bears, concentrations are still high. Levels of POPs, primarily PCBs, in parts of the polar bear population in Svalbard and Franz Josef Land (no new data obtained since 1995) exceed the thresholds for effects on the hormone and immune system. There is therefore reason to believe that POPs in polar bears are having a negative impact on the immune system and on reproductive capacity. Levels of POPs measured in Brünnich's guillemot eggs are all below the thresholds for effects on reproduction and/or survival.

Radioactivity levels have been measured in several marine mammal species since 2000 and in seabirds since 2005. The levels are low, but a comparison of caesium-137 concentrations in marine mammals and in their prey suggest that caesium-137 accumulates from one level to the next in the food chain.

Trends for mercury are less clear, with a decline in polar bears but no change in seabird eggs.

PCBs have been shown to have a negative impact on reproduction in seals. Ringed seals and harp seals, which are the most important prey species for polar bears, have a limited ability to metabolise POPs, and have accumulated high concentrations of PCBs.

Levels of pollutants in fish and shellfish are generally low in the Barents Sea.

It is extremely important to monitor pollutant levels in fish and shellfish to ensure that the seafood placed on the market is safe. For most of the indicator substances for food safety, measured values in seafood are well below the specified maximum levels. However, results from monitoring in the Barents Sea since 2006 show that the content of contaminants is variable and in certain cases exceeds statutory maximum levels. Systematic surveys are therefore needed to provide information on trends. Knowledge is also needed on the reasons for variations between species and geographical areas.

There are indications that environmental levels of the best known new POPs that have now been regulated (for example the brominated flame retardant PBDE) are declining.

However, low concentrations of emerging POPs that have not been regulated can also be detected, and some of these may be showing an upward trend. Surveys of organophosphorus flame retardants show higher levels in cod species in the Barents Sea than in coastal cod in fjords in southeastern Norway. Such finds are unexpected, since the reverse is generally found for classic POPs.

Box 3.8 Safe seafood

Maximum limits have been set for the content of a number of pollutants in fish and other seafood. Some of the results from monitoring by the National Institute of Nutrition and Seafood Research since 2006 are as follows:

- Mercury dominates among contaminants in lean fish, whereas dioxins, PCBs and other organic pollutants are most often found in fatty fish.
- Measurements in cod fillet, shrimps, capelin and polar cod show low values for all pollutants that have been tested. Levels of heavy metals in cod are below the maximum levels set for human consumption. The average values for cadmium, mercury and lead in cod fillet have remained at about the same level since monitoring began in 1994. Levels of dioxins and dioxin-like PCBs in cod liver are close to the maximum level for human consumption.
- The maximum level for mercury is exceeded in certain fish species. Levels of mercury are not a problem in the most important products from the Barents Sea, such as cod fillet. However, high mercury levels are found in halibut and Greenland halibut, especially in large mature specimens. This had not been documented in 2005. For Greenland halibut, the results show that the mercury content is lower in fish caught off the coast of Finnmark than in those caught along the edge of the continental shelf and northwards towards Svalbard.
- New data show that a substantial proportion of Greenland halibut caught along the edge of the continental shelf and northwards towards Svalbard contain concentrations of organic pollutants exceeding maximum levels, while levels in fish caught off the coast of Finnmark are considerably lower.
- Radioactivity levels in fish and seafood have been monitored since 1991. Levels measured in both fish and shrimps are low. Levels of caesium-137 in cod have shown a downward trend in the period 1991–2008, which is to be expected since the main source of the substance is the 1986 Chernobyl accident, and its half-life is 30 years.

Focus on marine litter is needed

Large quantities of litter wash up on the beaches in the management plan area. Litter along the shoreline is used as one of the indicators in the monitoring system to assess whether the target of avoiding litter and other environmental damage caused by waste from activities in the management plan area is being achieved.

The only time series for litter from the management plan area is organised by the Office of the Governor of Svalbard. Litter has been cleared from three short stretches of shoreline in Svalbard and weighed each year since 2001. This material is not sufficient to draw any definite conclusions about trends in the quantity of litter. The fishing fleet in the Norwegian and Barents Seas is assumed to be the source of most litter along the shoreline in Svalbard, but a good deal may also originate from cruise ships. Litter is found scattered over wide areas, and the problem is greatest along the northwestern coast of Spitsbergen.

Another problem is that there are variations in the types of litter registered and the methodology used. In 2010, a beach survey and clean-up was carried out at Kvaløya in Tromsø municipality in accordance with OSPAR's methodology for marine beach litter surveys. The results showed that plastic litter from the fishing and aquaculture industries was the category of litter most frequently found in this area.

The Norwegian authorities have not established a system for reporting waste streams from ships to land-based reception facilities. This means that there are no figures available that provide any information on trends.

Plastic litter can be a major threat for example to surface-feeding birds such as fulmars and to marine mammals, which may become entangled and drown, or ingest plastic litter and suffer damage to the digestive system. This is a serious problem in other sea areas, but not much is known about the scale of the problem in the Barents Sea.

Projections for 2025

Climate change is expected to have a considerable effect on transport routes for hazardous substances to the management plan area and their spread within it. However, on the basis of current

Figure 3.25 Litter on the beach at Rekvika bay, Tromsø municipality

Source: Climate and Pollution Agency (photo: Bo Eide)

Figure 3.26 Fragments of plastic in the stomach contents of a fulmar

Source: OSPAR/KIMO. Photo: Jan van Franeker

knowledge it is not possible to predict what the impacts will be. It will therefore be important to focus on building up knowledge of the impacts of climate change.

The reduction in inputs of several of the substances that are subject to international regulation has stagnated. It is uncertain why this has happened, and difficult to predict what will happen in the future. A continued reduction in levels of classic POPs would be expected as their use is halted globally, but it is uncertain to what extent this is being counteracted by rising inputs as a result of climate change. The situation as regards new POPs will depend on how their use is regulated globally. If there is a global decline in inputs of dioxin-like PCBs to the environment, concentrations in fish and other seafood would be expected to decline in the period up to 2025.

3.4 Most important knowledge needs in the future

According to the 2006 white paper, our general knowledge of the Barents Sea–Lofoten ecosystems is fairly comprehensive, but we need to know more about interactions between species in the food chain. The 2006 white paper further points out that studies of the ecology of the area have been concentrated on a small number of species. We still know little about the impacts of human activity on the various parts of the ecosystem, particularly the synergistic effects of different pressures. There are still gaps in our knowledge in certain areas that were highlighted in 2006, including the transport, accumulation and impacts of hazardous substances and radioactive substances. More knowledge is also needed about the synergistic effects of interactions between hazardous substances and between hazardous substances and other stress factors such as climate change, food shortages and disease. The report from the Management Forum points to the need for more knowledge about the resilience of the ecosystems in the Barents Sea–Lofoten area to major changes, or regime shifts. Ecosystems are generally resilient to large-scale change. However, it is important to learn more about the factors that influence resilience to change in ecosystems of the management plan area. Variations in climate and pressure from human activities determine the framework for sustainable development in the area. Developing an understanding of which processes can cause irreversible change and how resilient the Barents Sea–Lofoten area is to change is an important cross-cutting topic.

Baseline studies and long time series will always be important, and should in many cases be included when planning how to meet knowledge needs; examples are monitoring of ocean acidification, seabird populations and inputs and levels of pollutants. It is therefore important to continue existing programmes such as MAREANO, SEAPOP and the Marine Pollution Monitoring Programme, and to strengthen other monitoring coordinated by the Advisory Group on Monitoring. A systematic monitoring programme for inputs of marine litter to the shoreline throughout the management plan area should also be established, and more knowledge is needed about the origins of the litter.

Increasing attention is being paid to the problem of ocean acidification, and also to interactions between the impacts of ocean acidification and climate change, and between these and the impacts of human activities such as fisheries, petroleum activities and shipping. Ocean acidification and climate change may also affect the transport of pollutants into the management plan area and how they accumulate in and are metabolised by living organisms.

It is also important to develop technology and know-how that can be used to prevent or reduce anthropogenic pressures and impacts.

Climate change in the Barents Sea–Lofoten area may have major impacts on ecosystems and society. Calculations using current global and regional climate models indicate that there will be major change in the future. However, process understanding needs to be improved, and better modelling tools are needed to build up knowledge of impacts on ecosystems and consequences for society. It is also important to focus on the impacts of climate change on technology and industrial structures and the risk of accidents. Knowledge in many other areas will also be relevant to the cross-cutting area of climate change and its impacts.

More knowledge is needed about environmental pressures and their impacts, particularly as regards the cumulative environmental effects.

We need to know more about the importance of the management plan area for value creation and Norwegian society, for example through studies of the importance to society of ecosystem services that are not associated with a particular industry and that are not at present traded in a market.

There is also a considerable need for more knowledge of benthic conditions and cumulative effects on benthic habitats and organisms.

4 Activities, management and value creation in the Barents Sea–Lofoten area

This chapter describes and evaluates the most important industries in the Barents Sea–Lofoten area, in terms of both the value creation and benefits to society they represent, and the pressures and impacts they exert on the environment. Section 4.9 deals in particular with value creation and social benefits related to the waters off the Lofoten and Vesterålen Islands and Senja.

The most important industries in the Barents Sea–Lofoten area today are fisheries, maritime transport and petroleum activities, but other industries, such as tourism, marine bioprospecting and possible future developments in offshore energy and prospecting for minerals on the seabed, are included in this white paper as well. The importance of marine ecosystem services for value creation and Norwegian society is also discussed.

4.1 Fisheries and aquaculture

4.1.1 Trends in fisheries management

At present the major fish stocks in the Barents Sea are in good condition and are harvested within safe biological limits. They are managed in accordance with the principles set out in the Marine Resources Act and in line with the management objectives of the Nature Diversity Act. Cooperation with the Russian fisheries management authorities is extremely important for ensuring the sustainability of harvesting in the Barents Sea. Over the last 10 years the fisheries authorities have made very successful efforts at the national and international level to reduce the illegal, unreported and unregulated fishing (IUU fishing) of cod in these sea areas, and in 2009 no incidents of IUU fishing of cod and haddock were detected. This was the result of close cooperation between the Norwegian and Russian authorities and of the development of new control mechanisms such as the port state control system under the North East Atlantic Fisheries Commission (NEAFC). Control of resources and a harvesting level in line with the quotas that are set are essential for maintaining a sustainable management regime.

Satellite tracking is an important part of Norwegian resource monitoring. All Norwegian fishing vessels with a length of more than 15 m are required to have a tracking device installed on board that automatically transmits data, regardless of where they are. The same applies to foreign vessels operating in Norwegian waters.

Much work is being done on the international rules for bottom fisheries with a view to safeguarding biodiversity, and in Norway there are new regulations relating to bottom fisheries. In addition new fishing gear is continually being developed that reduces the impact of fisheries on the seabed. For example new trawling methods are being developed that reduce the impact on benthic habitats and at the same time reduce fuel consumption and NO_x emissions. An important factor in this connection is that the extent of bottom trawling declined from 2005 to 2009.

4.1.2 Activities

The most important fisheries in the sea areas from the Lofoten Islands northwards along the coast up to and including the Barents Sea have always been for Norwegian spring-spawning herring, Northeast Arctic cod, Northeast Arctic haddock, Northeast Arctic saithe, and capelin. Generally speaking stocks have increased over the last 10 years, especially cod and haddock, and quotas have increased accordingly. In 2011 the Norwegian quota for cod was 319 000 tonnes, for haddock 148 000 tonnes, for saithe 173 000 tonnes, for Norwegian spring-spawning herring 602 680 tonnes and for capelin 275 000 tonnes.

For some years, Norwegian vessels mainly fished for Norwegian spring-spawning herring in the Vestfjorden area. However, in 2003 the migration pattern of the herring changed, and the younger year classes began to overwinter on the bank areas and in the waters west of the Lofoten and Vesterålen Islands and southern Troms. At the same time the stock increased substantially. In the last few years there has been very little herring in southern Troms. The new migration pat-

Box 4.1 Regulation of fisheries in the Barents Sea–Lofoten area

General prohibition on trawling in areas less than 12 nautical miles from the baselines

There is a general prohibition on trawl fishing off the Norwegian mainland in areas less than 12 nautical miles from the baselines. However, there are exceptions to this rule that permit fisheries in areas to within 6 nautical miles of the baselines. The prohibition does not apply to trawling for kelp or Norway lobster, or shrimp trawls without bobbins or rockhopper gear.

Trawl-free zones and flexible areas

In order to protect larvae and vulnerable areas, a number of trawl-free zones (permanently closed to trawling for all or part of the year) and flexible areas outside the 12-mile limit have been established under the Regulations relating to sea-water fisheries. These provisions have also promoted the sharing of sea areas to avoid gear conflicts.

The term «flexible areas» is used to mean delimited areas where fishing is regulated during specific periods by means of restrictions on or a prohibition on fishing with particular gear in the whole area or certain parts of it. In such areas, the number of vessels participating in the fishery may also be limited.

Coastal shrimp trawling

Coastal shrimp trawling is carried out in both the northern and the southern parts of the management plan area. This is conducted in certain particular areas by smaller vessels using lighter gear, and there is no reason to believe that this activity causes significant damage to vulnerable benthic habitats. This type of fishery is strictly regulated by local regulations for different stretches of the coastline.

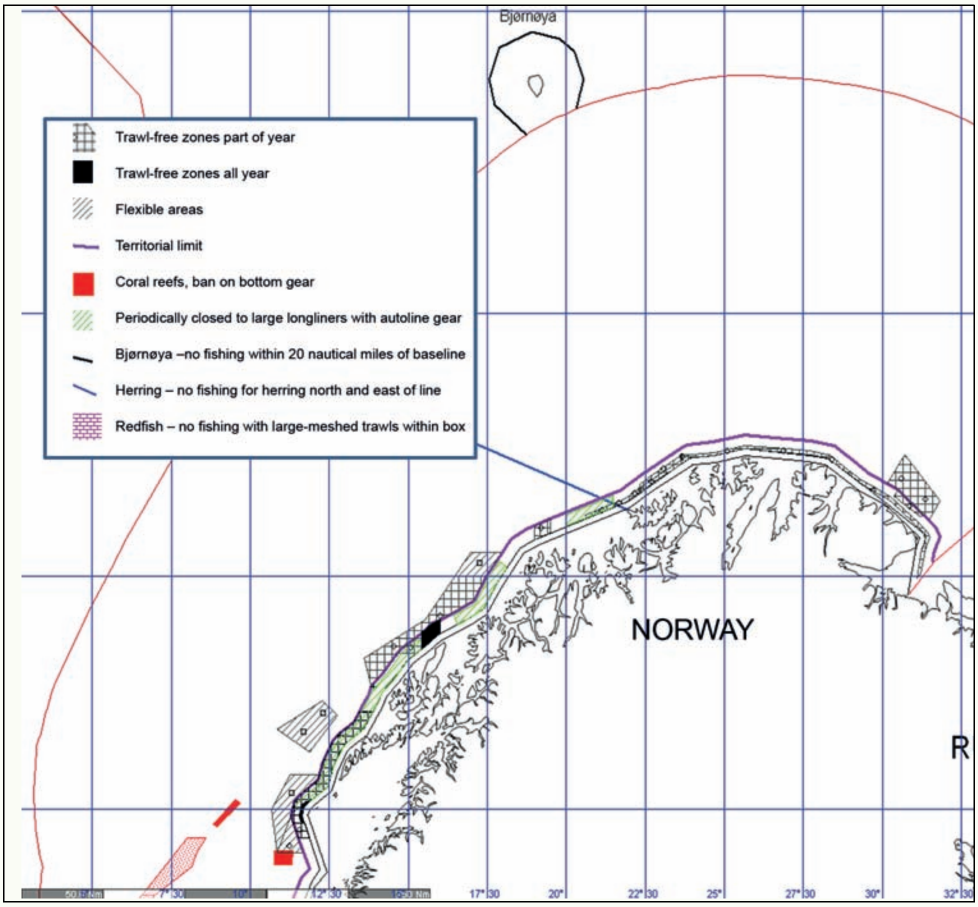

Figure 4.1 Trawl-free zones and flexible areas in the Barents Sea

Source: Directorate of Fisheries

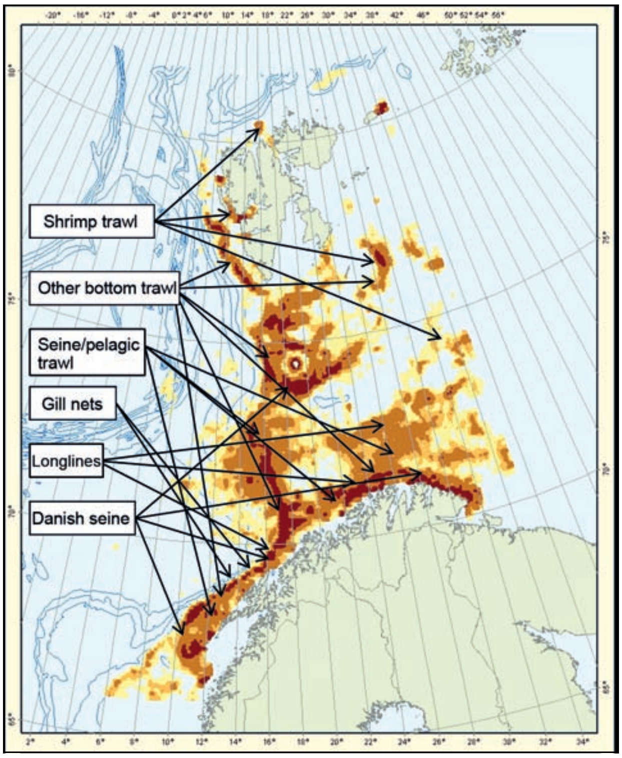

Figure 4.2 Fishing vessel activity for vessels with a length of more than 21 m in 2009. The dark shading shows the greatest activity.

Source: Directorate of Fisheries

tern also means that more seine fishing and trawling is carried out in these areas than previously.

The traditional spawning-season cod fishery in the Vestfjorden area from February to April is now substantially reduced because the migration pattern of the cod has changed. In recent years spawning has begun to take place further out, around the Lofoten Islands as far as Røst, northwards around the Vesterålen Islands and as far north as western Finnmark. This more northerly distribution is not entirely new, since it also occurred in the period 1930–50. Fishing vessels that normally used to fish in the Vestfjorden area have transferred their activities westwards and northwards along the coast.

Changes in the structure of the fishing fleet and fishing grounds

In 2009, 1.17 million tonnes fish were landed in the three northernmost counties, and the structure of the fisheries has been gradually rationalised. The number of vessels has been reduced, which has increased productivity and profitability since it means that the total catch is divided between fewer vessels. The total catch has remained relatively stable from year to year, and any fluctuations have primarily been due to biological variations. There are variations in the migration patterns of Northeast Arctic cod and spring-spawning herring from year to year and over time, which means that fisheries move from one area to another, and it is not always possible to know beforehand where fisheries activity will be highest.

4.1.3 The importance of fisheries and aquaculture for value creation and Norwegian society

On the basis of figures from Statistics Norway and Nofima, the direct commercial importance of fishing and aquaculture for Norway as a whole, measured in terms of its contribution to GDP, was estimated at NOK 18 billion in 2009. Furthermore, in addition to the core activities (fishing, aquaculture, fish processing and wholesaling), fishing and aquaculture have spin-off effects in other sectors. These include employment in technological sectors, for example jobs in local shipbuilding companies or with suppliers of various types of technical equipment. According to the SINTEF Group, in 2008 every krone generated by core activities in the fisheries and aquaculture sector resulted in NOK 0.96 in value creation in other sectors, which means that the value creation in core activities alone had almost doubled.

The total export value of the fishing and aquaculture industry was NOK 44.7 billion in 2009 and NOK 53.8 billion in 2010.

The sector accounts for just under 5 % (around 11 000 persons) of employment in North Norway. In addition it generates a considerable number of jobs in for example the supply, fish processing and transport industries. There are strong links between settlement and access to marine resources in the fisheries sector, but the importance of the sector varies considerably within the region. On some of the islands, such as Træna, Røst, Værøy and Moskenes, the fisheries industry accounts for over 40 % of total employment.

Fisheries

According to figures from Statistics Norway, the total landed value of the catch in the Barents Sea–Lofoten area was NOK 6.3 billion in 2009, or 56 % of the total landed value for Norwegian fishing vessels in the same year.

The total catch in the management plan area rose from approximately 750 000 tonnes in 2000 to

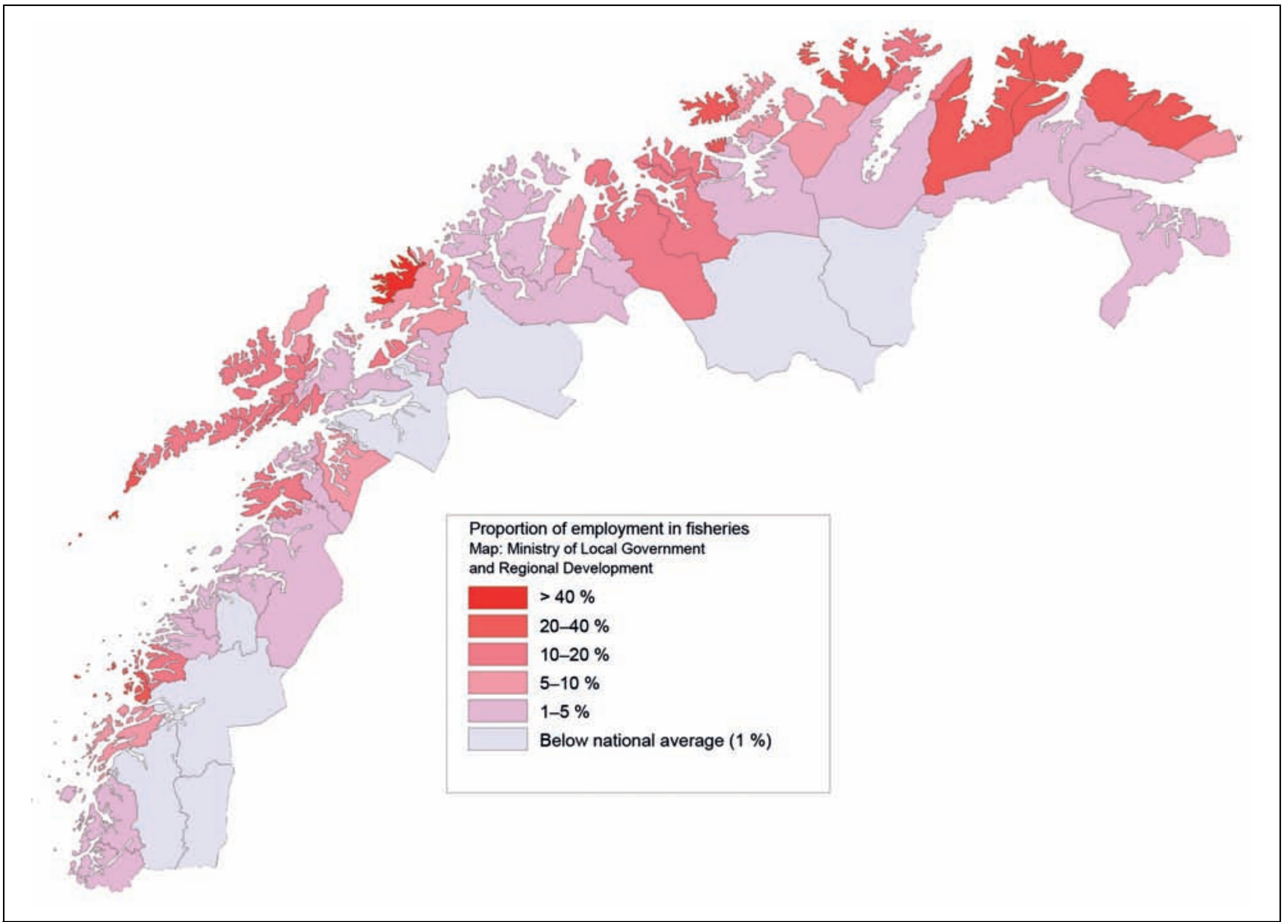

Figure 4.3 Employment in the fisheries sector in North Norway, as a percentage of total employment.

Source: Statistics Norway and the Panda Group

over 800 000 tonnes in 2009. In the last few decades Norwegian fisheries have developed from a relatively unregulated industry to a strictly regulated one, subject to quotas and licensing requirements. All our most important fish stocks are shared with other nations, which means that international cooperation is vital for the Norwegian management system. Due to sound and sustainable resource management, it has been possible to increase the quotas in the last few years. The coastal fishing fleet plays a vital role in the Barents Sea–Lofoten area, and accounts for just over 40 % of the landed value. In the coastal municipalities from the Lofoten Islands to Norway's border with Russia, fishing is a full-time occupation for 4 900 persons and a part-time occupation for 1 300. In the same area 90 % of the 3 650 registered fishing vessels are small vessels less than 15 m total length. These vessels generally fish in waters close to home, are less mobile than larger vessels and are used mainly to fish cod. In a number of small communities the fleet of small vessels accounts for a large percentage of employment, and there are few employment alternatives.

Aquaculture

The aquaculture industry operates inside the baselines and thus outside the management plan area. However, the industry is likely to be affected by the general state of the environment and by any accidents in the Barents Sea–Lofoten area.

About one-third of aquaculture production in Norway takes place in North Norway. In 2009, 280 000 tonnes of salmon, 23 000 tonnes of trout, 11 500 tonnes of cod, around 500 tonnes of other marine species and 500 tonnes of shellfish were produced in the three northernmost counties. The landed value in these three counties was NOK 7.5 billion in 2009, most of which was exported. The industry alone generated around 1 600 jobs in North Norway in 2009.

There has been substantial growth in aquaculture production in Troms and Nordland in recent years. In Troms it has doubled since 2005 and in Nordland it has increased by 35 %. Production in Finnmark has been stable. There are large accessible areas of coastline in North Norway, which means that there is great potential for further development of this industry in the region. In the 2009 allocation round, about half of the 65 new licences were granted for salmon, trout and rainbow trout farms in North Norway. In addition the Government permitted a production increase of up to 5 % for salmon and trout farms in Troms and Finnmark in 2011.

Safe seafood – the importance of a good reputation

Value creation in the seafood industry depends on ensuring that Norwegian seafood products are safe to eat and have a high national and international reputation. Transparency and information are also important. To ensure this, the authorities should have a monitoring system for:

- levels of known hazardous substances in seafood,
- parasites that reduce seafood quality or that may cause disease in humans,
- naturally occurring toxins in shellfish,
- hygiene indicators,
- screening for new hazardous substances.

Such knowledge helps to ensure that Norwegian seafood is safe to eat and preserves its high reputation in markets at home and abroad. At present monitoring of contaminants in wild fish stocks is conducted through baseline studies and sampling, and by mapping contaminants in fish feed and farmed fish.

Another factor that contributes to the high reputation of seafood is that Norway follows international rules in the field of food safety, and effectively monitors compliance by the industry. The Norwegian Food Safety Authority has a variety of measures it can call on when violations of the rules are detected, and increases the severity of the measures taken in the event of serious and repeated violations.

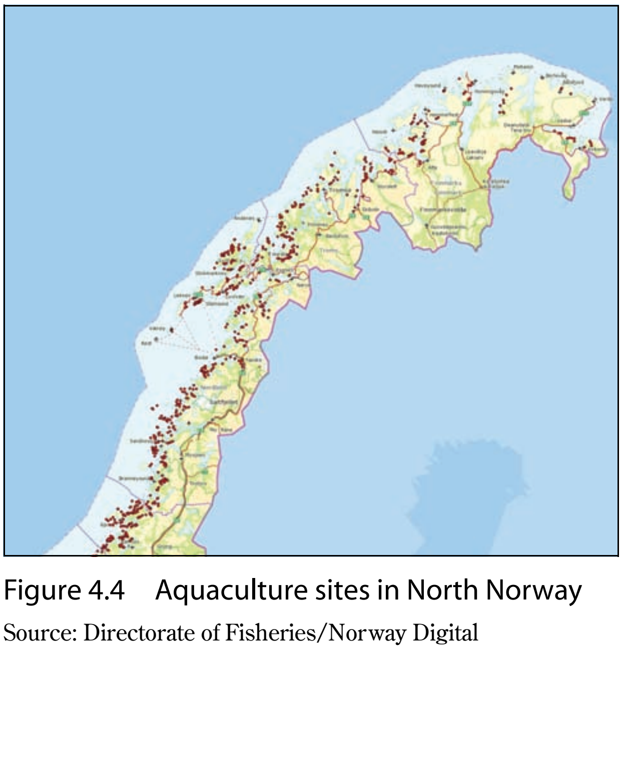

Figure 4.4 Aquaculture sites in North Norway

Source: Directorate of Fisheries/Norway Digital

In the event of an accident resulting in pollution that could compromise seafood safety, the authorities must be able to monitor and control seafood safety in the area concerned. Previous experience of oil spills and of cases where a product has attracted negative attention has shown that in the short term it is difficult to sell products from the polluted area, including those that are obviously not contaminated and even products from other industries with links to the area. However, no clear impacts on prices have been found over the long term.

Future developments in value creation

Climate change, new developments affecting the resource base, new technology and new framework conditions will all have impacts on future commercial activity based on marine resources. The most important fish stocks in the Barents Sea are in good condition and the fisheries management regime is effective. However, natural migration and other factors cause the composition and size of stocks to vary. The impacts of climate change are uncertain, for example with regard to ocean acidification, and it is difficult to predict how this will affect the growing conditions for farmed fish. It is also possible that the composition of wild fish stocks will be altered and that this will have consequences for the fisheries. However, this is very uncertain.

Environmental sustainability, competing uses of the same area and the state of the market influence the growth and development of the seafood industry. If the current trend continues, employment and value creation in the industry will increase. The structure of the fisheries has been undergoing gradual rationalisation for a long time. The number of vessels has been reduced and this has increased productivity and profitability. If the present trend in the management regime continues, employment in the fisheries industry will gradually decline and value creation will increase over the long term.

Taken together, these factors indicate that value creation in the fisheries and aquaculture sector will increase in the period up to 2025.

4.1.4 Evaluation of the pressures and impacts associated with the fisheries

The fisheries represent a considerable pressure on the ecosystems in the Barents Sea–Lofoten area. Harvesting a fish stock is bound to have an effect on it, and under normal circumstances is the most important anthropogenic pressure. However, an ecosystem is in a constant state of flux due to variations in natural conditions such as predation, migration (in response to changes in temperature and food supply) and disease. Sustaina-

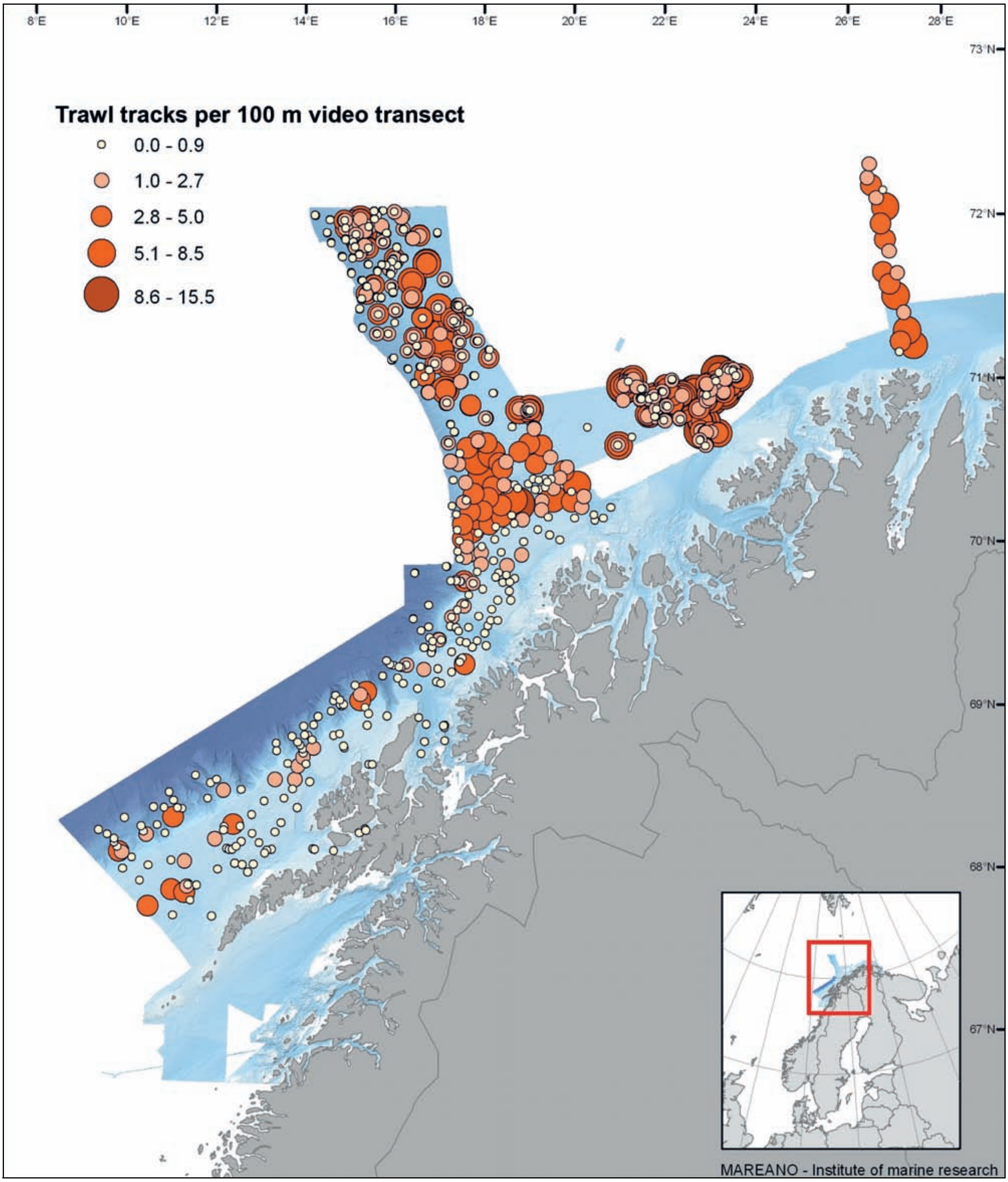

Figure 4.5 Density of trawl tracks on the seabed in areas mapped by MAREANO up to the 2009/2010 season.

Source: MAREANO/Institute of Marine Research ble management of fish stocks means that it is the surplus production of the stock that is harvested. At present the harvest of the most important commercial fish stocks (capelin, herring and cod) is within safe biological limits, but fishing pressure is considered to be too high for certain smaller stocks such as blue ling, golden redfish and beaked redfish. Steps are still being taken to rebuild these stocks, and new measures are considered annually.

More thorough mapping of the seabed in recent years has shown that fisheries activity, especially bottom trawling, has had greater impacts on benthic ecosystems than was previously believed. In this connection the Institute of Marine Research has conducted a number of experiments with pelagic trawls and surveyed the impacts of different types of trawls on different benthic habitats. The results have provided new knowledge that can be used to further develop pelagic trawls and to design gear that exerts less pressure on benthic ecosystems.

There is considerable fisheries activity in the Tromsøflaket area, and as one would expect, there is relatively serious damage to coral reefs and sponge communities. Fisheries have also been shown to have impacts along the edge of the continental shelf and in some places at greater depths in Nordland VII. MAREANO surveys conducted along the edge of the continental shelf have shown that trawl tracks are very common; they were found in 51 of the 76 localities investigated. In the areas with the greatest density of tracks, 42 tracks per km seabed were found, or one track for every 25 m. Very few traces of human activity other than fisheries have been detected. To summarise, in the localities investigated about two of 10 coral reefs had suffered damage to a greater or lesser extent and about 6 % of all investigated reefs in the management plan area had been destroyed. There is considerably less trawling that there was a few decades ago, and many of the observed instances of damage go back many years.

Locally, areas that have been trawled repeatedly over time will be populated by opportunist, short-lived species. Recolonisation and recovery are affected, and such areas tend to remain at an early successional stage. In the long term this could result in permanent changes. In areas that have been bottom trawled it is often only possible to find small specimens of sponges.

Fisheries also put pressure on seabirds and marine mammals, in the form of impacts on food supplies, unintentional bycatches in fishing gear and marine litter from fishing vessels. Our knowledge of the scale of unintentional bycatches of seabirds and marine mammals is limited, and studies are being conducted. As from 2011, bycatches of seabirds and marine mammals have to be included in the information recorded in electronic catch logbooks. No changes have been registered for the impact on seabirds, but for marine mammals in general bycatches have declined, although as a result of greater knowledge the estimated figures for bycatches of common porpoise in certain areas have risen.

4.2 Shipping

A number of measures have been implemented to strengthen maritime safety and governmental preparedness and response to acute pollution, including further development of knowledge and technology and measures to reduce the probability of

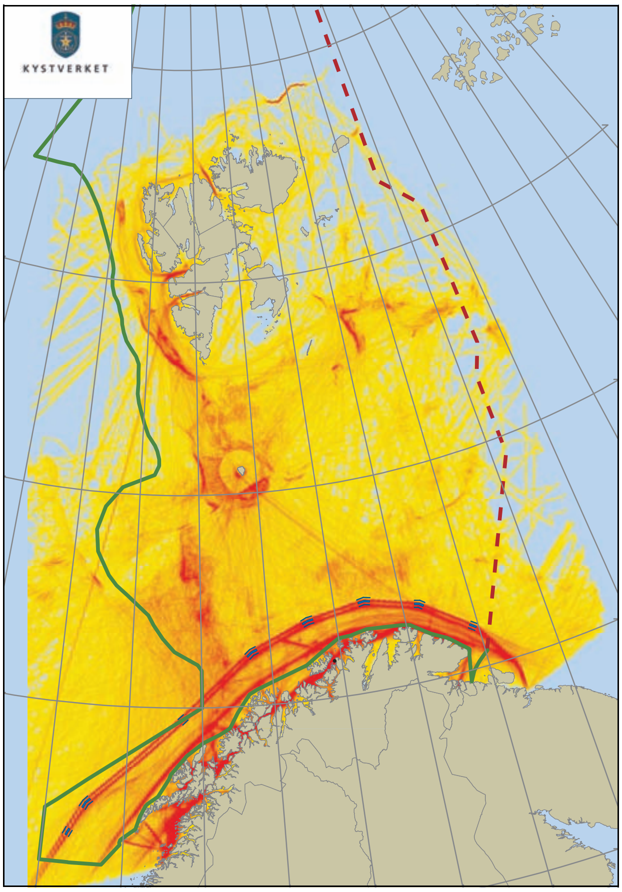

Figure 4.6 Traffic density in the management plan area, the traffic separation schemes between Vardø and Røst (thick red line) and nearcoast areas in the second half of 2010. The highest traffic density is indicated by the red shading.

Source: National Coastal Administration

accidents. This subject is discussed in more detail in Chapter 5 in the section on risk. In the present chapter, value creation by shipping and the pressures exerted by normal operations are discussed.

4.2.1 Activities

Trends in maritime traffic 2005–09

The volume of traffic of seismic survey vessels, offshore supply vessels and tankers has shown a considerably greater increase than that of other vessel types, but from relatively low levels. Tanker size has also increased. In 2008 fishing vessels accounted for the largest number of ship movements and about 58 % of the total distance sailed in the management plan area.

More than 80 % of the total distance sailed in the Barents Sea–Lofoten area by vessels of gross tonnage over 10 000 now lies within the areas covered by the traffic separation schemes between Vardø and Røst, and this includes almost 100 % of all tanker traffic. The remaining traffic in the area is dominated by cargo vessels of gross tonnage 1 000–5 000, but there is also some traffic of other cargo vessels and offshore and other service vessels.

The transit traffic consists of large tankers and bulk carriers sailing to and from Russian ports. Up to 2008, the volume of traffic was relatively stable in terms of both cargo volume and number of ships. The cargo volume was an estimated 10–12 million tonnes per year, carried on 200–240 fully loaded ships. However, in 2009, the volume rose considerably (see Figure 4.7). There are many indications that transit cargo volume will continue to rise in the years ahead. The average size of oil tankers is also expected to rise.

The volume of maritime traffic to and around Svalbard has fluctuated over the last 10 years. The traffic consists of large foreign cruise ships, expedition vessels, goods traffic, research vessels, fisheries traffic along the coast and in certain fjords, and transport of coal mined in Svalbard.

Ship-to-ship transfers of Russian crude oil take place in winter in the Bøkfjorden at Kirkenes and in the Sarnesfjorden at Honningsvåg. During the winters of 2005/06–2008/09 there were an average of nine transfers each winter, but there have been none during the last two winters (2009/10 and 2010/11). This activity alters the local level of risk because it means that the tankers sail closer to land. There are special emergency preparedness requirements for ship-to-ship transfers.

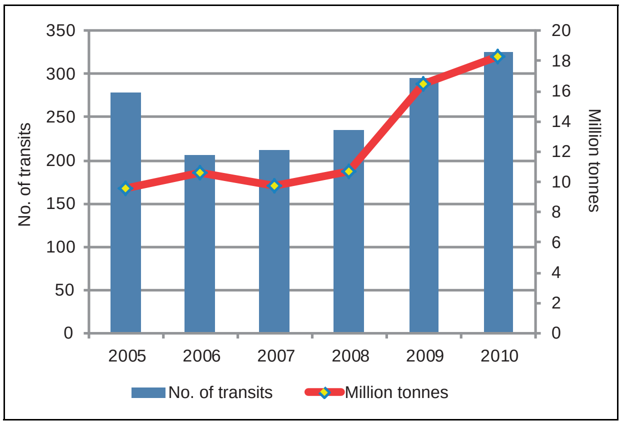

Figure 4.7 Numbers of vessel transits by fully loaded tankers, and millions of tonnes of oil and petroleum products transported along the Norwegian coast from northwestern Russia

Source: Norwegian Defence Forces

The number of calls at the largest ports relevant to the management plan area has declined somewhat since the peak year 2005. The volume of goods for different ports in the region fluctuates and does not correspond to the trends in the number of calls. Narvik is still much the largest port, and the volume of goods consists almost entirely of iron ore transports from the mining company LKAB. Development of the Snøhvit field has resulted in a large increase in goods transports to and from Hammerfest.

Projected trends in maritime traffic up to 2025

There is less activity in the Barents Sea–Lofoten area than in the sea areas further south. Projections for the area indicate a small increase (about 3 %) in the total distance sailed in the period 2008–25 and a general increase in the distance sailed for most types of ships (see Figure 4.8), with most of the increase occurring towards the end of the period. For fishing vessels, on the other hand, a marked decrease in the distance sailed is expected. In 2008 fishing vessels accounted for around 58 % of total distance sailed in the area, while in 2025 the figure is expected to be around 50 %. Tanker activity in the area is likely to increase by more than 100 %, especially for large oil and gas tankers.

Projected maritime traffic across the Arctic Ocean during ice-free periods

The rapid ice-melt in the last few years has led to increased interest in maritime traffic across the

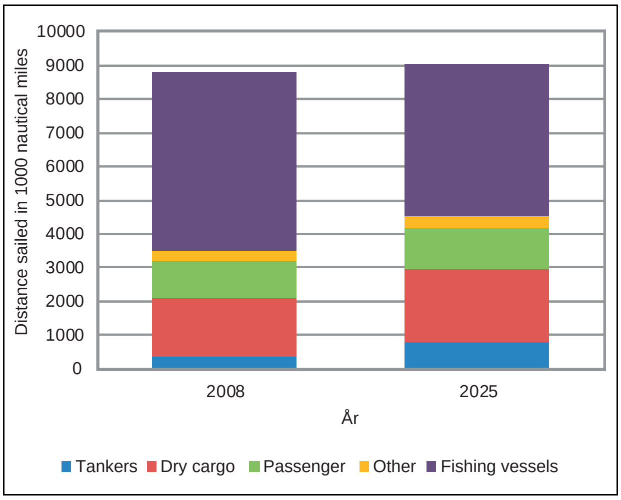

Figure 4.8 Projected trends in distance sailed for various types of ships in the period 2008–25

Source: National Coastal Administration

Arctic Ocean, including the Northeast Passage. The Arctic summer ice is retreating so rapidly that in periods all or part of the traffic lanes north of Russia and Canada/the US are open until the ice re-forms. The ice-melt also means that increasing areas of the Arctic Basin are covered by first-year ice, which is thinner, making it easier for ships to force their way through. At present the volume of traffic in the Arctic Ocean itself is small and ships with destinations in the area are expected to continue to dominate maritime traffic for the next few years.

As a follow-up to its 2009 report, the Arctic Marine Shipping Assessment, the Arctic Council's working group on the Protection of the Arctic Marine Environment (PAME) is now considering which sea areas in the Arctic are likely to require special protection against the environmental impacts of future maritime traffic across the Arctic Ocean. The group's conclusions will form the basis for the Norwegian authorities' assessment of the need for measures to strengthen maritime safety, such as proposals to the International Maritime Organization (IMO) for new sea areas that should be designated as Special Areas or Particularly Sensitive Sea Areas (PSSA).

4.2.2 Importance of maritime transport for value creation and Norwegian society

Maritime transport is important for coastal communities in the management plan area since the largest proportion of goods and passengers within the region is transported by ship. However, the domestic and international maritime transport industry accounts for less than 2 % (3 700 persons) of employment in the three northernmost counties. The Government's goal is for a larger share of goods transport to be transferred to water.

At the national level, the maritime industry is a large and important sector that employs around 100 000 persons and resulted in value creation of NOK 85 billion in 2008. The figures for the management plan area have become more reliable since 2006. In North Norway and Nord-Trøndelag there are around 700 businesses related to the maritime industry, with about 10 000 employees and a total turnover of around NOK 15 billion (2007). The fisheries industry accounts for 25 % of employment. Value creation in Nordland amounts to NOK 3 billion, in Finnmark just under NOK 1 billion and in Troms approximately the same. Subcontractors include about 40 operative shipyards in North Norway. These deal with modification and maintenance, especially for the fishing fleet and high-speed and other ferries.

The maritime industry in North Norway is built on two cornerstones. These are the fisheries, which encompass a wide range of large and small vessels, and coastal passenger transport under contract to the state sector. There are 150–200 shipowners in the local transport and cruise traffic sector, mostly small businesses but also a number of major companies such as Torghatten trafikkselskap, Veolia Nord and Hurtigruten. The Coast Guard is another important actor. Shipowners form a larger proportion of the maritime industry in North Norway than in the rest of the country.

There has been a marked shift from international to domestic maritime transport (see Figure 4.9). The decline in the number of Norwegian seamen employed in international shipping is related to changes in the conditions of competition and

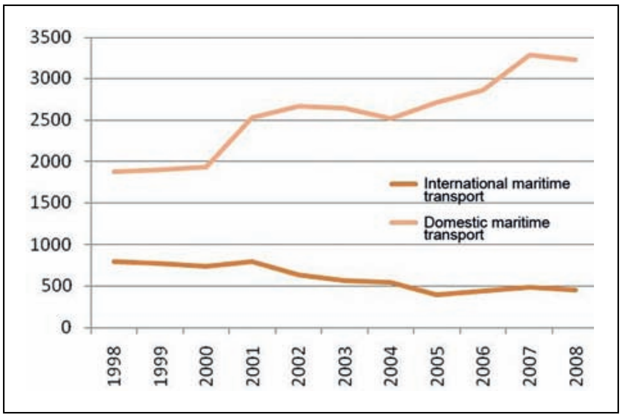

Figure 4.9 Employment in maritime transport in North Norway, 1998–2008

Source: Statistics Norway and the Panda Group the use of foreign seamen. The increase in the number of persons employed in domestic shipping is related to the decline in those employed in the fisheries sector. This is due to the better employment conditions in the domestic maritime transport sector, where the wages are higher due to the tax refund scheme for seafarers.

Projected trends up to 2025

Developments in maritime transport in the management plan area will affect the demand for other goods and services, for example for port services. Maritime traffic passing through the area is not expected to influence value creation or social conditions to any great extent. Projections for the effects of petroleum activities on the demand for maritime transport and services up to 2025 are uncertain. Petroleum activities in a sea area increase the need for maritime transport, and experience from other areas on the Norwegian continental shelf indicates that these activities increase the demand for services that require supply ships, which in turn will require greater resources and capacity on land.

4.2.3 Evaluation of the pressures and impacts associated with maritime traffic

Shipping may have negative environmental impacts in the management plan area through spills of petroleum products and other chemicals, operational discharges to water and air, releases of pollutants from anti-fouling systems, noise, the introduction of alien species via ballast water or attached to hulls, and local discharges from zinc anodes in ballast tanks. In spite of this, ships are on the whole a relatively green form of transport.

The traffic separation schemes between Vardø and Røst have significantly reduced the risk of ship accidents in this sea area. The government emergency tugboat service, together with traffic surveillance by the Vardø vessel traffic service centre, has also helped to reduce the risk. The risk of acute pollution from ships, and preventive measures to enhance safety at sea are discussed in Chapter 5.1.1.

Operational releases from ships have been estimated on the basis of the volume of traffic in 2008 and projections for 2025. CO_2 emissions are expected to increase as a result of the larger number of ships with larger engines, while NO_x and SO_x emissions are expected to decrease as a result of new rules and technological developments. However, it is not possible to quantify operational discharges to the sea or to calculate their impacts.

Maritime transport can result in the unintentional introduction of alien species into the ecosystems of the management plan area. The risk will increase with the growth in ship traffic, especially traffic from areas with a similar marine climate. A warmer climate could increase the likelihood that species introduced from further south will be able to establish themselves in Norwegian waters, and if the Northeast Passage is opened for traffic, this may increase the risk of introductions from more distant areas with a similar marine climate.

The impacts of maritime transport on seabirds are related to discharges of oil and litter. Illegal operational discharges from ships may result in oil on the surface, leading to higher mortality in adult seabirds. We know that small quantities of oil are discharged illegally, but not to what extent. It is not possible at present to quantify operational discharges of this kind or to calculate their impacts. Although littering by ships has been banned since 1998, plastic waste is still being found in the marine environment. It seems likely that illegally discarded marine litter, particularly plastic objects and particles, has negative impacts on many species in the management plan area. Marine litter is harmful to species that feed on the sea surface such as black-legged kittiwake, fulmar and marine mammals because they can become entangled in the waste or eat the plastic, which can injure the digestive organs. No changes have been registered in the level of impact from marine litter since 2006.

Noise, especially from propellers, has now been discovered to be a greater problem for marine mammals that was previously believed. Apart from major spills of chemicals and petroleum products, no negative impacts from shipping on fish stocks and seafood are known or documented.

The possibility of a greater volume of maritime traffic in the Arctic Ocean, much of which will be sailing through Norwegian sea areas, is attracting considerable attention. In the Barents Sea, the volume of Russian oil transports has risen since 2006, and in the next few years this type of traffic, which is based on transport of resources from the Arctic, will increase in the peripheral seas of the Arctic Ocean. There is already some intercontinental transit traffic, and if the routes across the Arctic Ocean become more profitable than land transport and other sea routes, and if they are considered sufficiently reliable and safe, this type of traffic could increase.

4.3 Petroleum activity

4.3.1 Current framework

Seismic surveys and exploration drilling for oil and gas began in the Barents Sea in 1980. Parts of the Tromsøflaket (in Troms I) were opened for petroleum activity in 1979 and further areas in the southern part of the Barents Sea were opened in the first half of the 1980s (Bjørnøya South, Troms I Northwest and the northern part of Finnmark West). The southern part of the Barents Sea was formally opened for exploration in 1989 (Report No. 40 (1988–1989) to the Storting) on the basis of an impact assessment of the area. The assessment concluded that Troms II should not be opened.

In 2001 all petroleum activities in the Barents Sea apart from the development of the Snøhvit field were suspended pending completion of the impact assessment of year-round activities in the Barents Sea–Lofoten area. In December 2003 the Bondevik II Government decided that year-round activities in the area could be resumed, apart from the coastal areas in Nordland VI and off Troms and Finnmark, and the polar front, the marginal ice zone, Bjørnøya and Tromsøflaket, which have been identified as particularly valuable areas.

The decision in 2003 imposed the requirement that there were to be no discharges to the sea during normal operations (see Box 4.2). In practice this is a requirement for zero discharges except for cuttings from the tophole section. The reasons for this precautionary approach were the fact that the sea area was relatively clean and under little pressure from human activity, the presence of vulnerable species and habitats, and uncertainty about the long-term impacts of discharges. Furthermore, there was no technology available to remove hazardous and radioactive substances from produced water, and injection of produced water, drill cuttings and drilling fluids was believed to be geologically and technologically possible. Thus the rules relating to discharges from petroleum activities are stricter for the Barents Sea than for other parts of the Norwegian continental shelf (see Box 4.3).

Box 4.2 Stricter requirements for oil and gas activities in the Barents Sea

The requirements for activities in the Barents Sea–Lofoten area were set out in a white paper on petroleum activities (Report No. 38 (2003–2004) to the Storting) and are listed below:

- Injection or another suitable technology must be used to prevent discharges of produced water.
- A maximum of 5 % of the produced water may be discharged during operational deviations provided that it is treated before discharge. Precise requirements for treatment will be set by the licensing authorities in each case.
- Drill cuttings and drilling mud must be reinjected or taken ashore for treatment.
- Drill cuttings and drilling mud from the tophole section may be discharged provided they do not contain substances with unacceptable properties, i.e. environmentally hazardous substances or other substances that may have a negative impact on the environment. However, such discharges are only permitted in areas where assessments indicate that damage to vulnerable components of the environment is unlikely. Such assessments must be based on thorough surveys of vulnerable components of the environment (spawning grounds, coral reefs, other vulnerable benthic animals). Operators will be required to apply for permits for such discharges.
- Petroleum activities in the area must not result in damage to vulnerable flora and fauna. Areas that might be affected must be surveyed before any activities are started.
- There must be no discharges to the sea in connection with well testing.
- Oil spill preparedness must be at least as effective as on other parts of the continental shelf.

The requirement for zero discharges of drill cuttings and produced water to the sea is considerably stricter than the standards that apply on other parts of the Norwegian continental shelf.

Licensees who have been awarded licences for blocks within the Barents Sea-Lofoten area will not be permitted to engage in year-round petroleum operations unless they can substantiate that their operations will meet the requirement for zero discharges to the sea.

Box 4.3 General zero-discharge targets for the oil and gas industry

Zero-discharge targets were adopted in the white paper on an environmental policy for sustainable development (Report No. 58 (1996–1997) to the Storting). The targets and the measures for reaching them have been further specified in a number of later white papers, most recently in the white paper on the Government's environmental policy and the state of the environment in Norway (Report No. 26 (2006–2007) to the Storting).

Environmentally hazardous substances

- Zero discharges or minimal discharges of naturally-occurring environmentally hazardous substances that are also priority substances.
- Zero discharges of chemical additives that are black-category (use and discharges prohibited as a general rule) or red-category substances (high priority given to their replacement with less hazardous substances), cf. the Activities Regulations for the petroleum industry.

Other substances

Zero discharges or minimal discharges of the following if they may cause environmental damage:

- oil (components that are not environmentally hazardous),
- yellow-category substances (not defined as belonging to the black or red categories, but not on the PLONOR list drawn up by OSPAR, meaning that they are considered to pose little or no risk to the environment), and green-category substances (included on the PLONOR list), cf. the Activities Regulations for the petroleum industry,
- drill cuttings,
- other substances that may cause environmental damage.

Radioactive substances

- Discharges of naturally occurring radioactive substances to be gradually reduced until, by 2020, the concentrations in the environment are close to the natural background levels.

The following is a more detailed list of the targets and measures:

- As a rule, oil and substances that may be environmentally hazardous may not be discharged to the sea. This applies both to substances added as part of the production process and to naturally-occurring substances. The precautionary principle is to be used as the basis for assessing the potentially damaging impacts of the discharges.
- Environmentally hazardous chemicals (red- or black-category) may only be discharged if serious technical or safety considerations make this necessary.
- Replacement of environmentally hazardous substances must be given high priority. Operators must draw up plans for replacing environmentally hazardous chemical additives and report them annually to the authorities, cf. the Activities Regulations for the petroleum industry.
- The steps taken to replace environmentally hazardous additives must be based on an overall assessment. This means that for example if the use of a small amount of a red-category substance would reduce releases of other components and thereby reduce the overall environmental risk, this should be taken into consideration.
- Releases of red-category substances must have been eliminated by 2005 in cases where there are adequate substitutes.
- Injection or reinjection of produced water is the most effective method of achieving the zero-discharge targets for naturally-occurring environmentally hazardous substances.
- The chosen solution must be based on an overall, field-specific assessment that includes the environmental impacts, overall safety issues, reservoir engineering factors and cost issues.
- If there are weighty reasons for doing so, provision may be made on the basis of an overall, field-specific assessment for minimal releases of naturally-occurring environmentally hazardous substances on the priority list.
- Economic cost-benefit analyses will be conducted for new and old fields that include overall environmental assessments of measures to prevent discharges of produced water and/or drill cuttings and drilling mud.

4.3.2 Activities

Exploration drilling and production

From the start of petroleum activities in the southern part of the Barents Sea in 1980 and up to the end of 2010, 79 exploration licences had been awarded and 85 exploration and appraisal wells had been drilled, 21 of which were begun in 2005 or later. About half of these wells have indicated the presence of hydrocarbon deposits. A number of small and medium-sized discoveries have been made, mainly of gas, and since 2006 additional exploration and appraisal wells have been drilled to investigate these discoveries further. Several of them are believed to be of interest, including Tornerose and Nucula.

From discovery to production is a long process. At present only one field is on stream in the Barents Sea, and another is under development. The Snøhvit gas field is located in the Hammerfest Basin off Finnmark (Troms I) and consists of the Askeladd West, Askeladd Central, Askeladd, Albatross, Snøhvit North, Beta and Albatross South discoveries (Figure 4.10). Production started in August 2007 and the field will continue to produce gas for at least the next 30 years. Since there are no surface installations, the gas is piped over a distance of 160 km to be liquefied at the LNG processing plant on Melkøya. CO_2 is separated from the wellstream and then pumped back into the formation below the reservoir in the Snøhvit field. Recoverable resources when production started were 160.6 billion Sm^3 gas, 6.4 million tonnes natural gas liquid (NGL) and 18.1 million Sm^3 condensate.

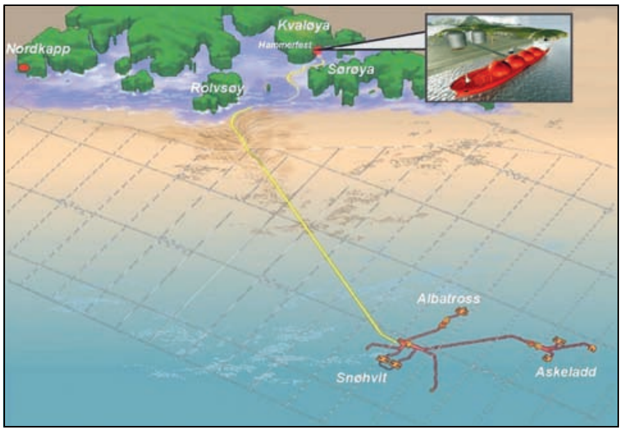

Figure 4.10 Snøhvit. The three discoveries Snøhvit, Askeladd and Albatross have been developed together as the Snøhvit field, with remotely operated subsea installations at depths of 250–345 m. Gas and condensate are transported by pipelines to the LNG (liquefied natural gas) processing plant on Melkøya. Liquid gas is then transported onwards by LNG carrier. (The processing plant and the carrier are shown in the insert.)

Photo: Even Edland/Statoil
Source: Statoil

The Goliat field, 85 km north-west of Hammerfest, is the first oil field to be developed in the Barents Sea. A plan for development and operation of the field was approved by the Storting in 2009, and production is expected to start in 2013. The field, which will have a floating production, storage and offloading unit, is being developed by the operator Eni. Oil will be loaded onto oil tankers for transport to the markets. Total investment in the development project is expected to be almost NOK 30 billion. Proven recoverable resources amount to about 28 million Sm^3 oil and about 8 billion Sm^3 gas.

Award of licences

Since the publication of the first management plan for the Barents Sea–Lofoten area in 2006, acreage has been allocated through ordinary licensing rounds, which are normally held every other year, and through annual awards in predefined areas (APAs). The APA system, which was established in 2003, is the annual licensing round for allocation of blocks in more mature areas. The mature areas are the most thoroughly explored areas on the continental shelf, where the geology is known and where there are fewer technical challenges and a well developed or planned infrastructure. The overall framework for oil and gas activities (areas, restrictions on when drilling is permitted, other considerations) is established in management plans for each individual sea area, which are based on the existing knowledge about ecosys-

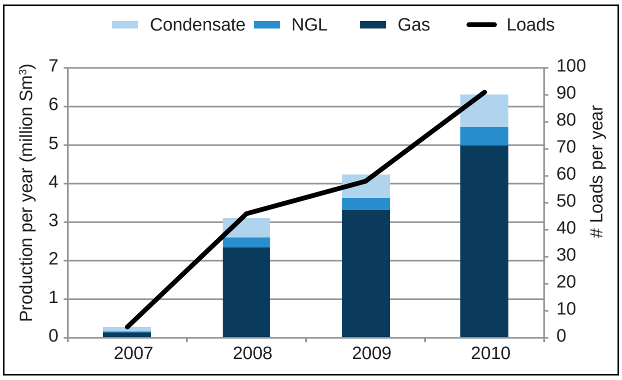

Figure 4.11 Production of hydrocarbons (in Sm^3 oil equivalents) and number of transports from Snøhvit since the field came on stream.

Source: Ministry of Petroleum and Energy tems and fisheries. These management plans apply to all new licences awarded in an area, regardless of whether they are announced through the APA system or in a numbered licensing round. The APA system has been evaluated, and the Government will discuss the evaluation in more detail in the forthcoming white paper on petroleum activities.

In APA 2007, seven new production licences were awarded, and in APA 2008, APA 2009 and APA 2010, two, three and two new production licences respectively were awarded in the Barents Sea. Six new production licences were awarded in the 19th licensing round, in 2006, and nine new licences were awarded in this area in the 20th round, in 2009. In the 21st licensing round, in autumn 2010, 51 blocks in the management plan area were announced. Further production licences were awarded in spring 2011.

Assignment of licences in APAs has resulted in greater and more stable activity in the management plan area. Since 2006 the total APA area has been almost doubled (Figure 4.12). The APA system will be evaluated in the white paper on oil and gas policy to be presented in spring 2011.

4.3.3 Surveys of oil and gas resources

The Barents Sea is the least explored petroleum province on the Norwegian continental shelf. However, together with the deep-water areas in the Norwegian Sea and the areas off the Lofoten and Vesterålen Islands, it is believed to be the province where the probability of future large discoveries is highest. In the Norwegian part of the Barents Sea outside the area covered by the maritime delimitation treaty between Norway and Russia, the statistical expected value of undiscovered resources is 945 million Sm^3 o.e., which corresponds to 37 % of the total undiscovered resources on the Norwegian continental shelf.

When the Storting debated the integrated management plan for the Barents Sea–Lofoten area, the Norwegian Petroleum Directorate was given the task of surveying the geology of Nordland VII and Troms II in connection with the possibility that there were petroleum resources in these areas. During the period 2007–09, the Directorate collected geological, seismic, electromagnetic and gravimetric data in the waters off the Lofoten and Vesterålen Islands and Troms (Nordland VII and Troms II) (see Figure 4.12).

Following up the management plan for the Norwegian Sea, which concludes that the possibility of initiating an opening process for the northern part of the coastal zone in Nordland will be considered, the Petroleum Directorate also estimated, on the basis of existing data, the resource potential in the Vestfjorden, the unopened part of Nordland V, Nordland VI and the Eggakanten area along the edge of the continental shelf. With the exception of Nordland VI, knowledge of these areas is limited and no prospects have been identified, but the Directorate considers that the presence of hydrocarbons in these areas cannot be excluded.

The waters off Nordland and Troms have varied and interesting geological features. The geological continental shelf is at its narrowest here, in some places narrower than 20 km. After sloping down to a depth of about 400 m, it drops sharply to the deep sea plains more than 2 500 m below the sea surface. In the context of petroleum deposits, these areas are expected to show continuations of geological trends from the north and further south. Some of the most important types of reservoir rock in Nordland VI are likely to be similar to those in the discovered reservoirs of the same age further south in the Norwegian Sea. The northern parts of Nordland VII and Troms II, on the other hand, are expected to show more similarities with the geology of the Barents Sea. The main type of source rock for oil and gas in the area is organically rich claystone from the late Jurassic period. The types of reservoir rock with the greatest petroleum potential in the surveyed areas are sandstones laid down in the Triassic, Jurassic, Cretaceous and Palaeogene periods, with the greatest potential in the Triassic and Jurassic layers. Most of the petroleum prospects lie close to the coast.

The main conclusions from the seismic surveys are that, on the basis of existing knowledge:

- 202 million Sm^3 o.e. is expected to be discovered (with an uncertainty range of 76–371 million Sm^3 o.e.) in the surveyed area.
- Nordland VI appears to be the area with the greatest petroleum prospectivity.
- The total expected resources in Nordland VII and Troms II are at the same level as the expected resources in Nordland VI.
- The probability of finding oil is greatest in Nordland VI and VII, and that of finding gas is greatest in Troms II.

In its report, the Petroleum Directorate concluded that the seismic data for Nordland VII and Troms II are now adequate, but that knowledge of the geology of the areas off the Lofoten and Vesterålen Islands and Senja is still limited, and the

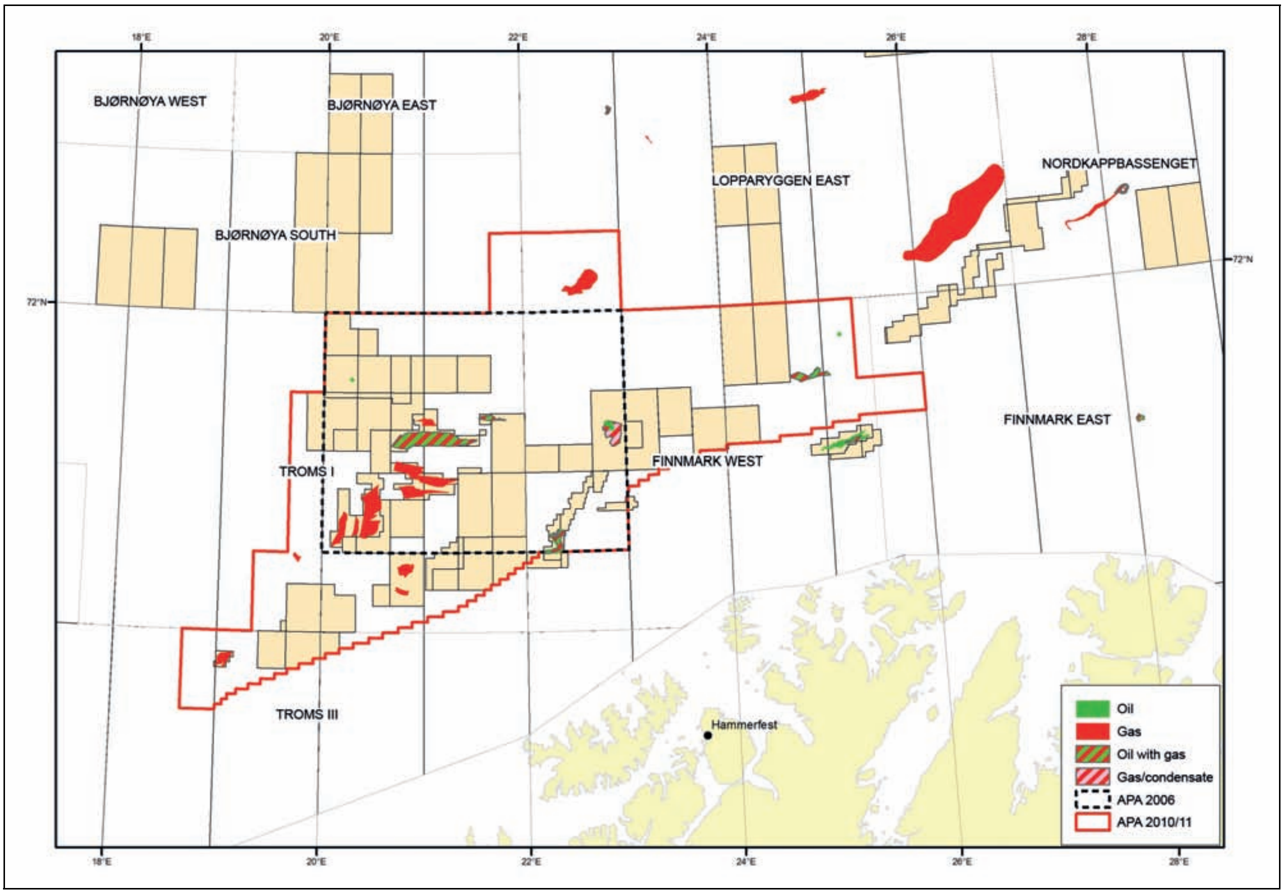

Figure 4.12 The awards in predefined areas (APA) system in the Barents Sea. The black dotted line shows the border of the APA in 2006. The red line shows the extent of the area in 2010/11.

Source: Norwegian Petroleum Directorate

estimates of undiscovered resources are very uncertain. However, the level of uncertainty can be reduced by further processing of the data and exploration drilling.

4.3.4 The importance of petroleum activities for value creation and Norwegian society

The petroleum resources on the Norwegian continental shelf have laid the foundation for the development of a substantial oil and gas industry in Norway. The petroleum sector includes oil companies, supplier industries and petroleum-related research and education institutions. It accounts for a substantial proportion of Norwegian value creation and provides employment in all parts of the country.

In 2009, the petroleum sector accounted for 22 % of Norway's GDP, and in the same year the value of petroleum exports was almost NOK 480 billion. The sector also accounts for over one-quarter of state revenues and total investment. During the 40 years of oil and gas production on the Norwegian continental shelf, the value created by the industry has amounted to around NOK 8 000 billion at the current monetary value.

The demands created by the petroleum industry generate a large number of jobs. Statistics Norway has estimated that in 2009 the industry was responsible, directly or indirectly, for around 206 000 jobs.

Since petroleum activities have only recently been started in the north and have so far been limited, employment resulting from the industry in the region has been far below the national average. The industry employs just over 2 000 people in North Norway, which is less than 1 % of all employment in the region. However, the growth in petroleum activity is resulting in rising employment, and the increase is higher than the national average in all the counties in North Norway. This applies especially to Finnmark, due to the development and operation of the Snøhvit field.

Development of the Snøhvit field in 2002 was the first gas development in the Barents Sea, and the plant at Melkøya near Hammerfest was the first LNG processing plant to be established in

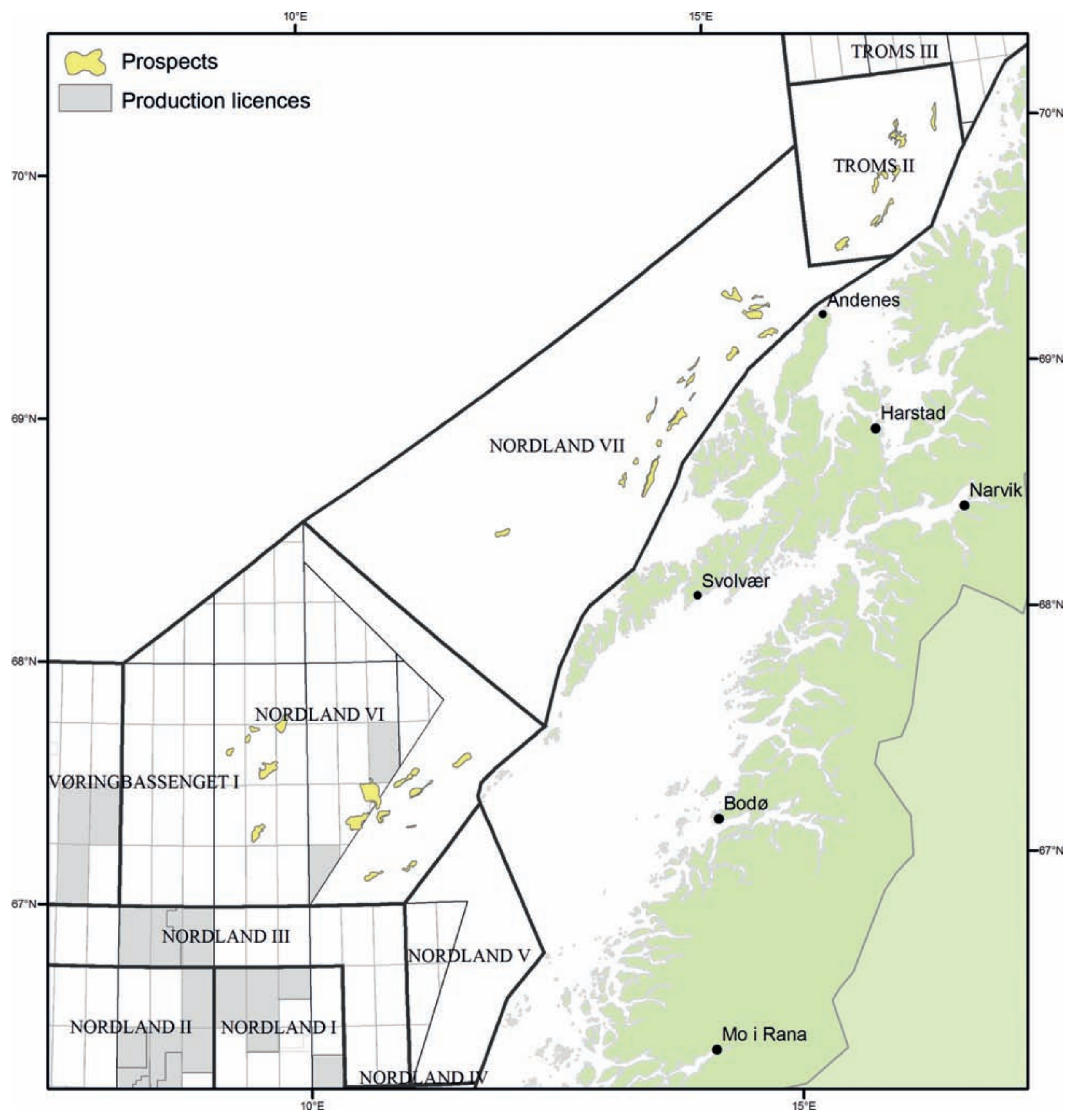

Figure 4.13 Mapped prospects in Nordland VI, Nordland VII and Troms II, 2007–09

Source: Norwegian Petroleum Directorate

Norway. Up to 2 500 people were employed in the construction phase up to the start of production in 2007. Operation, maintenance, modification and support services for the field have created over 300 permanent jobs in North Norway and led to large investments in the regional business sector. Almost NOK 3 billion of total deliveries to the Snøhvit field are supplied by businesses registered in North Norway.

Case studies show that Snøhvit has reversed the negative population and employment trends in Hammerfest. New companies are being established, and there is now a shortage of manpower in the region. Housing construction is expanding considerably, and a substantial increase in municipal revenues is expected. Substantial investments have been made in upgrading school buildings and infrastructure and in developing cultural facilities. The higher level of competence in the region resulting from the Snøhvit development has also benefitted other industries.

The Goliat development will be able to build further on this industrial expansion and increased expertise. The regional office responsible for operations will be situated in Hammerfest and the helicopter and supply base in the surrounding area. Together they will create 150–200 jobs in the operational phase, and the spin-off effects will generate additional jobs in supply industries and in the region as a whole. The operational phase for Goliat is estimated at a minimum of 15 years, and the operator will be cooperating with the supplier network.

As a result of cooperation with the fisheries industry, fishing vessels can now be used in oil spill response, both along the coast and on the continental shelf, in order to strengthen preparedness and response and make it more flexible. From now on types of vessels such as tugboats, aquaculture vessels and search and rescue vessels can also be used in oil spill response.

For almost 25 years Helgelandsbase in Sandnessjøen has supplied exploration rigs and oil fields, such as Norne on the Nordland area of the Norwegian continental shelf, with goods and equipment for activities off the Helgeland coast. Around 50 persons are employed at Helgelandsbase, which in 2007 purchased goods and services worth about NOK 280 million from businesses in Nordland. In the same year almost 390 ships called at the base. The Skarv and Idun oil and gas fields are equipped with production ships, and Helgelandsbase in Sandnessjøen serves as their supply base. From 2006 to 2008 Sandnessjøen doubled its petroleum-related turnover, showing how proximity to the Norne, Skarv and Idun fields has promoted growth in the region.

In Nordland more than 20 % of the industrial turnover, amounting to over NOK 1.5 billion, was petroleum-related in 2008. This was an increase of 50 % from 2006.

Future scenario

Petroleum activities provide jobs at both the local and the regional level. The number of jobs depends primarily on whether discoveries are made, the size of the discovery and the type of development.

In cooperation with the Nordland Research Institute, Asplan Viak has carried out a study examining the possible spin-off effects of the potential expansion of petroleum activities in the Barents Sea and the northeastern part of the Norwegian Sea. The conclusions of the report that apply to oil and gas activities in the waters off the Lofoten and Vesterålen Islands and Senja are discussed in more detail in section 4.9 below.

The analysis was based on a resource scenario developed by the Norwegian Petroleum Directorate that includes the sea area from the coastal zone in the Norwegian Sea up to and including opened areas in the southern part of the Barents Sea. The study provides a basis for estimating spin-off effects with different resource outcomes. It includes 18 different fields with an overall resource estimate of nearly 600 million Sm^3 o.e. The expected recoverable resources in the northeastern part of the Norwegian Sea and the Barents Sea are considerably larger than those on which the 2009 prognosis was based.

The Asplan Viak study estimated that development of the 18 fields could provide increased employment in North Norway of between 4 000 and 6 000 full-time jobs from 2016 to 2043. Until 2016 employment will rise gradually, while after 2043 it will gradually decline. According to these estimates, activity will be greatest in the northern part of the region, mainly because larger resources are expected to be found in the sea areas bordering on this region. According to the report, further development of the Snøhvit field would result in an employment peak of almost 2 800 jobs in the development phase, and in the operational phase well over 1 000 new jobs. A large proportion of these employees are expected to come from northern Troms and Finnmark.

4.3.5 Evaluation of the pressures and impacts associated with petroleum activities

Produced water

Produced water contains residues of chemicals introduced during drilling and production, and environmentally hazardous substances that occur naturally in the reservoir (for example alkyl phenols, polycyclic aromatic hydrocarbons (PAHs), heavy metals and radioactive substances). The volume of produced water increases with the age of the well. Produced water occurs primarily in oil extraction and only to a lesser extent in gas production.

The acute impacts of operational discharges of produced water and drill cuttings are assessed as insignificant since they will generally be local and short-term and will not have effects at population level. Nor have any long-term effects at this level been demonstrated by monitoring. However, further studies are being done on the long-term impacts of exposure to low concentrations of environmentally hazardous substances in produced water.

Norwegian waters are in general subject to strict discharge requirements, and zero-discharge targets were adopted in the white paper on an environmental policy for sustainable development (Report No. 58 (1996–1997) to the Storting). This means that as a general rule, no oil or environmentally hazardous substances, whether naturally occurring chemicals or chemicals added during the production process, may be discharged to the sea (see Box 4.3). In addition stricter requirements have been imposed in the management plan area, where discharges of produced water and/or drill cuttings are not permitted (see Box 4.2).

The Norwegian Sea and the North Sea

Although produced water is treated before discharge, not all the environmentally hazardous substances from the reservoir can be removed with existing treatment technology. According to the Climate and Pollution Agency's 2010 evaluation of the status of the work on zero discharges, injection of produced water is the only method that can eliminate discharges of naturally occurring chemicals. Treatment can substantially reduce the content of oil and oil-related components such as PAHs and alkyl phenols, but has no effect on the content of heavy metals or radioactive substances.

The general zero-discharge targets for environmentally hazardous chemical additives for the continental shelf are considered to have been reached since 2005, but not the targets for certain naturally occurring chemicals. In 2008 new requirements for discharges to sea in the North Sea and the Norwegian Sea were considered, but a report from the Pollution Control Authority (now the Climate and Pollution Agency), the Petroleum Directorate and the Radiation Protection Authority concluded that general requirements for zero discharges of produced water and/or drill cuttings and drilling mud should not be introduced for the Norwegian continental shelf.

The Barents Sea

Petroleum activities in the Barents Sea–Lofoten area are subject to the general requirement of zero discharges to the sea during normal operations (see Box 4.2). However, this only applies to new developments. The requirement applied to the Snøhvit field is that the planned operations should not harm the environment, which means that no harmful substances may be discharged during operations. Discharges of small amounts of produced water are permitted, which can be treated at the onshore biological treatment plant for discharges to sea. All discharges to sea require a permit from the Climate and Pollution Agency. Water from treatment plants is released at a depth of 40 metres in an area with a strong current on the north side of Melkøya. The impacts of these discharges are considered to be small and very local. The development of the Goliat field has been designed to allow injection of produced water that can also be used as pressure support for enhanced oil recovery.

The impacts of oil spills are discussed in more detail in Chapter 5.2 on environmental risk.

Discharges of drill cuttings and drilling mud

Drill cuttings are sand and gravel that are removed from the bore hole as the well is being drilled, and contain chemicals from drilling fluids. Discharges of drill cuttings can affect benthic fauna such as corals and sponge communities by smothering them with sediment in small areas close to the bore hole. In the Barents Sea–Lofoten area the requirements for treatment of drill cuttings are stricter than those for the rest of the continental shelf, and it is a general requirement that drill cuttings must be reinjected or treated on land. Drill cuttings and drilling mud from the top-hole section may be discharged, but only in areas where damage to vulnerable components of the environment is considered unlikely. Such assessments must be based on thorough surveys of such components.

In connection with exploration drilling in the Barents Sea, the discharge permits issued to the operators under the Pollution Control Act have included specific requirements on reporting to the Climate and Pollution Agency for each exploration well. Operators are required to conduct environmental monitoring after the wells have been drilled and monitor the treatment of landed drill cuttings.

The operators (Statoil and Eni) have reported their experience of treating drill cuttings to the Climate and Pollution Agency. A total of 7 673 tonnes drill cuttings have been discharged as a result of drilling in the Barents Sea, 5 525 tonnes of which have been taken ashore for disposal and/or re-use (Table 4.1).

A number of different chemicals are used in the drilling process, including drilling fluids,

Table 4.1 Quantities of drill cuttings discharged, or taken ashore for disposal and/or re-use, in the Barents Sea, 2005 – 09

Operator	Discharges from the tophole section (tonnes)	Slurrified/ re-used (tonnes)	Onshore disposal (tonnes)
Eni (3 wells)	1 824		1 134
Statoil (13 wells)	5 849	652	3 739
Total	7 673	652	4 873

Source: Climate and Pollution Agency

cement chemicals, utility chemicals and pipe dope. Chemicals used in drilling account for about 90 % of the total consumption and discharge of chemicals. Seawater and potassium chloride (which also occurs naturally in seawater) are generally used in drilling the tophole section and pilot hole. The discharges consist mainly of water and green-category chemicals. Discharges of yellow-category chemicals amount to 0.04 % of total discharges, and the use and discharge of red-category chemicals are minimal (Table 4.2). No black-category chemicals are used or discharged (their use and discharge are as a rule prohibited).

No significantly elevated levels of hydrocarbons have been found in the sediment samples taken around any of the investigated exploration wells. Barium, which may indicate the discharge of drill cuttings, has been found around some of the wells.

The operators' investigations of the seabed after drilling showed that drill cuttings were deposited on the sediments within a radius of 50 m around the well. Outside this area sediment was partly covered out to a radius of 100 m. Statoil's investigations after drilling in the Snøhvit field indicate that the area where the cuttings have impacts on the fauna shrinks over time and that the fauna in the area returns to normal levels. These findings have been supported by studies conducted by Statoil at the Morvin field in the Norwegian Sea, which showed that after three years the fauna were returning to normal levels.

Table 4.2 Use and release of chemicals in drilling for wells in the Barents Sea, 2006 – 09. Green category: presumed not to have a significant impact on the environment. Yellow category: not environmentally hazardous and not classified as green. Red category: environmentally hazardous, high priority given to their replacement.

Category	Use	Released
Green	15 222 tonnes	5 444 tonnes
Yellow	176 tonnes	2.4 tonnes
Red	18 kg	1 kg

Source: Climate and Pollution Agency

Transporting drill cuttings to land, treating them for disposal and re-using them increases pressure on the environment. Transport uses large amounts of energy, resulting in large emissions to air (about 305 kg CO_2 per tonne cuttings). The Climate and Pollution Agency has estimated that CO_2 emissions from the transport of drill cuttings to land account for about 3 % of total CO_2 emissions generated by exploration drilling.

Cuttings from drilling with water-based mud must be treated before disposal on land in order to reduce the content of salt and dissolved organic carbon. The benefits of re-using drill cuttings in drilling other wells have been found to be smaller than expected because of the high transport costs and the need to add more chemicals. At present we do not know enough about the possibilities of re-using drill cuttings, but this alternative should be further explored, since re-use is normally a better solution than disposal. However, tests have shown that cuttings from drilling with water-based mud can be re-used as a raw material in the manufacture of concrete.

Ordinary hose systems for transferring cuttings from the rig to the ship cannot be used for drill cuttings containing water-based drilling mud. Thus at present cuttings are transferred from the rig to the ship in containers by means of cranes, which involves a risk to the personnel. However, better technology is being developed.

Acquisition of seismic data

In 2009 the Petroleum Directorate, the Directorate of Fisheries and the Pollution Control Authority (now the Climate and Pollution Agency) drew up a report on acoustic disturbance and other negative impacts on fish and marine mammals caused by seismic activity, with recommendations for testing. With regard to the scare effect on fish, it was not possible to ascertain how far away from the source of the noise the effect made itself felt, with the result that no recommended minimum distance from fishing activities, etc. could be established. This was mainly due to the fact that relatively little research had been done on scare effects, and that the commercial interests could not agree. It should be noted that the way sound waves travel and the distance travelled under water depends on hydrographic conditions, which vary through the year and often from area to area. The Institute of Marine Research conducted a seismic survey in the waters off the Lofoten and Vesterålen Islands in the period 29 June–9 August 2009 in order to obtain better documentation on the effects of noise from seismic surveys on several commercial fish species and thus on catch opportunities for fishermen.

The main conclusions of the study were that seismic surveys had not been found to harm marine life, but that the noise affected the behaviour of the fish and there were changes (increases or decreases) in the size of catches while the surveys were being conducted. Gillnet catches of Greenland halibut and redfish increased during and after the surveys, while longline catches of Greenland halibut and haddock declined but increased again after the surveys had been completed. Swimming activity increased, which can be a sign of stress. However, no significant changes in feeding by the fish were found. During the surveys the density of saithe in the area declined, but there were no changes in the distribution of the other species. With regard to direct damage to fish larvae, previous research has shown that only larvae within a maximum radius of 5 m from the sound source suffer any damage. On the basis of these studies it has been concluded that seismic surveys do not cause damage at the population level.

4.4 Tourism

4.4.1 Management

In the Government's High North Strategy of 2006 and the updated strategy of 2009, it was pointed out that the tourist industry in the region has a particularly strong competitive advantage. Encouraging tourist industries promotes development in coastal communities and creates new jobs that can halt or limit the depopulation that is depleting many coastal municipalities.

The High North and the Sami areas are given special mention in the Government's tourism strategy of 2007. The strategy states that there is a need for greater coordination across the borders of the three northernmost counties and that the region would benefit from a joint, focused marketing strategy for the foreign market. In 2009 the three northernmost counties established a joint marketing organisation, Nordnorsk Reiseliv AS, to promote the image of the region abroad. The organisation became operative in January 2010.

4.4.2 The importance of tourism for value creation and Norwegian society

The tourist industry depends on and helps to maintain viable coastal communities along the Norwegian coast. Few countries have as long and varied a coastline as Norway, and the coastal environment, the fjords and the open sea have great potential in terms of tourism. The industry comprises a wide range of activities and sectors, a large proportion of which involve sales to travellers. They include transport, accommodation and restaurant services, travel and tour companies, and companies offering attractions and activities of various kinds. Growth in the number of tourists has spin-off effects, especially in the retail sector, in addition to direct value creation by travel and tour companies.

Statistics Norway has published a report on tourism and its economic importance, which showed that the industry accounts for a larger proportion of total production in the three northernmost counties than in the rest of the country, apart from Akershus, where it accounted for 9.7 %. In 2006 tourism accounted for 6.7 % of total pro-

Figure 4.14 Whale safari

Photo: Dag Vongraven
Source: Norwegian Polar Institute

duction in Nordland and 6 % of total production in Troms and Finnmark. The average figure for mainland Norway as a whole was 5.5 %. Total consumption by Norwegian and foreign visitors and tourists in North Norway in 2009 was estimated at NOK 19 billion, divided as follows between the three counties: Nordland NOK 8.6 billion, Troms NOK 6.6 billion and Finnmark NOK 3.8 billion.

The tourism sector in North Norway employs about 17 970 persons in the three northernmost counties. Half of these work in Nordland, one-third in Troms and one-sixth in Finnmark. The industry is relatively speaking a more important creator of jobs in Nordland, where 8.6 % of the total number of employed persons work in the industry, than in Troms or Finnmark, where the corresponding figures are 5.7 % and 6.9 %.

The number of commercial guest nights in the three northernmost counties in the period 2005–09 rose by 5.9 % (Figure 4.15). North Norway's share of the total Norwegian market for guest nights decreased from 2003 to 2007, but since then the share has shown a considerable increase.

Some of the regions bordering on the management plan area have experienced particularly strong growth in the last few years. This applies particularly to the Lofoten Islands, where the number of guest nights has risen by 34.6 %. If parts of the natural and cultural landscape in the islands are inscribed on UNESCO's World Heritage List, this will also have a positive effect on the already rapidly growing tourist industry in the area. Inscription on the World Heritage List normally has a significant impact on tourism, and increasing attention is being paid within UNESCO to the possibilities and challenges of world heritage tourism. In some areas the number of visitors has increased by several hundred per cent, although in others the increase has been considerably smaller. The number of visitors to the Vega Archipelago increased sixfold from 2004, when it was inscribed on the List, to 2009.

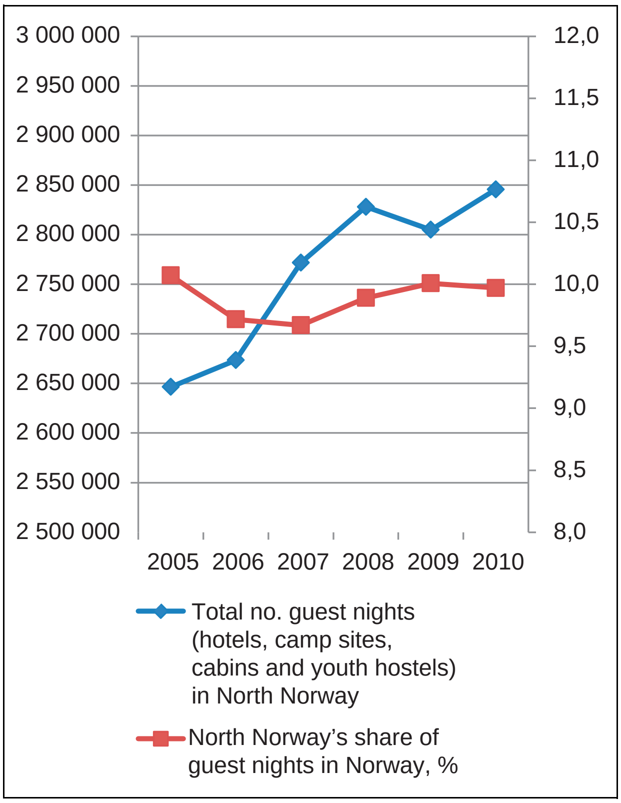

Figure 4.15 Number and market share of guest nights for North Norway in the period 2005–10

Source: Statistics Norway

The spectacular scenery, the exoticism of the Arctic and the viable coastal communities form the main foundation for the tourist industry in the High North, and occupy a key place in promoting Norway's image abroad. The coast and coastal culture, and Arctic Norway are two of the four key elements in Innovation Norway's branding strategy for Norway as a tourist destination.

The Lofoten Islands, the North Cape and Hurtigruten are among the best known tourist products in Norway. The cruise sector is growing rapidly along the entire coast, and in North Norway the Lofoten Islands, Tromsø and the North Cape area experienced particularly strong growth in the period 2006–10.

Six of the 18 national tourist roads that are being developed or planned are in the vicinity of the management plan area (Helgelandskysten Nord, Lofoten, Andøya, Senja, Havøysund and Varanger). Norway's national tourist roads have attracted international attention, and are expected to continue to play a central role in the promotion of North Norway. They will also encourage the development of tourist products in the areas through which they pass.

Tourism in Svalbard has grown substantially in the last 10 years, and the number of guest nights rose from 61 277 in 2000 to 81 718 in 2010, with a peak of 92 000 in 2008. From 2003 to 2009 the number of person-years in direct employment in the tourist industry rose from 165 in 2003 to 179 in 2009, having reached a peak of 227 in 2008. In addition to the 179 persons directly employed, tourism accounted for 73 person-years in tourism-derived industries in 2009. In the same period (2003–09) the turnover in the tourist industry increased from NOK 215 million to NOK 371 million, in addition to the turnover in local businesses, which amounted to around NOK 104 million. The most recent white paper on Svalbard

(Report No. 22 (2008–2009) to the Storting) stated that tourism is one of the three main industries in the archipelago, and that the Government is in favour of further development of the industry as a basis for additional value creation in the area and to promote settlement in Longyearbyen. Experiencing the attractions of Svalbard mainly requires traffic in and close to the islands' vulnerable, untouched nature, and this makes it imperative that further development of tourism in the area should take place within a safe and environmentally sound framework.

Whether to nominate parts of the Svalbard archipelago for inscription on the World Heritage List is being considered, and is discussed in more detail in the white paper on Svalbard.

Sea-fishing tourism

This form of tourism has grown considerably in the last 10–15 years in Norway. In several coastal communities it has contributed substantially to value creation and employment, especially during the summer season, when tourism is an important source of income.

Total value creation in Norway by the 434 fishing tourism enterprises is estimated at NOK 222 million a year, of which NOK 100 million is created in North Norway.

In order to help ensure the sustainability of sea fishing, the Ministry of Fisheries and Coastal Affairs has appointed a working group to examine the need to regulate commercial activities based on sea fishing tourism and suggest management measures. The members include representatives of the industry itself, relevant research communities and management authorities.

The group will present a final report on its work with proposals for new measures.

4.5 Environmental management

The environmental authorities have several important tools at their disposal in connection with activities in the Barents Sea–Lofoten area. For Norway's territorial waters these are mainly based on the Nature Diversity Act, while for Norway's exclusive economic zone and the Norwegian continental shelf, the most important tools are based on the Pollution Control Act, political action plans and strategies.

4.5.1 Management and measures

Marine protected areas

It is a national target to establish a representative network of marine protected areas (MPAs) in the different biogeographical regions in Norway's coastal and marine areas by 2012. Protection of selected marine areas is a key element of ecosystem-based management, and is intended to play a part in halting the loss of biodiversity, safeguarding the natural resource base and maintaining a representative selection of marine environments as reference areas for research and monitoring. Establishing MPAs will meet some of Norway's international commitments, including the target under the Convention on Biological Diversity that at least 10 % of coastal and marine areas are to be protected by 2020.

The fisheries authorities have already introduced various forms of protection for several areas as part of the management regime for living marine resources. In the white paper *Integrated Management of the Marine Environment of the Norwegian Sea* (Report No. 37 (2008–2009) to the Storting), the Government decided to draw up a marine protection plan. The first phase will cover 36 MPAs, and the planning process for the first 17 began in September 2009. Four of these (Lopphavet, Ytre Karlsøy, Rystraumen and Rossfjordstraumen) are in the coastal zone or just inside the Barents Sea–Lofoten area. The planning process for the remaining 19 MPAs will begin in 2011. Four of these (Tanafjorden transect, Indre Porsangerfjord, Andfjorden transect and Røstrevet) are also situated in the coastal zone or just inside the Barents Sea–Lofoten area.

In addition 87 % of the territorial waters around Svalbard, including Bjørnøya, lie inside nature reserves and national parks that are protected under the Svalbard Environmental Protection Act.

Protection of seabirds

An important part of seabird management is protecting their habitats. All Norwegian counties with a coastline have their own conservation plans for preserving important seabird colonies.

Hunting seasons for seabirds

The Directorate for Nature Management regulates which bird species may be hunted, the hunting season for each species and the areas where they may be hunted. The regulations apply for five years at a time. The current regulations apply until 31 March 2012, and will be revised by then.

Priority species

Under section 23 of the Nature Diversity Act, particular species may by regulations be designated as priority species. The provisions on priority species apply in Norway's territorial waters out to the territorial limit (12 nautical miles). Measures to protect a species may include a prohibition on removal of, damage to or destruction of the species, as set out in section 24, first paragraph, of the Act. The provision concerning protection of areas with specific ecological functions for the species (in section 24, first paragraph, b)) does not apply in the sea. The first proposal for designation of priority species was circulated in 2010 by the Directorate for Nature Management, and did not include any marine species or seabirds. However, further rounds of proposals will be held, which could include species that are found in the management plan area. The management of any marine species designated as a priority species will call for close cooperation and coordination between the environmental and fisheries authorities.

Selected habitat types

Under section 52 of the Nature Diversity Act, specific habitat types may by regulations be designated as selected habitat types in parts of or throughout the country, and the provisions apply in Norway's territorial waters out to the territorial limit (12 nautical miles). The objective is to maintain the diversity of habitat types within their natural range. When a habitat type has been designated as selected, special account must be taken in the exercise of public authority of areas of the habitat type, so as to avoid reduction of the range of the habitat type or deterioration of the ecological status of the areas. In 2010 the Directorate for Nature Management circulated a proposal for designation of five selected terrestrial habitat types. Although no marine habitat types have so far been proposed as selected habitat types, further rounds proposing new selected habitat types will be held, which could include habitat types that are found in the management plan area.

Alien species

Maritime traffic between biogeographical regions entails a risk of the spread of alien species through discharges of ballast water and hull fouling. In 2004, the IMO adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments (Ballast Water Convention), which is intended to reduce the risk of the spread of harmful aquatic organisms or pathogens. Although the convention has not yet entered into force, Norway has implemented some of its requirements in the Regulations on the prevention of the spread of alien species through ballast water and sediments from ships (the Ballast Water Regulations), which entered into force on 1 July 2010. The provisions regulating the depths at which ballast water may be exchanged apply to all ships sailing in and out of Norwegian territorial waters and Norway's exclusive economic zone that have taken up ballast water outside certain specified areas. Requirements for treatment of ballast water will be introduced when the Ballast Water Convention enters into force.

The first management plan for the Barents Sea–Lofoten area was followed up by a white paper on the red king crab (Report No. 40 (2006–2007) to the Storting). In addition analyses were made of the ecological risk posed by a number of alien species. Those posing a high risk were entered on the 2007 Norwegian Black List and a national Strategy on Invasive Alien Species was drawn up in 2007. Alien species in the Barents Sea, such as the snow crab and the red king crab, are both considered to represent a high risk to Norwegian ecosystems. The strategy emphasises that if the Northeast Passage is opened to traffic, this will further increase the risk of alien species from distant regions being introduced.

World Heritage status for the Lofoten Islands

In 2002 the Lofoten Islands were placed on Norway's tentative list of areas to be nominated for inscription on the World Heritage List. The nomination process was formally started by the Bondevik II Government in 2005, and was supported by all six of the Lofoten municipalities. However, at the request of Lofotrådet (a cooperation body for the six municipalities in the Lofoten Islands) the Ministry of the Environment suspended work on the nominations in September 2009 pending the update of the management plan for the Barents Sea–Lofoten area. At the request of the Ministry, the Directorate for Nature Management put together the nomination documentation as far as possible within the imposed framework and limitations. The documentation sets out the natural and cultural qualities of the islands that would qualify them for inscription on the List. If it is decided to

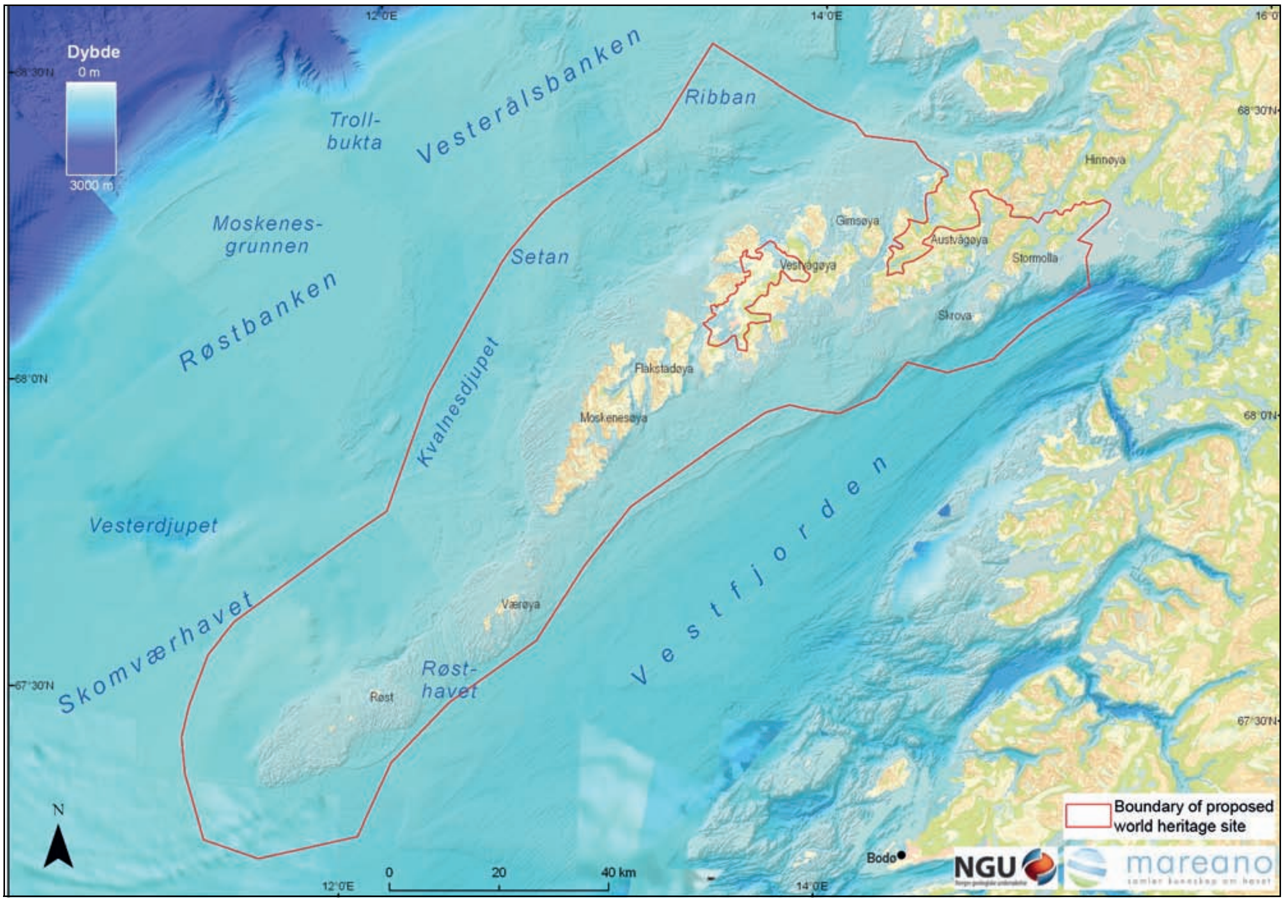

Figure 4.16 Map of the area proposed for inscription on the World Heritage List

Source: Ministry of the Environment

continue work on the nomination, a further process will be started to complete the material for submission to UNESCO. This will also involve seeking the necessary local political approval, since UNESCO insists that the local as well as the national authorities commit themselves to doing their utmost to protect and safeguard the cultural heritage values of the area over the long term.

4.6 Offshore energy

At present there are no offshore energy plants in the management plan area, but theoretically there is a very large potential for renewable energy production in Norwegian waters. Offshore energy includes offshore wind power, wave power, marine current power, tidal power and osmotic power.

4.6.1 Management

Under the Offshore Energy Act (see Chapter 2.3), offshore renewable energy production may in principle only be established after the public authorities have opened specific geographical areas for licence applications. The intention is that the authorities should introduce spatial planning processes to ensure that energy production takes place in areas where the potential for conflict is as low as possible. The Act stipulates that strategic impact assessments should be conducted under the auspices of the authorities before the decision to open geographical areas is made.

The first step in the process of deciding which areas are suitable for offshore renewable energy production was completed in autumn 2010. A working group consisting of the Norwegian Water Resources and Energy Directorate, the Directorate for Nature Management, the Directorate of Fisheries, the Norwegian Coastal Administration and the Petroleum Directorate has drawn up a report on proposed areas for impact assessments in connection with offshore wind power. Various sea areas were assessed for their suitability for offshore wind power development, and the evaluation included a discussion on the necessary technical and economic conditions, such as wind resources, water depth, electricity transmission and supply and market factors. Environmental interests and potential conflicts of interest over the use of sea areas were also discussed (see section 4.6.4 below). The report and the comments received during the consultation process will be used as the basis for selecting areas where the first series of strategic impact assessments will be conducted. The impact assessments will be started in 2011, and the status and plans for further work will be submitted to the Storting in connection with the revision of the offshore energy strategy in 2012.

Altogether the working group proposed 15 areas for impact assessments with a view to offshore wind power development, five of which lie off the Lofoten Islands, Troms and Finnmark (see Figure 4.17).

The only area to be assessed that is actually inside the management plan area is Sandskallen, which is just outside the baselines, while the Nordmæla area lies on the baseline. The other three areas lie just inside the baselines. The proposed areas are in water shallow enough for fixed installations to be built and connected to the electricity grid on land. Up to 2020 the only areas that are likely to be opened will be among those proposed by the working group.

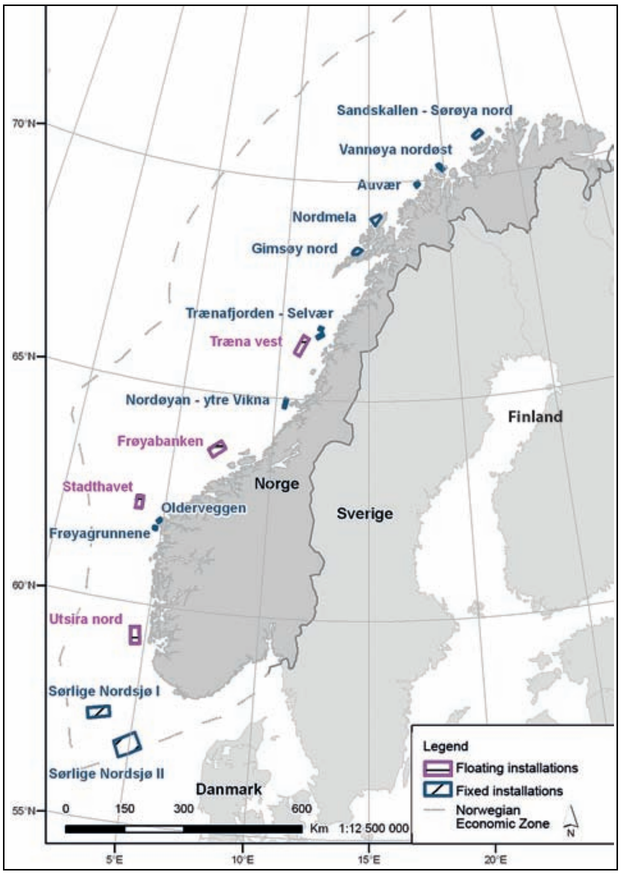

Figure 4.17 Proposed areas for impact assessments with a view to offshore wind power development

Source: Norwegian Water Resources and Energy Directorate

4.6.2 Activities

No renewable offshore energy plants have so far been established within the management plan area. However, there are two tidal power plants inside the baselines. A prototype tidal power plant in Kvalsundet in Finnmark has been in operation since 2003 and has been supplying power to the electricity grid. It was verified and reinstalled in 2009. In addition Hydra Tidal opened a prototype floating tidal power plant, Morild II, in Gimsøystraumen in Nordland in autumn 2009. Testing and verification of the plant began in November 2010.

At present the authorities are not aware of any plans for offshore energy plants in the management plan area, but the Norwegian Water Resources and Energy Directorate has received notification of three wind power projects inside the baselines off the Lofoten Islands and Troms (Lofoten havkraftverk, Gimsøy and Vannøya). Pending further work on the spatial planning processes for the proposed areas mentioned in section 4.6.1, the Directorate has been requested not to give priority to dealing with new reports of major wind power projects inside the baselines.

4.6.3 Importance for value creation and Norwegian society

The Norwegian business sector and research communities have a high level of expertise on various aspects of offshore technology, marine operations and other important fields that are vital for the development and operation of renewable energy sources and offshore infrastructure. The development and operation of onshore wind power plants will also provide knowledge that can be used in the future development of offshore wind power on a large scale.

The theoretical potential for offshore wind power production in Norwegian sea areas was previously estimated at up to 14 000 TWh/year. However, this was revised in the report on offshore wind power mentioned in section 4.6.1, where a rough screening was carried out and an estimate was given for the areas proposed for impact assessments. Energy system considerations and other environmental factors and user interests in the same sea areas were taken into account when selecting these areas. The potential capacity in MW for each of the areas in the report has been estimated. The figures are based on the geographical extent of the area and on how they would fit into the rest of the power supply system. Altogether it would be possible to build an installed capacity of up to 5–12 GW in these areas, which would produce 18–44 TWh. The five areas off the Lofoten Islands, Troms and Finnmark would have a possible installed capacity of 0.5–1.5 GW, and produce 2–5 TWh. As strategic impact assessments are carried out and if areas are subsequently opened for applications, more knowledge will be built up that can be used to improve estimates of the production potential.

4.6.4 Assessment of the pressures and impacts associated with future offshore energy development

Offshore wind farms will have environmental impacts in the construction and operational phases and when they are closed down and decommissioned. Since not many offshore wind farms have been established, our knowledge of the impacts on marine ecosystems is limited. Among the possible environmental impacts are negative effects of noise on fish and marine mammals, loss of habitats, damage to benthic habitats, collisions between seabirds and wind turbines, and the visual impact on the seascape. Wind farms are also likely to occupy areas where they will have impacts on other activities such as oil and gas production, shipping, fisheries, recreation and tourism, or that have been designated as marine protected areas (see section 4.8.6).

These factors are discussed in the report on offshore wind power and will be further examined in the strategic impact assessments prior to the opening of areas.

4.7 Other industries: bioprospecting and mineral extraction

4.7.1 Marine bioprospecting

The Government views marine bioprospecting as a means to new, sustainable value creation. The potential for value creation is substantial, and Norway is in a good position to make its mark in international competition. The Government considers that Norway's long coastline and extensive sea areas, with their access to resources and high species diversity, offer rich opportunities. In addition the infrastructure and research groups needed to collect and screen a wide variety of marine organisms are available in Norway. In combination with the national expertise that has already been developed in the marine sector and biotechnology, this gives Norway a good starting point for a national initiative for marine bioprospecting. In autumn 2009 the Government presented a national strategy to facilitate research and business development related to marine bioprospecting. The goal was to activate the entire range of value creation potential by means of a targeted, coordinated national effort. The High North is a key element in the strategy and priority will be given to gathering marine organisms from the northern sea areas.

Norway is responsible for managing large sea areas where few surveys have been made. Some of the marine organisms live under extreme conditions: in Arctic waters, under low temperatures and changing light conditions, or in oil reservoirs, under high pressure and high temperatures. Others live in coastal areas and fjord waters, where there are large concentrations of other species. Many of these marine organisms are likely to have properties that can be exploited and used in the manufacture of new products and processes in a number of industrial sectors.

Bioprospecting is based on consent and specifically regulated in sections 9 and 10 of the Marine Resources Act and Chapter VII of the Nature Diversity Act. Genetic material obtained from the natural environment is a common resource belonging to Norwegian society as a whole and managed by the state. It is to be utilised to the greatest possible benefit of the environment and human beings in both a national and an international context, also attaching importance to appropriate measures for sharing the benefits arising out of the utilisation of genetic material and in such a way as to safeguard the interests of indigenous peoples and local communities. The provisions of the two acts provide a legal basis for issuing regulations requiring a permit for investigation and collection or harvesting of genetic material and for the state to claim a share of the benefits from such activities.

The Government recognises the need for such regulation and will issue regulations to this effect under the Marine Resources Act and the Nature Diversity Act.

The University of Tromsø plays an important role in the promotion of marine bioprospecting, especially through the MabCent-SFI Centre for Research-based Innovation, and there are several other universities and institutes with expertise in the field. These research communities all have an important place in the implementation of the national strategy for marine bioprospecting.

Business development in this area is still at an early stage. As with biotechnology in general, the commercialisation of marine bioprospecting is a long-term effort that requires a cross-disciplinary approach and high capital intensity, and where the risks are high. However, there are wide variations from one area of application to another; for example the cost of developing products for human medical treatment is normally far higher than for other products. There are a number of Norwegian businesses involved in marine bioprospecting, some already selling products and others still conducting trials. Bioprospecting in Norway has already shown that there are many organisms and compounds in our coastal and marine areas that possess interesting properties that have not previously been known or characterised.

4.7.2 Mineral extraction

Mapping of the seabed under the MAREANO programme has revealed areas of gravel and shell sand at depths of 100–300 metres on the continental shelf and along the continental slope in the southern part of the Barents Sea and off the Lofoten and Vesterålen Islands. The sand layer here is rich in carbonate, consisting mainly of whole shells and shell fragments. Shell sand would be a valuable resource in the coastal zone, and in the long term on the continental shelf as well. Gravel also has potential economic value in the long term. Southwest of Svalbard, the mid-ocean ridge lies inside the management plan area and fairly close to the coast. In certain places there is active seepage of mineral-rich fluids with temperatures of 200–400 °C, which may leave exploitable deposits of metal sulphides. In 2008, an area of active cold seeps with black chimneys was discovered, together with an adjoining area of deposits that may prove to have commercial potential. Extraction of metal sulphides, gravel and shell sand is only expected to be viable in the long term.

Box 4.4 What is marine bioprospecting?

People have been making use of substances from plants and animals since the dawn of time. Today, for example, substances found in the natural environment, largely on land, are used in the production of many of our medical drugs. Another example is alginate extracted from kelp, which has long been used in various industrial processes. However, in spite of the fact that the sea covers more than 70 % of the earth's surface, and that evolution in the marine environment began several million years before evolution on land, little research has been done on marine biodiversity.

Marine bioprospecting can be described as a systematic and targeted search for components, bioactive compounds and genetic material in marine organisms. This includes all types of marine organisms – micro-organisms such as bacteria, fungi and viruses, and larger organisms such as algae, shellfish and fish. Marine organisms are found in the open sea, coastal waters, fjords, the seabed and oil reservoirs beneath the seabed. Benefits derived from bioprospecting range from a molecule isolated from an organism and purified by a biological or synthetic process, to the entire organism itself.

Little is known about the molecular and genetic properties of the various marine species, especially cold-water species. So far research has been concentrated on forms of life that are found in tropical and temperate regions, but in the future the focus is likely to shift to biological material in northern waters. There is also a growing interest in marine life because products isolated from marine organisms tend to be more bioactive than corresponding compounds isolated from land organisms.

Thus marine bioprospecting has the potential to result in the discovery of components, bioactive compounds and genetic material that can be used in commercially or socially beneficial products and processes. Marine bioprospecting is therefore not an industry in the traditional sense of the term, but a way of obtaining a variety of compounds that can be used in many different sectors, including the pharmaceutical industry, food and feedstuffs production, the cosmetics industry, bioenergy production and the oil and gas industry.

4.8 Coexistence and conflicts of interest between industries

4.8.1 Petroleum activities and fisheries

Ever since oil and gas activities started on the Norwegian shelf about 40 years ago, the authorities have emphasised the importance of coexistence with other industries, particularly the fisheries industry. Since 2006 our knowledge about the possible effects of seismic activity on fish has improved, and a compensation scheme has been established to cover financial losses incurred by Norwegian fishermen as a result of petroleum activities (cf. Chapter 8 of the Petroleum Activities Act).

Acquisition of seismic data

Seismic surveys are carried out at all stages from the early exploration phase and well into the production phase, when they are used for reservoir surveillance purposes. Seismic surveys have resulted in most conflict between the petroleum industry and the fisheries. These conflicts, which are limited to certain periods and areas, are due to the fact that the sound waves emitted by seismic vessels have temporary effects on fisheries in the area, and that while the survey is being conducted the hydrophone cables towed behind seismic vessels occupy a large area and have limited mobility.

To reduce the level of conflict between the fisheries and seismic surveys, a working group with representatives from the Petroleum Directorate and the Directorate of Fisheries was appointed to review the legislation governing such surveys. In response to the group's report, the provisions of the Resource Management Regulations relating to seismic surveys have been amended. The amendments include requirements for fisheries experts to follow a training course, clarification of the role of fisheries experts, updated requirements relating to fisheries experts and to the keeping of a log with a specified format. The amendments also entail coordination of requirements relating to reporting on exploration activities and track and other subsurface surveys, specification of the area of the survey, including the turning area, and that any changes are reported. The provisions of the Petroleum Act and appurtenant regulations on tracking of seismic vessels have also been amended. A cooperation agreement has been concluded between the Norwegian Coast Guard, the Directorate of Fisheries and the Petroleum Directorate under which the Coast Guard is the primary point of contact for the fisheries experts, and several training courses for fisheries experts have been held.

To meet the requirement of coexistence between the petroleum and fisheries industries, seismic activities are currently regulated to take into account both fish resources (spawning etc.) and the fisheries. The most important policy instruments to which the Government will continue to give priority are:

- temporal and spatial restrictions for seismic data acquisition,
- requirement for seismic survey vessels to carry a fisheries expert on board.

Occupation of areas by the petroleum and fisheries industries

The development and operation of petroleum installations on the Norwegian shelf occupy areas of the sea for varying lengths of time. When activities are terminated, the area has to be cleared and restored to its original state. Currently there is one field on stream and one under development in the Barents Sea. The Snøhvit field began production in August 2007 but is a gas field, without any surface installations. The Goliat field is expected to start production in autumn 2013. This field will have a floating production unit with subsea wells and will therefore occupy only a small sea area during the production phase.

Norwegian legislation requires operators to establish safety zones around petroleum installations that project above the surface of the sea. A safety zone covers an area extending to a distance of 500 m from the outer limits of the installation. An exploration rig, including its anchor spread, occupies an area of about 7 km^2 for a period of one to two months for each well. However, dynamically positioned rigs are often used in the management plan area, and these occupy a safety zone of less than 1 km^2. On the Norwegian shelf, safety zones occupy about 100 km^2 of the total area of 675 571 km^2 that is open for petroleum activities.

The area occupied by fisheries depends on the availability of the fish, whether or not the fisheries are seasonal, the location of the fishery and the type of vessel used.

Fishing in the vicinity of subsea structures

It is not permitted under Norwegian law to establish safety zones round subsea structures, and all subsea structures are required to be overtrawlable. Such structures do not normally occupy areas used by vessels fishing with conventional gear such as gillnets and longlines or engaged in pelagic fisheries using purse seines and trawls, but in practice many fishing vessels avoid them for fear of trawl gear becoming snagged and damaged.

Only fisheries using bottom gear such as trawls and Danish seines can be impeded by pipelines on the seabed. There is very little Norwegian fishing with Danish seines round pipelines on the Norwegian shelf, and there have been no reports of major problems linked with fishing near these pipelines. It is very unlikely that existing pipelines will be the cause of noticeable catch losses for trawlers fishing on the Norwegian shelf. Most of the problems experienced by trawl fisheries are caused by pipelines with rock fillings, free spans or external damage.

Pipelines and cables that are buried in the seabed and stabilised interfere very little with fishing.

These problems can be further reduced by advance information about new developments, by inspections and by information about alterations to subsea structures.

4.8.2 Maritime transport and the fisheries industry

Collisions

The International Regulations for Preventing Collisions at Sea apply to fishing vessels as well as other shipping, and if due care is taken conflicts can be reduced to a minimum. In the management plan area the potential for conflict has been further reduced by the establishment of traffic separation schemes between Vardø and Røst in North Norway in 2007 after the IMO's adoption of the Norwegian proposal on 5 December 2006. When determining the positions for the proposed traffic separation schemes, the Norwegian authorities took account of fishery activities in the area, which means that the through traffic to and from northwestern Russia will not in general come in conflict with fishing with passive gear by the coastal fleet. The traffic separation schemes are discussed elsewhere, particularly in Chapter 5.1.1.

Coastal ship traffic is more likely to give rise to conflict, especially in connection with fishing with passive gear. However, experience has shown that this can be avoided if the gear is clearly marked.

Vessel noise

All motor traffic at sea generates noise, and in areas of heavy traffic this type of noise tends to have a scaring effect on fish, which may reduce catch opportunities for fishermen. In the management plan area, however, the volume of ship traffic is so small that it is unlikely to have noticeable effects on catches.

4.8.3 Impacts of acute pollution on aquaculture

The aquaculture industry is dependent on clean, unpolluted sea areas to maintain production and safeguard the high reputation of Norwegian farmed fish.

Fish kept in cages cannot escape from an oil slick, and may be injured by escape behaviour in the cage. Injuries may also be caused by blocked gills or uptake of harmful substances from the oil. Adult farmed fish are not particularly vulnerable to oil pollution, but fatty fish such as salmon may absorb fat-soluble oil components that accumulate in the body and change the taste, smell and colour of muscle tissue. Some of the PAHs found in oil are toxic, mutagenic and/or carcinogenic, and may pose a health risk to the consumer. In addition to reducing the quality of farmed fish, an oil spill may also contaminate production equipment and render it useless. For fish farmers who are dependent on access to naturally occurring larvae, as in mussel farming, an oil slick can affect both current and future production.

Most of our knowledge of the impacts of oil spills on the aquaculture industry comes from shipping accidents. Examples of such accidents in Norway are the *Rocknes* shipwreck (2004) and the *Server* accident (2007). Both accidents occurred during winter, off the coast of Hordaland, and in both cases the oil spill was limited to an area of 400–500 m^3. Several fish farms were affected by the spill, but not badly enough to make special measures necessary.

Large oil spills (more than 75 000 tonnes) in other countries have shown how the possibility of effects on fish quality have affected the reputation and sales of farmed fish from the area concerned in the world market. After the wreck of the oil tanker *Braer* off the Shetland Islands, market-ready salmon from an area of more than 1 000 km^2 were slaughtered. This was done to prevent any possibility of contaminated fish reaching the market and thus to give the message that Shetland salmon are always clean. In spite of this, the reputation of seafood from the Shetlands deteriorated considerably in the subsequent months because of the media's extensive coverage of the accident. Thus the loss of market value and the slaughter of salmon that were not even affected by the oil did greater harm than direct damage from the oil pollution. However, no clear effect on prices was detected over the long term.

4.8.4 Maritime transport and the petroleum industry

Collisions

The volume of maritime traffic in the management plan area is relatively moderate, and the general rules in the International Regulations for Preventing Collisions at Sea reduce the risk of conflict between petroleum-related shipping and the movements of other ships to a minimum. The traffic separation schemes between Vardø and Røst, and the Norwegian Coastal Administration's vessel traffic service centre in Vardø, which monitors ship traffic in the management plan area, also reduce the risk of collisions.

Oil and gas installations in the area will be clearly marked, and all traffic in their vicinity will be monitored. This applies to both the permanent structures and the temporary installations established for drilling and pipe-laying.

Anchoring over pipelines

All subsea installations and pipelines must in principle be overtrawlable. This means that they must normally be strong enough to withstand accidental anchor contact without any threat to their integrity.

4.8.5 Petroleum activities, maritime transport and travel and tourism

Experience gained from the Snøhvit and Ormen Lange fields shows that development of oil and gas fields often leads to increased activity in the local travel and tourism industry in the form of increased demand for accommodation and other services, especially during the construction phase. In the operational phase, training programmes, conferences and other business-related activities also generate increased traffic in the region, which to some extent compensates for the seasonal nature of tourism.

Marketing of the Lofoten and Vesterålen Islands focuses mainly on the nature and landscape. The islands offer authenticity, well-cared-for cultural landscapes, clean waters and spectacular scenery. This raises the question of how far this image is compatible with the presence of large-scale and highly visible petroleum activities. An oil spill from a platform or ship would in the short term have an extremely negative effect on the tourist industry in the region, and even in Norway as a whole. Innovation Norway markets the country as a destination for sustainable tourism, and spectacular untouched nature it offers to visitors is one of Norway's comparative advantages. International media focus on an oil spill off the Lofoten and Vesterålen Islands would detract from the image that Innovation Norway has spent many years building up.

4.8.6 Future offshore wind farms and other industries

Large-scale offshore wind farms will affect relatively large areas, but the scale of wind farm development in Norwegian sea areas is uncertain. The distances between wind turbines may be as much as 1 km, and the turbines are linked by a network of power cables on the seabed, which are joined to a cable that transmits the generated electricity to shore. The waters off the Lofoten Islands, Troms and Finnmark and the areas proposed for impact assessment in the report on offshore wind power measure between 105 and 332 km^2 (Figure 4.17). The size of these areas is likely to be reduced once strategic impact assessments have been conducted. Since the report is based on the assumption that each wind farm will have a maximum capacity of 300 MW for transmission to the regional grid, a wind farm would affect an area of up to 60 km^2, depending on the size of the turbines.

The report establishes that there are no areas suitable for offshore wind farms that would not at the same time affect environmental interests and those of other users, but that the proposed areas are believed to be those that will give rise to the fewest conflicts of interest. Strategic impact assessments will identify the negative effects for the various interests and propose measures to reduce them.

Wind power and the fisheries industry

It may be necessary to impose restrictions on traffic, passage and other activities in the area occupied by a wind farm. There are considerable traditional coastal fisheries in the areas proposed in the report, and gill nets, longlines, jigging machines, Danish seines, traps, pots, trawls and purse seines are all used to a varying extent in different areas. It is not yet known which restrictions will be imposed on fisheries in and in the vicinity of future Norwegian offshore wind farms. In Denmark there is no general prohibition on traffic in areas where there are wind farms, nor is there a general prohibition on fishing, but there are restrictions on fishing methods, for example trawling.

Since few offshore wind farms have been established, their impacts on the marine environment are uncertain. Offshore turbines may to some extent function as artificial reefs, and thus attract fish. Other factors that may affect fish include changes in light conditions caused by the shadowing effect of the towers and shadow flicker from the rotor blades of the turbines, noise generated by the vibrations in the turbines, and the electromagnetic fields around cables and transformers. Since the effects will vary from area to area, it is difficult to draw any general conclusions about the impacts of offshore wind farms. For example, none of the areas identified in the report are free of fishery interests. In addition to the impact assessments conducted prior to any development, an environmental monitoring programme should be established for wind farms that are being developed.

Power cables will have to be buried in the seabed or covered by rock armour so that they are overtrawlable. Thus the presence of cables will probably not make it necessary to introduce formal restrictions on fishing. A compensation scheme has been established to cover financial losses incurred by Norwegian fishermen as a result of wind farm development, cf. Chapter 9 of the Offshore Energy Act.

Wind power and petroleum activities

The areas off the Lofoten Islands, Troms and Finnmark proposed in the above-mentioned report on offshore wind power lie close to the coast and are suitable for fixed wind turbines down to a depth of 70 m. In these areas there would be no direct conflict between petroleum installations and wind farms over occupation of the area. A number of petroleum plays have been mapped in some of the proposed areas. Although the resource potential for petroleum is currently low in these areas, the presence of petroleum deposits cannot be excluded. Any new information about the resource potential for petroleum will have to be evaluated in further studies before the areas can be opened for offshore renewable energy production.

Wind power and maritime transport

Any conflicts of interest arising between these two industries would be over competing uses of the same area and the risk of collisions.

The degree to which offshore wind farms would come into conflict with maritime transport will depend on the location and number of turbines, and the size of the area occupied. Up to 2020, a large-scale wind farm off the Lofoten Islands, Troms or Finnmark could occupy an area of almost 60 km^2. Apart from certain parts of the Sandskallen area off Sørøya, none of the areas proposed in the report would come in conflict with fairways, but in some places there is local traffic. Parts of the Sandskallen area are located in the approach to Sørøya and Hammerfest, but care has been taken to avoid the most heavily trafficked routes.

Normally plans for a wind farm can be adjusted to take account of coastal traffic routes. The distance between wind turbines will be up to 1 km, which allows fairways to run through wind farms.

Wind power, tourism and outdoor recreation

The establishment of an offshore wind farm may have impacts on outdoor recreation and tourism by directly occupying an area, through shadow flicker and noise and through their visual impact on the landscape. The effects will vary according to the number of wind turbines, the distance between the wind farm and the recreation area, and the value of the recreation area.

Landscapes and natural and cultural environments of outstanding quality or of symbolic value are considered to be areas of particularly high quality. Examples are nationally valuable cultural landscapes, islands and archipelagos, fjords, valleys and smaller areas of symbolic value. Such areas are often very valuable for outdoor recreation and tourism and as a source of enjoyment.

The areas off the Lofoten Islands, Troms and Finnmark that are proposed for impact assessments in the report lie close to the coast (0–14 km). The report does not deal with outdoor recreation and tourism interests, but these will be considered in the strategic impact assessments.

4.9 Importance of the areas off the Lofoten and Vesterålen Islands and Senja for value creation and Norwegian society

North Norway has a fairly stable population, but settlement is becoming increasingly centralised within the region. Thus the population in the central areas is growing while that in peripheral areas is declining; for example all the counties in North Norway have a net internal migration loss. This is has more to do with the fact that some urban regions in Norway are expanding fairly rapidly than the fact that the population of peripheral regions is declining. The population decline in Norway's outlying districts is also considerably smaller than is the case in similar areas in other European countries.

The labour market in North Norway is slower, and labour force participation is somewhat lower, than in other parts of the country. Unemployment in the region is at approximately the same level as the average for the country as a whole. The educational level is low, apart from that in the Tromsø area. Growth in total employment from 1998 to 2008 was just above 14 % in North Norway, as against 21 % in the country as a whole. In several areas of the region employment has declined. Economic growth has been weaker than in the rest of the country and in some parts of the region it has been negative.

The public sector is one of the largest employers in North Norway, and provides jobs for about 39 % of the labour force, as against 29 % for the country as a whole. The retail and other private services sectors account for just under 28 % of employment, as against 38 % for the country as a whole. The fisheries sector accounts for 4.7 % of employment in North Norway, as against 1 % for the country as a whole, but in some island communities fisheries account for more than 40 % of employment. Tourism is a relatively important industry and employs about 8 % of the labour force, which is marginally higher than for the country as a whole. Direct employment in the oil and gas industry is less than 1 % in North Norway, as against the national average of about 2.5 %. This is due to the fact that there is little petroleum activity in the region. However, employment in the industry and the level of petroleum activity are increasing, especially in Finnmark, owing to the development and operation of the Snøhvit field.

The following analyses of economic developments in the management plan area have been conducted as part of the basis for the updating of the plan:

- Asplan Viak and the Nordland Research Institute: Study of the local and regional spin-off effects in connection with the updating of the integrated management plan for the Barents Sea–Lofoten area.
- SNF, Institute for Research in Economics and Business Administration: Commercial importance of the fishing and aquaculture industry in the Barents Sea–Lofoten area.
- Sweco Norway: Marine ecosystem services in the Barents Sea–Lofoten area – description, assessment and valuation.
- Vista Analysis: Economic analysis of future expansion of oil and gas activities in the Barents Sea–Lofoten area.

Such analyses will always be based on simplifications, assumptions and methods that can be criticised. For example the three economic studies use rather different assumptions about the consequences of petroleum activities for the regional labour market. In line with its terms of reference, Vista's analysis has only two scenarios: a zero scenario for future developments where there are no new oil and gas activities and a scenario where the whole area off the Lofoten and Vesterålen Islands and Senja is opened up. The development scenario is highly simplified and for reasons of time the zero scenario has not been fully explored. The following is a summary of the main content of these studies, without any comments on or evaluations of their assumptions or the results. These are expressed either explicitly or implicitly in Chapter 7, insofar as they are considered to be relevant to the Government's conclusions.

4.9.1 Economic analysis of expanding oil and gas activities in the Barents Sea–Lofoten area

The consultancy firm Vista Analysis has conducted an economic analysis of the results of expanding oil and gas activities in the waters off the Lofoten and Vesterålen Islands and Senja. The analysis is based on the background reports for the updating of the present management plan, which include the Petroleum Directorate's estimates of oil and gas resources in the area and the report by the Forum on Environmental Risk Management.

In the Vista analysis a zero scenario under the current management regime, i.e. no petroleum activity at all, is compared with a scenario in which the whole area is opened for oil and gas activities. On the question of the economic benefits, Vista concluded that according to their calculations, oil and gas extraction in the sea areas concerned is likely to provide economic benefits as long as the discoveries are commercially viable. However, they point out that the figures on which they have based their calculations are both incomplete and uncertain; for example there are no reliable figures for the costs to the fisheries and aquaculture industry of a major oil spill. On the other hand, they see no reason to believe that such costs would have decisive effects on the results of the analysis, at any rate over the long term. According to Vista, the limitations of the knowledge base, in terms of both the volume of petroleum resources and the consequences of petroleum activities, particularly for the environment, indicate that there may be a not insignificant option value in delaying any decision on whether to open the area for petroleum activities. The Petroleum Directorate indicates in its report that the level of uncertainty with regard to the volume of petroleum resources could be reduced by further processing of the seismic data and by exploration drilling.

In the present context «economically beneficial» means that the present value of future revenues from oil and gas activities in the areas concerned will exceed the present value of the future costs of such activities, for Norway as a whole. A discount rate of 4 % was used in the analyses. Vista also tested the robustness of the results by varying the discount rate and other assumptions in the calculations. The benefits are to some extent influenced by the discount rate used, but most strongly by assumptions about the volume and market value of oil and gas. The present value was found to be positive in all cases.

The following is a more detailed discussion of the analysis.

Vista Analysis has based its calculations on the Petroleum Directorate's estimates of the recoverable petroleum resources in 50 prospects in the areas Nordland VI, Nordland VII and Troms II. The projected present value of the benefits (the resource rent, i.e. the return in excess of the compensation for factor inputs such as labour and capital) of the development as a whole is approximately NOK 105 billion. The sample space is NOK –7 to NOK +650 billion, where a negative present value indicates a complete absence of commercially viable discoveries. The highest figure corresponds to a wild-card scenario at the limit of the range of uncertainty for the distribution of resources, in which there are large volumes of petroleum resources divided between a small number of large discoveries.

The analysis also includes an estimate of the present value of production partly or wholly based on ecosystem services from the sea area, such as fisheries, aquaculture and tourism. However, while it is simple in the analysis to assume that the present value of petroleum resources is zero in a zero scenario, it is more difficult to estimate the present value of future revenue flows from other industries. The resource rent for the fisheries and aquaculture industries is at present relatively low. The calculated present value of the resource rent for these industries varies from NOK 3 billion, assuming that the profitability of the industries continues at the same level as in 2004, to approximately NOK 48 billion. Vista has based these estimates on the SNF report, which is discussed in section 4.9.4. The high estimate assumes remission of customs duties in export markets, doubled production in the aquaculture industry and structural measures in the coastal and ocean-going fishing fleets.

Tourism in the Lofoten and Vesterålen Islands is almost entirely based on enjoyment of the natural environment. The profitability of the industry is low, due partly to the short summer season, and in many cases tourism is a subsidiary occupation. Vista was not able to find a basis for calculating the present value of tourism in a zero scenario without petroleum activities, but writes that tourism is likely to grow in the coming years. The report also discusses the shipping and petroleum-based industries and possible new commercial activities based on marine bioprospecting, but has not attempted to estimate the present value in a zero scenario.

The discussion of ecosystem services, apart from provisioning services such as those that underpin fisheries and aquaculture, is mainly based on the Sweco report, which is discussed in section 4.9.2 below. Vista points out that there are no figures for the value of the ecosystem services in the Barents Sea–Lofoten area and no reliable estimates from other areas that are applicable.

In conclusion, Vista states that it is not possible to calculate the present value of the zero scenario, since the background reports do not provide sufficient information for valuing the economic benefits of the relevant industries and the ecosystem services provided by the sea area. However, they do not consider this to be essential to the analysis. They state that it is more important to focus on changes in the benefits provided by other industries and of ecosystem services that are not traded in markets in areas that are opened for petroleum activities.

With regard to the petroleum development scenario, Vista writes that the costs of normal operations, without oil spills, in the form of inconvenience to other industries and environmental impacts, are marginal compared with the projected resource rent from petroleum activities. In support of this view they cite the strict environmental standards imposed on petroleum activities, such as the requirement of zero discharges to the sea during normal operations. This means that the uncertainty attached to the economic benefits is related to the possibility of oil spills.

Vista's general conclusion is that fisheries and aquaculture will be able to coexist with petroleum activities during normal operations. The potential areas of conflict identified in the analysis are seismic shooting, occupation of areas and competition over labour. With regard to the fisheries, conflicts over the use of an area would mainly affect the coastal fishing fleet and fish farms. Vista found no evidence of the extent to which the occupation of areas by petroleum activities would affect fish farms, but writes that conflicts of interest over the occupation of areas could probably be avoided by taking this into account when deciding on locations.

Petroleum activities may have both positive and negative effects on travel and tourism in the form of an increase in business travel on the one hand and a reduction in holiday travel on the other.

Vista refers to the study of spin-off effects by Asplan Viak and the Nordland Research Institute (which is discussed in section 4.9.3 below), but considers that this type of analysis is not suitable for estimating the effect of petroleum activities on total employment or value creation in Norway and should be used with caution when calculating economic benefits. However, Vista considers that given the Norwegian regional policy goal of creating jobs in North Norway, analyses of spin-off effects are useful for estimating the activities generated by a particular measure.

With regard to the effect on the labour market, Vista refers to the SNF report (discussed in section 4.9.4 below), which indicates that petroleum activities would not put so much pressure on labour markets that they would displace fisheries and fish-farming. According to the report, the reason is that the extra need for labour is likely to be supplied by commuting, net immigration from southern Norway and abroad, and increased labour force participation. However, in Vista's view, the possibility that increased activity in the area would promote a more rapid restructuring by attracting labour away from the fisheries cannot be excluded.

With regard to acute pollution, calculations of the net economic impacts depend on the probability of different types of incidents occurring combined with the expected costs of each type. Vista states that a major incident could have high costs but that the risk is low, because it is calculated as the product of the probability that the incident will occur and the estimated costs of such an incident.

Vista has calculated the probability of the different categories of spills for the period 2012–2080 on the basis of frequencies derived from historical data (discussed in Chapter 5.1.2 in the present report). They point out that even though the probability of a spill is higher for several fields on stream than for one field on stream, experience shows that the relationship is non-linear. They state that where they have over-estimated the probability, this is defensible from the precautionary point of view. The precautionary principle, which is a fundamental principle of the management plan, is linked with risk aversion, irreversible effects and uncertainty that declines over time (i.e. the option value of acquiring new information). Vista concludes that in this context one possible way of applying the precautionary principle would be to give extra weight to the risk of acute pollution from petroleum activities.

Vista also discusses the possible costs of acute pollution from petroleum activities. Their assessment is based on the report by the Forum on Environmental Risk Management, and includes the cost of cleanup and the costs to the fisheries, fish farms and tourism.

Vista states that it is difficult to estimate the values of the various ecosystem services in the Barents Sea that are not reflected in market prices, and to predict the possible changes in these values in the development scenario. As mentioned above, they consider that these values cannot be estimated on the basis of our current knowledge. In some cases surveys of people's willingness to pay to maintain an undisturbed area of natural environment have been conducted. Vista writes that there is reason to believe that the Norwegian population exhibits a positive willingness to pay to avoid a major oil spill in the Barents Sea–Lofoten area, but that it is not possible to make a quantitative estimate of this on the basis of the background reports or other studies. They therefore recommend an implicit calculation of this «non-use value», in other words a calculation of what the value must be in order for total willingness to pay to exceed the expected net oil revenues minus other quantified cost components. Vista estimates the amount at a lump sum of NOK 18 000–275 000 per Norwegian household, depending on the estimated net present value.

4.9.2 Marine ecosystem services in the Barents Sea–Lofoten area

The ecosystems in the management plan area and their current state are described in Chapter 3. The benefits we obtain from ecosystems and our dependence on them can be expressed in the form of the wide range of ecosystem services we enjoy. In Sweco's report on marine ecosystem services in the Barents Sea–Lofoten area, the classification of these benefits, or ecosystem services, into four types is used:

- Supporting services, such as maintenance of biodiversity and primary production, which are necessary for the production of all other ecosystem services.
- Regulating services, such as climate regulation and water purification.
- Provisioning services, which are the products obtained from ecosystems, such as fish, shellfish and energy sources, and genetic resources that provide a basis for the pharmaceutical and biotechnology industries.
- Cultural services, which provide non-material benefits in the form of recreation, aesthetic experience and a sense of place and identity.

The classification was used in the 2005 Millennium Ecosystem Assessment and in the Economics of Ecosystems and Biodiversity (TEEB) study.

Sweco states that although ecosystem services are essential for our well-being and quality of life, most of them are public goods that are not traded in markets and therefore do not have a market price. They point out that in recent years many attempts have been made to describe and classify these types of goods and services and in some cases to assign an economic value to them, in order to be able to include them in economic analyses and enhance their visibility in decision-making processes. However, this applies more to terrestrial than to marine ecosystems.

Sweco makes use of an approach used in the TEEB study to describe the interactions between ecosystems and society. Ecosystems produce services that contribute in various ways to human well-being, in some cases in the form of market products but often outside markets. The TEEB approach shows how many human activities, such as land use change, pollution and harvesting of resources, act as drivers of change, affecting ecosystems and altering the services they produce, which in turn has impacts on human well-being.

Market prices can be found for some provisioning services, for example oil and gas or fish and shellfish. Sweco cites figures for the economic value of some of these services, but has chosen to focus on describing and evaluating marine ecosystem services that are normally *not* described or assigned an economic value. They have therefore devoted less space to describing commercial goods, and in this connection refer to other background reports. Most of the other provisioning services have option values related to their future use. These include genetic and other biological resources of use to the pharmaceutical, chemical and biotechnological industries that cannot at present be given an economic value.

The value of some cultural services, such as recreation and aesthetic value, can be indicated to some extent by market prices, for example in figures for the tourist industry, and Sweco cites production figures for tourism in the Lofoten and Vesterålen Islands. However, production expressed in economic terms cannot convey the whole range of the recreational value. Sweco points out that important values such as aesthetic value, cultural heritage, the sense of identity and the value of ensuring that future generations can continue to enjoy the benefits of the sea and its ecosystems are difficult to measure in monetary terms.

Willingness to pay for ecosystem services that are not traded in markets can be investigated by questionnaire surveys or more indirect methods. Sweco cites the estimated recreational value of sports fishing in the three northernmost counties, but not for the Lofoten and Vesterålen Islands specifically. They also reviewtional and international literature on estimating for example recreational value and the value of avoiding oil spills and highly visible installations, but none of these studies are directly linked to the management plan area.

The regulating ecosystem services do not have any direct market value either, but their value can sometimes be assessed by estimating the avoided costs represented by these services. The value of CO_2 uptake by the sea can for example be calculated on the basis of the future price of emission allowances. However, Sweco points out that the capacity of a particular regulating service may be limited.

Box 4.5 Examples of ecosystem services that are not currently traded in markets

Examples of provisioning services with a value for the pharmaceutical, chemical and biotechnological industries: A number of algae extracts have been shown to induce programmed cell death in liver and leukaemia cells, which is likely to be useful in the fight against cancer. Chitosan, which is produced from shrimp and crab shells, has a potential as a replacement for impregnating agents that contain heavy metals. An enzyme from cod liver has many different uses in gene technology. The newly established MabCent-SFI Centre for Research-based Innovation in Tromsø does research in the field of marine bioprospecting, with a focus on molecules and genetic material from benthic animals that can be used in products with a beneficial effect on health. Marine bioprospecting is another field with a great untapped potential.

Examples of regulating services – CO_2 buffering capacity of the oceans: Ocean ecosystems are involved in climate regulation, producing oxygen we need for breathable air and moderating global warming. Carbon enters the oceans from the atmosphere when the greenhouse gas CO_2 dissolves in seawater, making the carbon available to marine organisms. When such organisms die, they sink to the seabed where the detritus is deposited, so that marine ecosystems function as a carbon sink. As the atmospheric CO_2 concentration rises, so does carbon uptake by the oceans, and the seawater becomes more acidic (carbonic acid forms). This reduces the concentration of carbonate, which is necessary for many organisms that build calcium shells and skeletons (plankton, corals, molluscs, crustaceans) and indirectly for animals that feed on them – fish, birds and mammals.

Examples of supporting ecosystem services – the waters off the Lofoten Islands are a spawning ground for large fish stocks: The Barents Sea–Lofoten area, especially the areas off the Lofoten and Vesterålen Islands, includes some of the richest spawning and nursery areas for fish in the world. This is an example of a supporting ecosystem service that is fundamental to the existence of harvestable stocks. For example, the world's only well-managed cod stock has its spawning ground in these waters.

The economic value of the supporting ecosystem services lies primarily in the fact that they are necessary for the production of all the other ecosystem services that contribute more directly to our well-being.

Thus there are no primary studies that have attempted to assign values to ecosystem services provided by the Barents Sea that are not traded in markets. Sweco writes that if the value of these services is to be measured in monetary terms, we will have to either conduct specific studies for the Barents Sea or extrapolate the economic values from existing studies of other sea areas, which will result in a higher level of uncertainty.

Sweco concludes that there are considerable gaps in our knowledge of the natural resource base; interactions between species, physical and chemical factors in the ecosystem; the services provided by marine ecosystems, both now and in the future; and methods of economic valuation. They conclude that in cases where there is a high level of uncertainty regarding the probability of possible outcomes or consequences of a particular development or project, in cases where we do not know all the possible outcomes and in cases where certain outcomes would have irreversible impacts, decisions should to a large extent be based on principles other than economic valuation or economic analyses. These include ethical considerations such as the precautionary principle and the principle of establishing safe minimum standards for ecosystem services as long as the costs are not unacceptably high.

Sweco has not examined the extent to which ecosystem services are affected and potentially degraded by activities in the management plan area. This is discussed in detail in other background reports, notably that of Vista Analysis (see section 4.9.1).

4.9.3 Local and regional spin-off effects of future expansion of oil and gas activities

In cooperation with the Nordland Research Institute, Asplan Viak calculated the possible spin-off effects on land of oil and gas activities in the management plan area as part of the background material for the updating of the plan. The study, which includes both opened and unopened areas, estimates the expected employment effects of development of fields of different sizes, in different ways and at different locations.

The study is based on the Petroleum Directorate's Resource Report 2009, which in turn is based on a resource scenario developed by the Directorate. The scenario includes the sea area from the coastal zone in the Norwegian Sea up to and including opened areas in the southern part of the Barents Sea. It is described in more detail in section 4.3.4.

The study analyses spin-off effects in two large regions:

– Nordland, southern Troms and central Troms
– Northern Troms and Finnmark

The scenario in the Asplan Viak analysis comprises four oil discoveries (including the Goliat field) that would be offshore developments, and five gas discoveries where the gas would be piped ashore for processing on Melkøya, all in the southern part of the Barents Sea (northern Troms and Finnmark). Off the Lofoten and Vesterålen Islands and Troms, a further three oil discoveries were postulated, two of which would have offshore processing plants, while the oil from the third would be processed on land. A further five gas discoveries were postulated, where the gas would be processed at a new LNG plant on land.

For the purposes of the analysis, assumptions were made concerning the goods and services required for the petroleum activities that the two regions would be able to supply.

Asplan Viak estimates that development of the fields could provide increased employment in North Norway of between 4 000 and 6 000 full-time jobs from 2016 to 2043. Until 2016 employment would gradually rise, while after 2043 it would gradually decline.

According to these estimates, the greatest activity will take place in the more northerly of the two regions, mainly because greater resources are expected to be found in the sea areas bordering on this region. According to the report, further development of Snøhvit would give the region a peak in employment of almost 2 800 jobs in the development phase and well over 1 000 new jobs when the field comes on stream. A large proportion of these employees are expected to come from northern Troms and Finnmark. On the other hand, business activities in the southerly region will be more diversified and more petroleum-related, which means that more businesses will be able to obtain contracts with the oil and gas industry.

In the period up to 2050 an average of about one-quarter of new jobs will be accounted for by the oil and gas industry and almost one-quarter by the transport, storage and supply sectors. The most important industries in the remaining half will be business services and the retail and hotel and restaurant sectors. This diversity will provide a broad business and employment base in the region, especially in the private sector. According to the study, this could counteract the emigration of young people from the region during this period, and in some areas it could also curb the negative trend in the age structure.

The resource estimate in the Asplan Viak study is markedly lower than the figure for recoverable resources in the Petroleum Directorate's resource accounts. Furthermore, areas such as Jan Mayen and the previously disputed area are not included. The Petroleum Directorate's resource estimate for the Barents Sea is almost three times as large as the resource base used for the spin-off report. The spin-off effect on employment in North Norway may therefore be greater than the 4 000–6 000 jobs estimated by Asplan Viak.

For the unopened areas off the Lofoten and Vesterålen Islands and Senja, Asplan Viak has calculated the effects for the development of each field. The employment effect depends on the size of the discovery and whether or not the oil or gas is to be processed on shore. For example, development of an oilfield with recoverable resources of 35 million Sm^3 o.e. in Nordland VI, with offshore production, is estimated to generate around 800 jobs in Nordland, southern Troms and central Troms during the development phase and over 300 when it is on stream. If in addition the gas fields in Nordland VII and Troms II, with their recoverable resources of 100 million Sm^3 o.e., are developed, with processing at a land-based plant, this could generate a total of 3 000 to 4 000 jobs during the development phase and 1 300 in the operational phase in Nordland, southern Troms and central Troms. For North Norway as a whole the figures could be higher.

In comparison, the Petroleum Directorate has estimated on the basis of its resource surveys that the resources in the sea areas off the Lofoten and Vesterålen Islands and Senja amount to 202 million Sm^3 o.e., with a range of uncertainty of 76–371 million Sm^3 o.e. Since the number of jobs will depend on the size of the discoveries and whether they are commercially viable, the spin-off effects may be larger or smaller than those indicated in the Asplan Viak study.

Asplan Viak considers it unlikely that the extent and diversity of the effects will displace other industries such as fisheries or tourism. Tourism is expected to have an international labour market and the qualifications required are different from those in petroleum-related activities. Nor do they expect the fisheries to be threatened by competition over labour in the long term. The fisheries are competitive in terms of wages and will also be able to recruit labour from outside the region.

4.9.4 Economic importance of fishing and aquaculture in the Barents Sea–Lofoten area

SNF, Institute for Research in Economics and Business Administration, has conducted a study of the economic importance of fisheries and aquaculture activities in the management plan area from a long-term perspective. Numerical models were used to calculate the effects of different assumptions on factors such as production value, material inputs, value added, employment and resource rent. Indirect spin-off effects were not included in the analysis. In addition SNF estimated some of the impacts of new petroleum activities on certain fisheries and aquaculture activities.

The study was limited to the coastal and marine areas in the management plan area. It was based on the fishery resources that Norway has access to in this area (measured as the size of Norwegian catches and farmed quantities), and the fish are followed from catch or farm to market. 2004 was used as the base year for catch sizes and quotas, and was kept constant in all the calculations. Catches by foreign fishing vessels were not included in the calculations. When calculating the value of the Norwegian resources, no account was taken of where the vessels were registered or where the fish was processed.

Calculations were made using different assumptions for the customs regime, growth in aquaculture and the structure of the fishing fleet. The assumptions were not based on political goals but were intended to explore a range of theoretical possibilities over the very long term.

The present value of the production value (using a discount rate of 4 %) for most of the scenarios was found to range from NOK 277 billion to NOK 372 billion. In most cases the present value of the resource rent was estimated at between NOK 3 billion and NOK 48 billion. The resource rent is the main indicator of profitability for the fisheries, and is defined as the return on labour and capital in excess of what would be normal in other industries, based on the utilisation of a limited natural resource. The resource rent was found to be positive but relatively low.

Employment in 2004 is estimated at just over 11 000 person-years, which amounts to 0.5 % of total employment in Norway and around 5 % of employment in North Norway. The figure includes employment in the fisheries, in aquaculture and in the processing of fish resources in the management plan area. The analysis showed that taken in isolation, growth in the aquaculture industry will increase employment in both primary production and fish processing. Over the long term a doubling of aquaculture production will generate growth in total employment of 1 000 person-years. On the other hand, restructuring the industry within the framework of current management policy would over the long term reduce employment by around 2 000 person-years. The combined effect of the two scenarios would thus result in a reduction of around 1 000 person-years. Given the size of current fisheries quotas, any increase in fisheries-based employment in the region will come primarily from growth in the aquaculture industry.

Potential displacement and synergy effects of oil and gas activities

SNF found no definite evidence that oil and gas activities would put so much pressure on the labour market that they would displace fisheries and aquaculture activities in the management plan area as a whole. According to estimates by Asplan Viak and the Nordland Research Institute, oil- and gas-related growth in employment would be low in relation to both total employment and other important industries in the region. The growth in employment would also be spread over several different segments of the labour market, with clear differences in qualifications and wage levels.

SNF also considers it probable that any extra need for labour could be met by a combination of commuting, net immigration from southern Norway, increased labour force participation and immigration from neighbouring countries, and that this will prevent pressure on the labour market. If increased oil and gas activities in North Norway were to put pressure on the labour market, SNF considers it unlikely that this would reduce production or utilisation of fisheries and aquaculture resources. However, increased petroleum activities could step up the pace of restructuring of the fishing fleet by providing higher wages, and in the fish processing industry this could lead to less work-intensive processing.

The demand for goods and services by the oil and gas and the fishing and aquaculture sectors will to some extent be met by the same business sectors. This applies particularly to transport, storage, and the manufacture of machinery and maritime equipment, but also to retail and insurance. Establishment costs are normally low in these industries, which means that over time they are likely to show considerable flexibility and competitiveness. There is therefore no reason to conclude that increased demand from the oil and gas industry will entail higher costs for the fisheries and aquaculture sector.

The oil and gas industry will also require public services that are public goods in the sense that their consumption by one industry will not reduce the service available to other industries. The services will mainly consist of infrastructure such as roads and quays. In a broader context these services also make a particular area attractive to live in. This is an example of a positive synergy effect of oil and gas activities that will also benefit the fisheries and aquaculture sector. SNF did not examine issues related to competition over the use of areas, seismic surveys, etc.

Economic consequences of oil spills – impacts on fish stocks

One of the consequences of a major oil spill is that it reduces the future production potential by causing the loss of fish eggs and larvae. SNF used existing estimates of the economic costs for cod and herring stocks, and calculated the dispersal of fish larvae and hydrocarbons in sea water on the basis of estimates by DNV.

Recruitment to the stock in the year an oil spill occurs is a crucial factor in determining the impacts of the spill. In the case of a medium-sized year class of cod, a 50-day spill of 4 500 tonnes oil per day would result in an accumulated reduction in catches over 15 years of 0.57 % of the total catch if there had been no spill (corresponding to NOK 1.17 billion over 15 years, based on the 2007 price level). The corresponding figures for herring are 1.13 % of the catch and NOK 0.5 billion.

In a worst-case scenario based on DNV estimates (strong recruitment in the year of the spill) the accumulated reduction in catches of cod over 15 years is estimated at 4 % of the total catch without a spill. This corresponds to almost NOK 8.5 billion for the whole period, based on the 2007 price level. For herring the accumulated reduction would be 1 600 000 tonnes in the worst-case scenario, which is almost NOK 4 billion in accumulated value over 15 years.

Potential effects of oil and gas activities on seafood reputation

Citing the experience of previous oil spills (*Exxon Valdez, Prestige, Braer*) and products that have received negative publicity over a period of time, SNF discusses whether long-term negative effects on the reputation of seafood (after coastal and marine areas have been cleaned up or during normal petroleum operations) have been observed in the form of lower prices. Most experience of oil spills has shown that for a short period it is difficult to sell products from the area, including obviously non-contaminated products, and even products from other industries with connections to the area. However, no clear impacts on prices have been found over the long term.

5 Trends in the risk of acute pollution, and preparedness and response to acute pollution

It is a government objective to keep the risk of environmental damage from acute pollution at a low level in the Barents Sea–Lofoten area, and to make continuous efforts to reduce it further. To this end, preventive maritime safety measures and oil spill preparedness and response will be designed and dimensioned to effectively keep the risk of damage to the environment and living marine resources at a low level.

Risk is defined as a combination of the probability of an event occurring as a result of human activity and the consequences of that event, taking uncertainties into account. Thus risk is not a description of an actual event but of the possibility that an event may occur, and is therefore always associated with some degree of uncertainty. One of the primary aims of risk assessment is to identify uncertainties so that they can be addressed as far as possible and accidents and damage can be avoided. Trends in the risk level associated with acute pollution (the risk of spills) from maritime traffic, oil and gas activities and releases of radioactivity in the management plan area are discussed in section 5.1.

Environmental risk expresses the probability of a spill of oil or other environmentally hazardous substances combined with the scale of the expected environmental damage, taking uncertainties into account. The environmental risk level is assessed by combining the risk of acute pollution with the influence area and the presence of vulnerable species and habitats.

The environmental risk associated with acute pollution depends on a number of factors. The most important of these are the probability of a spill, the magnitude of a particular spill, its geographical position in relation to vulnerable areas and resources, when it occurs in relation to periods when vulnerability to pollution is particularly high and the spill trajectory. The effectiveness of preventive measures and of preparedness and response to acute pollution, is another important factor.

The authorities have conducted new environmental risk assessments for oil spills from petroleum activities off the Lofoten and Vesterålen Islands and Senja. These are discussed in section 5.2.

No new environmental risk assessments have been conducted for other parts of the management plan area. Since the environmental consequences depend considerably on the location of the spill, conclusions drawn from the specific spills and locations that have been analysed cannot be generalised to the whole management plan area. This means that there may be local, area-specific consequences of different types of spills that have not been analysed. However, assessments of the probability of a spill, the causal mechanisms, and the measures to prevent and/or limit the volume released are generally applicable to the whole of the management plan area. For example all the areas that have been identified by the Petroleum Directorate as possible fields in 2030 have been included in the risk assessments conducted so far.

No new comprehensive environmental risk analyses of maritime traffic have been conducted for the management plan area as a whole, but the Norwegian Coastal Administration has started work on an updated environmental risk analysis for maritime traffic along the coast of mainland Norway.

The Forum on Environmental Risk Management, which is headed by the Coastal Administration and has representatives from the Climate and Pollution Agency, the Petroleum Safety Authority Norway, the Institute of Marine Research, the Directorate for Nature Management and the Petroleum Directorate, has reviewed the preliminary lessons learned from the Deepwater Horizon oil spill in the Gulf of Mexico and assessed how far they are relevant to the present update of the management plan. The Forum's report was submitted on 29 November 2010. Preparedness and response to acute pollution is discussed in section 5.3.

5.1 Trends in risk level in the management plan area

The level of activity in the Barents Sea–Lofoten area is relatively low, and the probability of acute pollution from shipping and petroleum activities is still considered to be low. However, collation of data on acute pollution incidents involving the petroleum industry on the Norwegian continental shelf with various activity indicators shows that there is no direct linear relationship between activity level and the number or severity of spills. The influence of activity level on the level of risk should not be overestimated.

In addition to the risk of acute oil and chemical pollution, there is a risk of accidents in connection with the transport of radioactive material through the management plan area.

5.1.1 Maritime traffic

The size of the tankers in transit through the management plan area increased substantially during the period 2005–09, but there were no significant changes in the overall volume of maritime traffic in the area during this period. Projections for the area indicate a small increase (about 3 %) in the total distance sailed in the period 2008–25 and a general increase in the distance sailed for most types of ships, with a marked increase for large oil and gas tankers. For fishing vessels, on the other hand, a decrease in distance sailed is expected. Trends in maritime traffic are discussed in more detail in Chapter 4.2.1.

DNV was commissioned by the Norwegian Coastal Administration to analyse the probability of acute pollution from shipping along the Norwegian coast, on the basis of traffic data from 2008 and projections for 2025. DNV concluded that the estimated increase in the volume of Russian traffic, combined with the increase in Norwegian exports of petroleum from the High North, means that there will be a marked rise in the probability of a spill up to 2025 along most of the coast of Nordland, Troms and Finnmark. Unless further maritime safety measures are introduced, the increase in tanker traffic will increase the probability of a major accident in this area. However, at present the probability of a spill is low, owing to the relatively low level of activity and the introduction of effective maritime safety measures, which are currently being extended to areas south of the Lofoten Islands.

There has only been one incident in the management plan area since 2005 that has resulted in acute pollution. This was in May 2009, when the Russian reefer ship *Petrozavodsk* ran aground on the southeastern shore of Bjørnøya. The ship had about 50 m^3 marine diesel on board, much of which leaked into the sea. In the period 2005–09, the average number of ship-related incidents of acute pollution in Norwegian waters was around 90 per year, most of them involving small spills.

The environmental risk associated with maritime transport can be reduced by preventive measures or measures to reduce the consequences. Cleaning up after an oil spill is time-consuming and resource-intensive. It is more cost-effective to prevent accidents, not only to avoid loss of life but also to protect society and the environment from pollution.

Since 2005, a number of steps have been taken to improve maritime safety (see Box 5.1), which have considerably reduced the probability of accidents. The most important measures – the traffic separation schemes between Vardø and Røst, the Vardø vessel traffic service centre (Vardø VTS Centre), and the emergency tugboat services – are described below. Together they have considerably reduced the probability of two types of accidents, collisions and groundings.

With the approval of the International Maritime Organization (IMO), traffic separation schemes were established on 1 July 2007 between Vardø and Røst in the Norwegian exclusive economic zone. Under these schemes, tankers of all sizes and other cargo ships of gross tonnage 5 000 and over are required to sail about 30 nautical miles from land. There are two traffic lanes for shipping in opposite directions. Routeing high-risk traffic further away from the coast reduces the probability of accidents and acute pollution. The authorities have more time to intervene and provide assistance to ships in trouble, and the possibility of avoiding accidents is greater. The traffic separation schemes also reinforces the effects of other maritime safety and oil spill response measures.

The Vardø VTS Centre was established in 2007. It monitors all tankers and other high-risk traffic along the entire Norwegian coast, and whether vessels are complying with the rules of the routeing system. If the VTS Centre observes irregularities, it calls up the vessel, guides it onto the right route, and if necessary summons assistance.

The emergency tugboat services in Norway are in principle based on the availability of private actors. However, in North Norway it has been further developed, and the state has hired three all-

Box 5.1 Measures implemented since 2005 to improve maritime safety

- The Automatic Identification System (AIS) for ships (information, tracking and collision prevention) has been introduced. It is estimated that the system has reduced the risk of collisions by 20 %.
- Satellite-based monitoring of sea areas has been further developed.
- The Vardø VTS Centre was established in 2007 and monitors high-risk traffic along the entire Norwegian coast, including Svalbard.
- The traffic separation schemes between Vardø and Røst were established in 2007.
- The emergency tugboat services have been further developed and three new tugboats have been hired on short-term contracts.
- The new Act relating to ports and navigable waters entered into force in 2010. It applies in Svalbard, and the earlier Harbour Act was made applicable to Svalbard in 2008 in regulations.
- The Norwegian Coastal Administration has developed a procedure for coordinating the actions of the authorities in situations where a vessel needs to be brought to a port of refuge. A prior assessment of suitable geographical areas has been made.
- To limit the damage in the event of a spill, a provision was introduced in 2007 forbidding ships calling at the nature reserves in eastern Svalbard from carrying or using any fuel other than light marine diesel. Since 1 January 2010 a corresponding provision has applied in the three large national parks in western Svalbard as well. A temporary exception until 2015 has been made for the approach to Ny-Ålesund and the Magdalenefjorden.

year tugboats on short-term contracts, which are at the disposal of the Vardø VTS Centre. The Centre deploys them according to the risk picture, and they can be deployed rapidly to ships that are drifting out of control to prevent grounding, which would cause acute pollution.

Since the most cost-effective measures have already been introduced, there are few additional measures that would further reduce the probability of a spill from shipping up to 2025.

5.1.2 Petroleum activities

The level of petroleum activity in the management plan area is currently low, with one gas field (Snøhvit) on stream and one oil field (Goliat) under development. At present, the risk of accidents and the probability of oil spills from the petroleum industry are low.

Trends in the probability of oil spills

The trends in the risk level between 2005 and 2010 have been assessed on the basis of:

- spills and near misses that could have resulted in acute pollution if the barriers had failed, given the amount of petroleum activity in the management plan area;
- corresponding data from the rest of the Norwegian continental shelf, since this provides an overall picture of the industry's ability to prevent oil spills;
- factors that influence the risk level, such as geographical location and trends in the types and scale of activities;
- the extent to which risk-reducing measures have been implemented.

Since there have been few large oil spills on the Norwegian continental shelf, experience is limited. The risk of accidents in connection with petroleum activities has been assessed on the basis of historical data for different types of spills and a set of assumptions to estimate the frequencies of spills for different development concepts and exploration drilling. The historical data often consist of national and international statistics, which frequently vary in quality and volume and may not be representative of the specific circumstances for each area, field, installation, operator, well, vessel, etc. It is also obvious that historical data are only to a limited degree representative of what may happen in the future. Thus, the calculated frequencies do not indicate how often an accident will occur in the future and/or how serious it will be, only how often the various types of accident have occurred in the past.

Comparing the historical frequencies of spills from different development concepts shows that a small spill is much more probable (has a shorter recurrence interval) than a large one. The frequency of spills is also highest for the smallest

Table 5.1 Recurrence intervals (number of years between spills) for spills from exploration drilling and fields on stream (floating production, storage and offloading units (FPSOs), and seabed installations)

Activity and spill volume	FPSOs, on stream	Exploration drilling (one oil well per year)	Seabed installations, on stream
1–1 000 tonnes	8.7	327	437
1 000–2 000 tonnes	974	12 821	1 296
2 000–20 000 tonnes	363	10 246	772
20 000–100 000 tonnes	6 321	69 444	12 516
> 100 000 tonnes	15 576	62 500	16 892

Source: Ministry of Labour/Ministry of Petroleum and Energy

spills within the category 1–1 000 tonnes. In Table 5.1 the frequencies of incidents of all types involving spills have been combined and expressed as average recurrence intervals (number of years between spills) for fields on stream (floating production, storage and offloading units (FPSOs), and seabed installations) and for exploration drilling.

Oil and gas activities in the management plan area have not resulted in acute pollution of any significance during the period since the management plan was adopted. In 2008 a near miss occurred during exploration drilling that could have resulted in an oil spill if the barriers had failed.

The annual reports on trends in risk level published by the Petroleum Safety Authority Norway are an important tool for monitoring the development of risk levels in Norwegian petroleum activities. Since 2000 comprehensive data on accidents and unintended incidents in connection with oil and gas activities has been collected as part of this process. Up to the present, the data have been used to assess trends in risk levels for accidents to personnel and major accidents. In 2009 work was begun on the use of these data together with data from another established database (Environment Web) to monitor trends in the risk level for oil spills on the Norwegian continental shelf. This will provide a better basis for implementing preventive measures in areas where they will be most effective.

Together with the petroleum companies' annual reports to the Climate and Pollution Agency on releases of oil and chemicals, the reports on trends in risk levels provide a good picture of developments on the Norwegian shelf. The risk data for 2001–09 and data from the Climate and Pollution Agency show that:

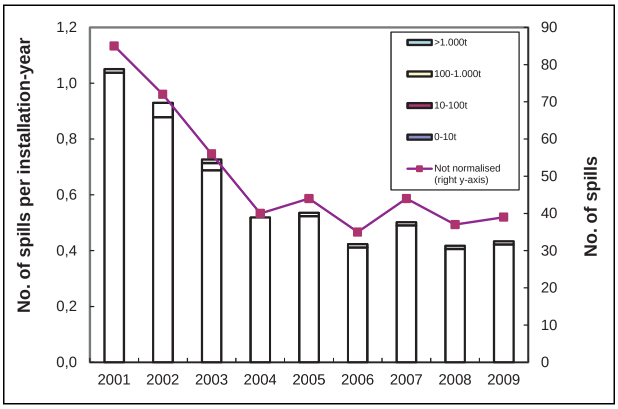

Figure 5.1 Spills of crude oil to the sea on the Norwegian continental shelf in 2001–09

Source: Petroleum Safety Authority Norway

- The total number of crude oil spills to the sea on the Norwegian shelf was more than halved in the period 2001–04 (from 85 to 40), and remained constant in the period 2004–09 (39 spills in 2009) (see Figure 5.1).
- There was no clear trend in the size of crude oil spills in the period 2001–09 on the Norwegian shelf as a whole, but most of them were smaller than 1 tonne. Four of the largest spills on the Norwegian shelf in the period 2001–09 occurred during the five years prior to 2009. In 2007 there was a single spill of around 3 700 tonnes.
- The number of near misses that could have led to spills on the Norwegian continental shelf declined throughout the period 2001–09, and the number of near misses per installation year in 2009 was the lowest for the whole period (see Figure 5.2).

- Well control incidents and hydrocarbon leaks were less serious in 2008 and 2009 than in the period 2004–06, but after a generally positive trend in the last few years the number of near misses related to hydrocarbon leaks and well control incidents rose in 2009 for the Norwegian shelf as a whole.
- Data on the availability of barriers intended to prevent near misses from developing into major accidents show stable levels for the Norwegian shelf as a whole, but some installations have substantially lower availability of barriers than the average for the industry.

Risk levels 2010–30

The level of activity is not expected to increase significantly up to 2030, when both the Snøhvit and the Goliat fields will be on stream. On the basis of assessments of the future level of activity in the management plan area, the Petroleum Directorate has also included an oil field with FPSOs and 11 production wells on stream. The scenario for 2030 also has an oil field with subsea templates with 11 wells on stream tied to an onshore facility by a 70-km-long pipeline. The Directorate included typical activities involved in well drilling in its evaluation of risk levels. However, the scale, type, location and technical solutions for future oil and gas activities are naturally very uncertain.

The probability of acute pollution is not expected to change significantly up to 2030, provided that the necessary preventive measures are implemented. Five priority areas of particular importance for maintaining low risk levels have been identified: choice of development concept/installation and other technical solutions, the actors involved, framework conditions, pace of development and icing conditions.

Reservoir and depth conditions are not considered to be particularly difficult in the assessed parts of the management plan area and have not been dealt with specifically in the description of risk-reducing measures.

The technical and operational barriers against oil spills that are to be used for Goliat are examples of preventive measures and are described in the next section.

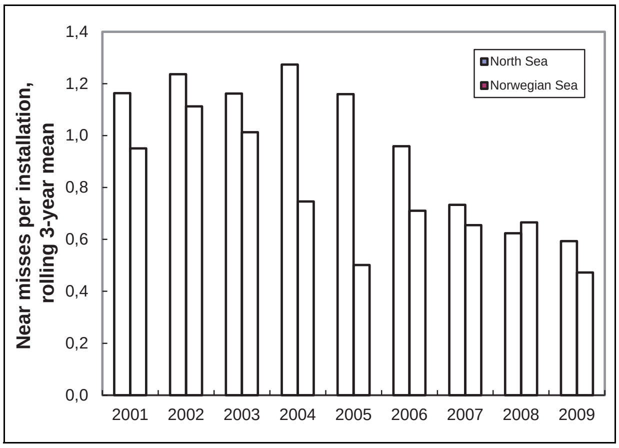

Figure 5.2 Number of near misses that could have caused a crude oil spill on the Norwegian continental shelf

Source: Petroleum Safety Authority Norway

Implementation of risk-reducing measures since 2006

A number of risk-reducing measures have been implemented since 2006 to maintain a low risk of accidents and further reduce the risk level. These include the measures implemented by the industry to prevent hydrocarbon leaks, maintain well integrity and improve chemicals management.

R&D projects have been begun or conducted on improving understanding of risk, adapting technology, planning and monitoring of operations, improving early detection of operational deviations, promoting more rapid and effective intervention, and improving access to essential information. R&D has also reduced the level of uncertainty for a number of factors that influence the risk level. For example several projects have been carried out to improve weather data and understanding of reservoirs and to provide a better overview of trends in the level of collision risk in relation to trends in maritime traffic.

The criteria for granting production licences have become stricter, so that only companies with operational experience and good financial capacity are eligible for difficult operations.

Cooperation between authorities in oil-producing countries has been strengthened and is resulting in transfers of experience, competence development and standardisation, all of which will reduce the probability of oil spills. A cooperation project under the Barents 2020 scheme has been established for petroleum activities in the High North. The project is headed by DNV and both Norwegian and Russian actors are involved. The aim is to identify the security challenges posed by oil and gas activities in the area, and recommendations will be made for HSE standards for oil and gas activities applicable to Norwegian and Russian operations in the Barents Sea.

The authorities should follow up petroleum companies closely in order to ensure sound management of the environmental risks inherent in oil and gas activities in the management plan area. For example, the plan for development and operation of the Goliat field contains an explicit description of site-specific factors that are considered to influence the risk of acute pollution and the measures that will be implemented to manage and reduce it. The technical and operational barriers used in this field to prevent acute pollution are considered to represent a minimum level for future developments in the area. The following are examples of such barriers:

– well design, including a hole diameter that will reduce the volume of potential seepage;
– well completion design with a life cycle that reduces the need for well interventions;
– well programme, including pilot wells and drilling sequence;
– robust design of well barriers, including dual safety valves in the wells;
– only one reservoir to be open at a time;
– decommissioning of all wells when the processing installation is decommissioned;
– robust design and materials adapted to expected weather and icing conditions;
– use of welded pipe joints to minimise leakage points;
– shutdown valves on the riser on the seabed;
– choice of materials, design and reliability of the subsea leak detection system.

Accident in the Gulf of Mexico and risk of blowouts

The Norwegian authorities are concerned about the accident in the Gulf of Mexico in 2010 and other similar accidents, particularly since the possibility of a major accident on the Norwegian continental shelf cannot be ruled out. The results and recommendations from investigations of the Deepwater Horizon accident are being followed up and evaluated by the different supervisory authorities in Norway, and also, as regards the assessment of environmental risk, across administrative boundaries. The authorities are giving priority to studies of the causes of the accident and the course of events, and are making active use of lessons learned from this accident in order to avoid similar incidents in Norway.

The Gulf of Mexico oil spill has resulted in a number of learning processes and improvements in Norwegian and international petroleum activities. One of the issues in focus is that of preparedness measures to halt blowouts at the source. At present drilling of a relief well is the only way of stopping a blowout if all other barriers have failed and cannot be repaired and if the blowout does not stop of its own accord (for example because the well has collapsed). In the Gulf of Mexico the blowout was finally stopped by technology developed by BP to cap the wellhead, cut off the oil stream and kill the well. In the light of this experience the Petroleum Safety Authority has requested the Norwegian petroleum industry to investigate emergency measures to deal with blowouts that are more effective than drilling a relief well. Work is also being done in this area internationally. For example four of the major companies in the Gulf of Mexico have undertaken to develop, within a short time frame, technology to stop blowouts at an earlier stage.

The accident resulted in many tragic consequences, including loss of life, but it has also succeeded in moving questions about the environmental impacts of major oil spills and the capacity of oil spill preparedness and response to a high place on the agenda at national and international level. The accident shows that the most effective response measures are to prevent oil spills from occurring and to limit the volume of hydrocarbons that can be released.

There are reliable figures for the period 1988–2007 for the numbers of wells drilled, blowouts and serious well incidents that could have led to a blowout if the barriers had failed for the North Sea (Norway, the Netherlands and the UK), and the US part of the Gulf of Mexico. The most widely recognised source of blowout data is the SINTEF Offshore Blowout Database. Its data show that 95 % of blowouts occurred and two-thirds of the wells were drilled (20 blowouts and 19 870 wells) in the US part of the Gulf of Mexico, while 5 % of blowouts occurred and one-third of the wells were drilled (1 blowout and 9 986 wells) in the North Sea. Thus, the ratio of blowouts to wells drilled has been significantly higher in the US part of the Gulf of Mexico than in the North Sea. Before the Deepwater Horizon accident in spring 2010, the Bravo blowout in the North Sea in spring 1977 was ranked as one of the largest offshore blowouts.

5.1.3 Radioactivity

The potential sources of releases of radioactive material in the management plan area today are connected with the transport of spent reactor fuel and with nuclear-powered vessels. There is also a possibility that floating nuclear power plants will be built in the Russian part of the Barents Sea, which will increase the risk of pollution. The Rus-

Box 5.2 Facts about the Gulf of Mexico oil spill

On 20 April 2010 an explosion occurred on the Deepwater Horizon drilling rig off the coast of Louisiana in the Gulf of Mexico, which resulted in a fire. The mobile offshore drilling unit was drilling on the Macondo Prospect at a depth of about 1 500 metres, about 80 km from the coast. The explosion killed 11 men and injured 17 others. The rig sank and this started a major oil spill that continued to flow until 15 July 2010.

The accident resulted in the largest marine oil spill ever recorded, amounting to an estimated total of almost 800 000 Sm^3 (4.9 million barrels, corresponding to approximately the volume carried by two supertankers) during the 87 days before the well was capped.

Extensive resources were deployed to contain, disperse and remove the oil and limit the damage. At its peak the response involved around 50 000 people and more than 8 000 vessels. Six months after the accident, more than 25 000 people were still engaged in the clean-up operation. About 900 km conventional booms and 3 000 absorbent booms were deployed, and approximately 7 000 m^3 dispersants were used altogether. About 1 040 km of the shoreline became covered in oil, 209 km of which was moderately to heavily polluted. In all, 8 183 oiled seabirds, 1 144 oiled sea turtles and 109 oiled marine mammals were found. At the worst almost 37 % of the US part of the Gulf was closed to all fishing. Although the area is being gradually re-opened, on 1 March 2011 a small area above the spill point was still closed.

Considering the size of the spill, the stretches of coastline that were seriously affected were relatively small. The surface temperature of the sea in the Gulf of Mexico is around 32 °C, and the high sea and air temperatures and strong sunshine had considerable consequences for the degree of weathering of the crude oil on the surface. Large quantities of oil were dispersed in the water column and did not reach the surface.

The first main report of the commission established by President Obama to investigate the accident was delivered on 11 January 2011. Some of the conclusions so far indicate that the accident could have been prevented. It has also been found that although the accident was not caused by external factors such as water depth or drilling conditions, these factors made it difficult to cope once the accident had happened. Weaknesses were identified in:

- organisation and follow-up by the authorities;
- the US regulatory approach and distribution of responsibility;
- the management's overall risk management system:
- the organisational safety culture.

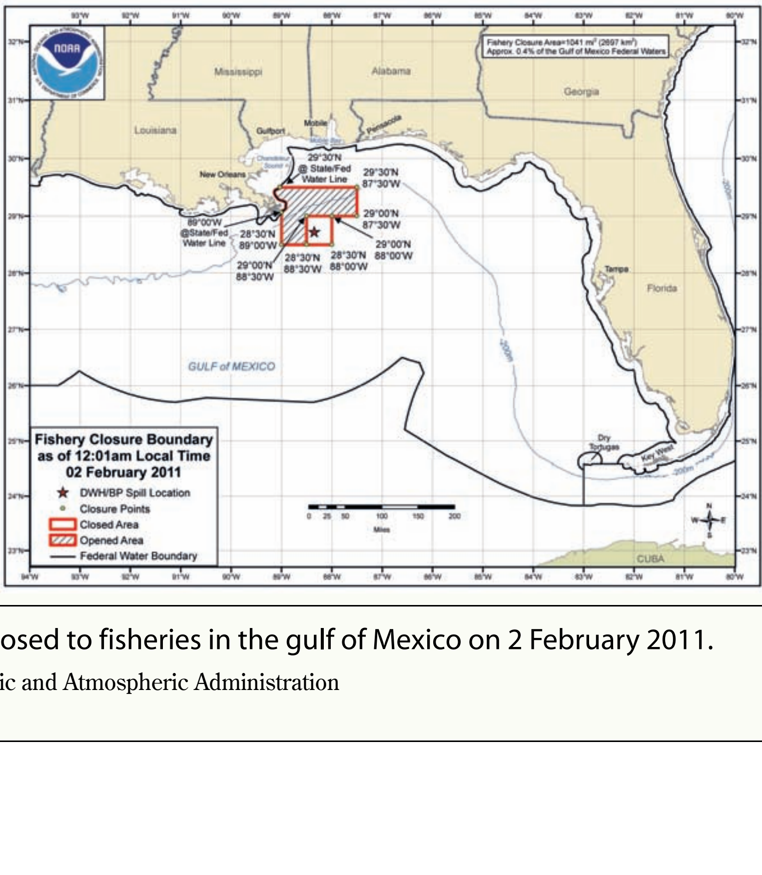

Figure 5.3 Areas closed to fisheries in the gulf of Mexico on 2 February 2011.

Source: National Oceanic and Atmospheric Administration

Box 5.3 Follow-up of the Gulf of Mexico oil spill in Norwegian safety work

The Petroleum Safety Authority Norway has established a project group to systematise and evaluate the experience and investigations of the Mexico oil spill. Many of the recommendations of the presidential Oil Spill Commission are already part of the Norwegian HSE system. However, the report also describes a number of conditions that are not unique to the US and that should be examined more closely to see whether they apply to the Norwegian petroleum industry.

The Petroleum Safety Authority's work has already had the following results:

- Priority is being given to analysis of factors related to well integrity, design and construction.
- The industry has been asked to evaluate its emergency response principles for stopping a subsea blowout and to examine the existing strategies for limiting damage until a blowout can be halted.
- The industry has been requested to examine alternative methods for killing wells (in addition to relief wells) in order to reduce or halt the oil stream.
- Stricter criteria for the awards of production licences have been applied from the 21st licensing round. For licence awards for deepwater and/or high pressure/high temperature (HPHT) areas, the operator and at least one other licensee are required to have experience of drilling at least one well on the Norwegian continental shelf as an operator, or similar experience. The requirement for at least one licensee to have drilled an HPHT well or a well in a very deep-water field as the operator continues to apply. This means that the safety authorities may not as a rule recommend the granting of 100 % ownership in any production licence for very deep-water or HPHT developments. The aim is to ensure that only the most experienced and competent operators operate in such areas.

sian authorities are developing floating nuclear power plants for use in relatively inaccessible locations in the Arctic, the first of which is scheduled to be completed in 2012. Transport or towing of such power plants through the management plan area would increase the risk. Today, an onshore nuclear accident, for example at the nuclear power plant on the Kola Peninsula or the reprocessing plant at Sellafield, would represent the greatest risk of inputs of radioactive material via air and water from sources outside the management plan area.

Maritime transport of radioactive material has increased since 2005. One transport of spent reactor fuel took place in 2009 and five in 2010, and a further increase is expected up to 2025. In principle there is no notification requirement for maritime transport of spent reactor fuel in international waters and Norwegian waters outside the baseline. However, the Emergency Response Department of the Norwegian Coastal Administration, the Vardø VTS Centre and the Norwegian Radiation Protection Authority have introduced a notification procedure that will ensure a reciprocal exchange of information when one of these agencies becomes aware of such a transport. In such cases the Maritime Directorate and the Norwegian Joint Headquarters will also be notified. The Radiation Protection Authority is the competent authority in the field of radiation protection and nuclear safety. The Authority is not formally notified until radioactive material is to cross the border or the baseline, but receives information about most transports through its own channels. Information about such transports is exchanged between the Radiation Protection Authority, the Norwegian Coastal Administration and the Norwegian Joint Headquarters, and the transports are kept under continual observation by the Vardø VTS Centre while they are in Norwegian waters.

There is no requirement to notify coastal states of maritime transport of radioactive material, but the International Atomic Energy Agency (IAEA) General Conference recommends that the practice of notification of coastal states by the sending state is followed. The Norwegian authorities will follow up the recommendation in order to strengthen and improve notification procedures. However, it should be noted that such transports are also covered by the Convention on the Physical Protection of Nuclear Material, which makes it a requirement to protect the confidentiality of any information received, in part to prevent attempts by unauthorised actors to interfere with the transport and threaten its safety.

In 2001 the IAEA concluded that the probability of a serious accident at sea involving transport of high-level radioactive waste was very low. The conclusion is based on the fact that high safety standards are maintained through the requirements established for the containers in which the waste is transported to the ship. The Agency considers that if this type of vessel meets with an accident it is unlikely that the radioactive material will leak out of the containers, but it also points out that any releases could lead to serious pollution.

There is considerable activity to reduce the risk of radioactive pollution in international forums such as the IAEA, OSPAR and the London Convention and Protocol, and bilaterally through for example the close cooperation between Norway and Russia. The following measures reduce the risk of radioactive releases and the probability of acute pollution incidents in the management plan area:

– The Government's Nuclear Action Plan focuses on nuclear safety in northwestern Russia and has led to increased attention being paid to risk-reducing measures, preparedness, monitoring and competence development.
– In 2006 it was decided to include Svalbard and Jan Mayen in Norway's nuclear accident preparedness, and contingency plans are being drawn up.
– The Norwegian Coastal Administration and the Radiation Protection Authority have concluded a cooperation agreement on exchange of information, notification and a preparedness and response system for dealing with incidents at sea.
– In September 2009 the last radioactive source in lighthouses along the coastline of northwestern Russia was removed.
– Norway is providing assistance for the dismantling of decommissioned nuclear vessels. Of the 198 nuclear submarines that have been decommissioned, 120 were located in northwestern Russia. Norway has financed projects to secure spent nuclear fuel and dismantle five submarines. Today only two of the original 120 submarines remain to be dismantled. The original date for completion was 2010, but was delayed until 2011.

5.2 New analyses of environmental consequences and environmental risk for the areas off the Lofoten and Vesterålen Islands and Senja in the event of oil spills

Environmental risk expresses the probability of a spill of oil or other environmentally hazardous substances combined with the scale of the environmental damage expected, taking uncertainties into account. The environmental risk level is assessed by combining the risk of a spill with the influence area and the presence of vulnerable species and habitats. The species and habitats most vulnerable to an oil spill are seabirds, marine mammals, the shoreline and the recruitment stages of fish.

A traditional scenario-based approach is used to assess the possible impacts of oil spills, in which a relevant range of acute pollution incidents and their consequences are postulated. The following factors have a decisive influence on the assessment of the environmental consequences and environmental risk:

– the probability that an incident will occur;
– the choice of scenario and discharge point;
– the oil drift model used (i.e. the vertical and horizontal spread of the oil);
– the geographical distribution of environmental resources;
– the vulnerability of environmental resources;
– the method used to calculate/assess the environmental consequences and environmental risk.

A description of environmental risk does not provide a complete picture or measure of the way a particular incident will develop and what damage it will cause. Assessments of the risks to vulnerable environmental resources are always simplified, since they are based on a set of assumptions. This means that there are limitations and some level of uncertainty attached to the results.

5.2.1 Oil spill scenarios and discharge points on which the analyses are based

Nine oil spill scenarios were developed for use in modelling the drift and spread of oil in the event of a spill, and risk analyses were carried out for oil spills at selected discharge points off the Lofoten and Vesterålen Islands and Senja. Most of them are for oil and gas activities (and petroleum-related shipping). They are based on the types of incident and types and volumes of oil considered to be representative of petroleum activities in the management plan area. The discharge points (see Figure 5.4) were selected on the basis of assumptions about future petroleum activities (including petroleum-related shipping) and mapped petroleum prospects off the Lofoten and Vesterålen Islands and Senja, but a scenario for a major shipwreck southwest of Røst was also modelled. Table 5.2 shows an overview of the various scenarios and discharge points. The environmental risk analyses focused mainly on scenarios 2, 4 and 7. The analysis of scenario 8 is restricted to discharge point 2 in Nordland VII, and does not include the nearcoast discharge points in Nordland VI and VII or Troms II.

Most of the incident types (blowout, well leak, spill during loading/unloading, etc) have a large sample space with regard to total spill volume (rate and duration), and the scenarios are based on representative spill volumes within the sample spaces. Scenarios 4 and 5 are of the same magnitude as the Ekofisk Bravo blowout in 1977. The Bravo blowout lasted for a week and released 10 000–17 000 tonnes oil; it is the largest oil spill from petroleum activities that has occurred on the Norwegian continental shelf. In addition, one scenario was chosen of a blowout of 4 500 tonnes oil per day lasting 50 days, which is intended to represent a very serious scenario for the Barents Sea–Lofoten area. The spill volume in scenario 8 is almost one-third of the spill in the Gulf of Mexico. The spill volumes in the various scenarios range from 42 tonnes to 225 000 tonnes oil.

After the Gulf of Mexico oil spill, the worst-case scenario was re-assessed. For the work on the management plan it was concluded that a scenario involving 4 500 tonnes oil per day for 50 days was still representative of a serious blowout that should be taken into account in decision-making for the Barents Sea–Lofoten area.

The Forum on Environmental Risk Management also pointed out the need to further develop the criteria for selecting information relevant to an environmental risk assessment.

5.2.2 Oil drift modelling

Oil drift was modelled for all the oil spill scenarios and discharge points shown in Table 5.2, and the results provide a basis for further assessment of environmental consequences and environmental risk. The resource estimate for oil is higher than for gas in Nordland VI and VII. In Troms II it is most likely that gas will be found, and condensate was therefore modelled for this discharge point. The modelling is focused on oil drift in the open sea and is less detailed for coastal areas. Emergency response measures taken in the event of a spill will limit the spread of oil and subsequent damage.

The simulations show that the duration and size of the spill influences the drift and spread of the oil and the influence area. The oil type and its properties are also important in determining the influence areas on the sea surface and in the water column. The results show that as a rule the extent of the influence area increases with the duration of a spill (see Figures 5.5 and 5.6). The spill rate also affects the extent of the influence area, but according to the simulations, less strongly than the duration. However, an increase in rate will result in larger volumes of oil in the influence area. The location of the discharge point in relation to land and coastal currents also has considerable influence on the drift and spread of the oil and the probability of stranding.

Spills from discharge points near the coast and further out to sea were modelled. Most of the discharge points are in the vicinity of the coastal current, but some are further out from land. The extent of landfall was calculated for all the scenarios modelled (different spill sizes) for all discharge points in Nordland V, VI and VII, with the exception of the seabed spill at discharge point 2 in scenarios 1 and 3. For many of the scenarios the simulations show a generally high probability of landfall: a probability of up to 30–80 % for scenario 4 and up to 70–100 % for the most serious scenarios. The shoreline extent of the influence areas for spills from all discharge points was relatively large in scenarios 2 to 9. This is mainly because the coastal currents carry the oil northwards along the coast. In Troms II the release of condensate from a nearcoast discharge point was modelled. As a rule condensate dissolves more rapidly in water than oil does, and the simulations show a smaller influence area for condensate than for oil, with no landfall for the smaller releases. However, the probability of landfall was high (30–40 %) for large releases of condensate from this discharge point.

There was a high probability of landfall of oil released from the nearcoast discharge points (Nordland V, VI and VII). If the release is prolonged, large volumes of oil are likely to reach coastal areas. Simulation of a blowout from a discharge point in Nordland VI further from the coast and outside the coastal current shows that the oil will affect open sea areas to a greater extent, but also indicates that it will be swept into the coastal current at the point where the geologi-

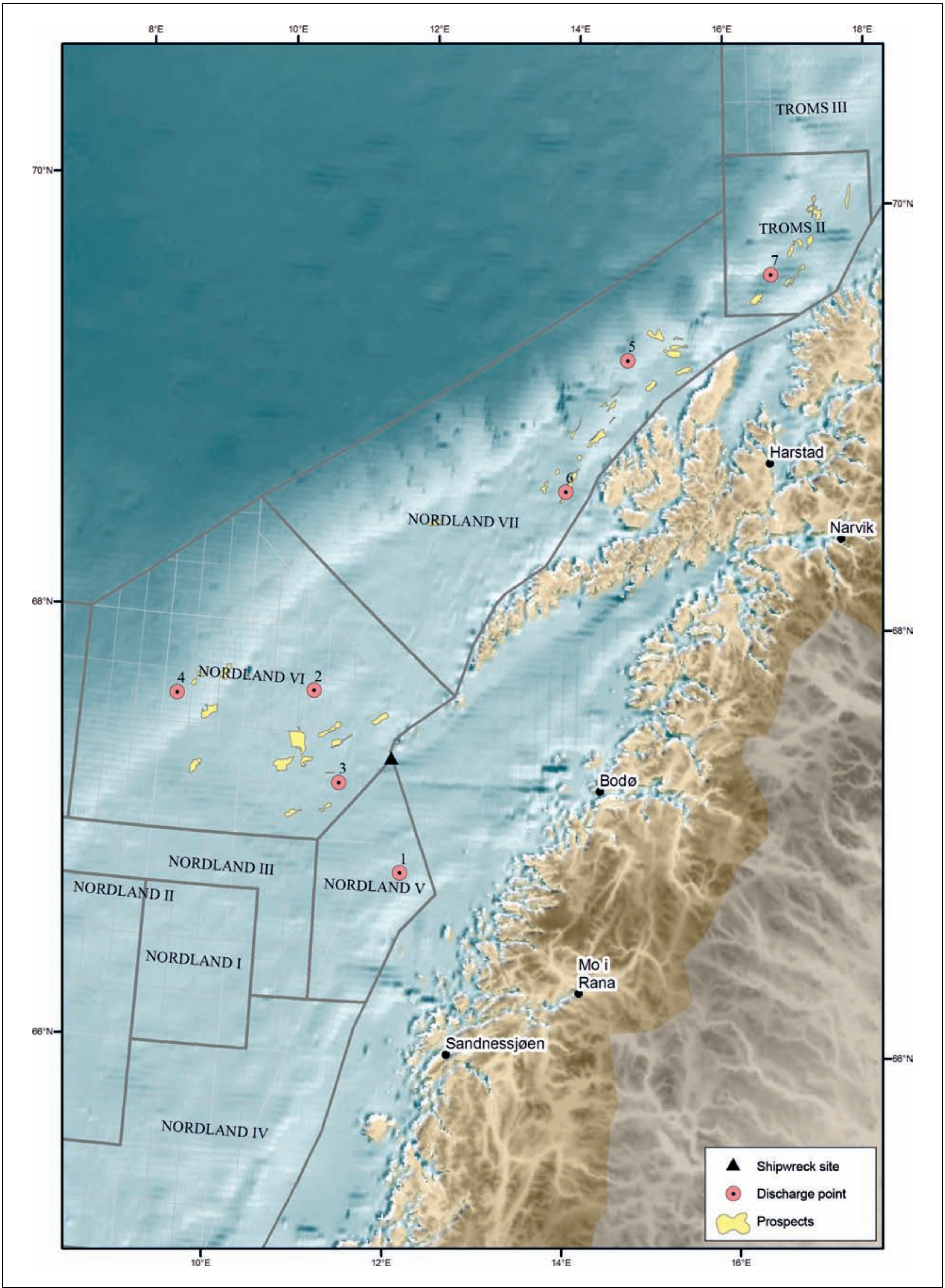

Figure 5.4 Discharge points used in the scenarios

Source: Petroleum Directorate

Table 5.2 Oil spill scenarios

Scenario no	Spill rate (tonnes /day)	Spill duration	Spill volume (tonnes)	Scenario representative of incident type	Discharge point (Figure 5.4)	
					Oil drift forecasts	Environmental consequences analysed for discharge points
1	500	2 hours	42	B, E	1, 2, 5, 7	2
2	35	14 days	490	D	1, 2, 5, 7	1, 2, 5, 7
3	1 000	2 days	2 000		1, 2, 5, 7	2
4	4 500	2 days	9 000	A, C, F, G	1–7	1, 2, 3, 5, 7
5	8 500	2 days	17 000	I, J	1, 2, 3, 5, 7	2, 3
6	5 400 1 000 200	2 days 13 days 35 days	29 000	A (declining discharge rate)	1, 2, 5, 7	2
7	4 500	14 days	63 000		1, 2, 5, 7	1, 2, 5, 7
8	4 500	50 days	225 000		1–7	2
9	15 000	4 days	60 000	Shipwreck*	Shipwreck	Shipwreck

A = Blowout; B = Well leak; C = Pipeline leak; D = Riser leak; E = Process leak; F = Spill from storage tank; G = Spill during loading/ unloading; I = Vessel collision with installation; J = Spill from shipping

* Shipwreck off Røst in Nordland VI.

cal continental shelf is at its narrowest, and then carried towards the coast of the Vesterålen Islands, including Andøya, and the mainland further north. A representative spill of 4 500 tonnes per day for 2 days from any of the discharge points apart from number 4 will have a very short expected drift time to shore: from a minimum of 1.5 days (Nordland VI, discharge point 2) to 0.3 days (Nordland VII, discharge point 6) up to 6.3 days further from the coast (discharge point 4). The average drift times for scenarios with landfall are 2.3 days for discharge point 1 (Nordland V), 4.1, 7.3 and 13 days for discharge points 3, 2 and 4 respectively (Nordland VI), 1 and 6 days for discharge points 6 and 5 respectively (Nordland VII) and 4 days for Troms II.

In the case of discharge point 6 (Nordland VII), which is 18 km off the coast of the Vesterålen Islands, modelling gives a high probability that the oil will contaminate long stretches of coastline. For 4 500 tonnes per day for 50 days simulations show an 80–100 % probability of landfall of oil from the Vesterålen Islands to Sørøya off Hammerfest.

Figure 5.5 shows the influence areas on the surface for a spill rate of 4 500 tonnes per day and a spill duration of 2 and 50 days respectively for the different discharge points. The modelling results for the other scenarios can be found in the background documents. Figures 5.5 and 5.6 show the probability of oil contamination in 10 km by 10 km grid cells for scenarios 2 and 4 and the shipwreck scenario. It should be noted that the influence areas do not show the area covered by a single spill but the overall area of contamination shown by all the simulations that have been run for each spill. The calculations of the environmental consequences in the next section do not take into account the emergency response measures that would be implemented and that could limit the spread of the oil and thus the damage caused.

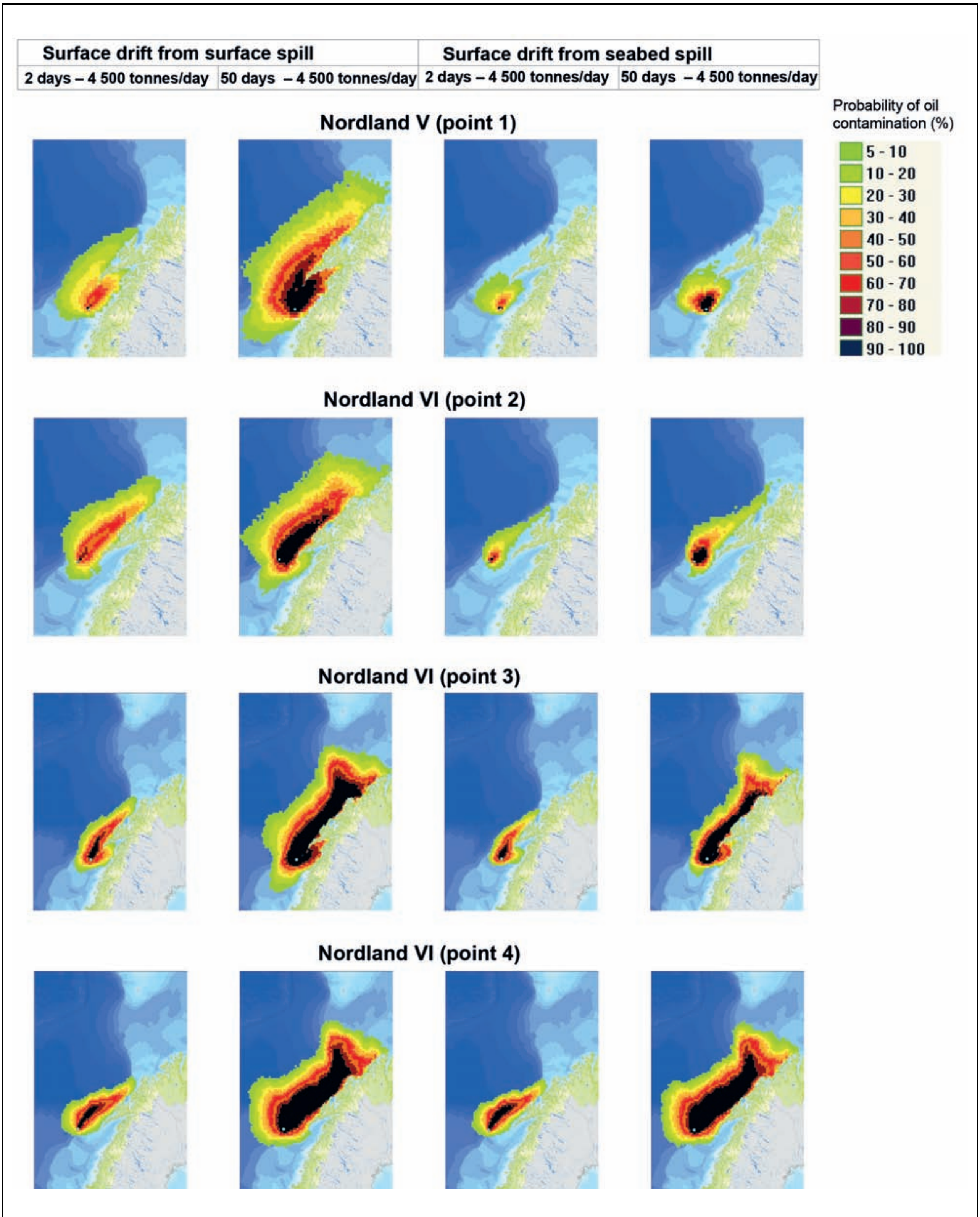

Figure 5.5 Results of modelling of oil spills off the Lofoten and Vesterålen Islands and Senja. The maps show the probability (%) of oil contamination on the surface (influence areas) for discharge points 1–7. The simulations are based on surface spills and seabed spills of 4 500 tonnes/day for 2 days and 50 days. The probabilities are calculated from 230–330 simulations for the 50-day spills and 1 120 simulations for the 2-day spills.

Source: DNV

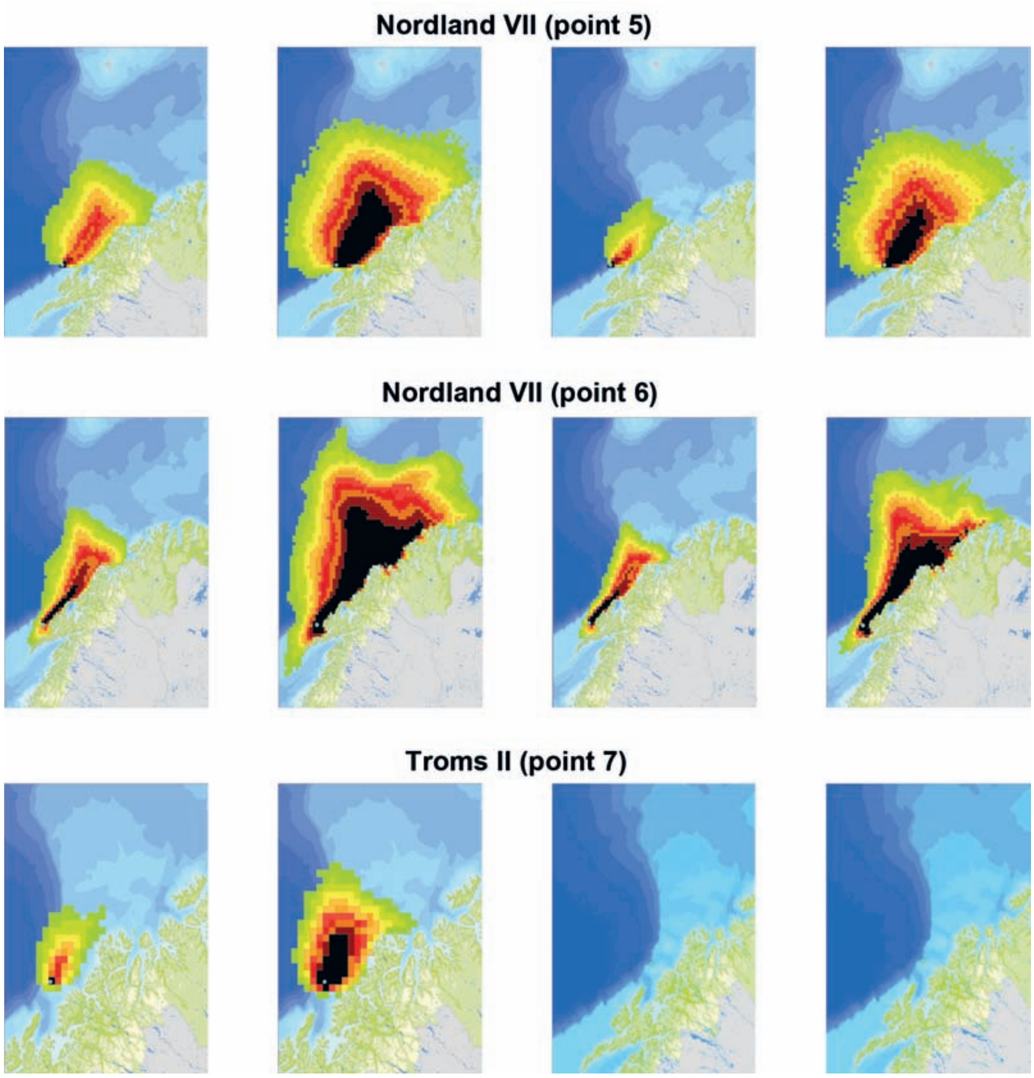

Figure 5.5 Cont.

Source: DNV

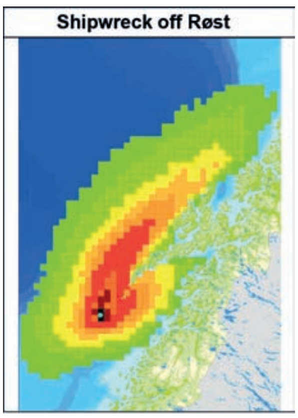

Figure 5.6 Result of modelling of an oil spill from a shipwreck off Røst in Nordland VI, with a spill of 15 000 tonnes/day for 4 days. The map shows the probability of oil contamination.

Source: DNV

5.2.3 Assessment of the environmental consequences and environmental risk

Environmental consequences

The assessments of environmental consequences in the present update make use of a great deal of new knowledge that was not available when the 2006 management plan was drawn up. The information comes from surveys, research and new methods and/or models for assessing the distribution of species and habitats and for calculating environmental consequences.

The environmental consequences for fish, fish eggs and larvae, seabirds, marine mammals and the shoreline were analysed in background reports for several of the discharge points and scenarios described above. The oil drift forecasts and environmental consequences analysed are

Box 5.4 Choice of relevant scenarios from a safety perspective

Scenarios are also used in a number of different ways by the public administration. Modelling scenarios clarifies the type of preventive measures and preparedness and response that are necessary. Purely quantitative assessments based on historical data may not always be representative and provide little information that can be used in risk management. This applies especially to major accidents, which are low-probability but high-consequences events.

The assessments on which the choice of scenarios is based must therefore take several different types of information into account to compensate for the limitations in the data material and the approach. The assessments developed for the management plan are based on available experience and information on petroleum activities on the Norwegian continental shelf (including the Barents Sea–Lofoten area), accidents and management of the risk of accidents, and national and international statistics. The information must:

- be relevant to the type of decision to be made,
- contribute to a good, well-balanced understanding of risk (must explain the assumptions, element of uncertainty and limitations),
- contribute to a good understanding of which measures will achieve the goal of maintaining a low risk level in the management plan area,
- form a sound basis for decisions that will result in risk reduction.

shown in Table 5.2. The analyses of environmental consequences and environmental risk focused mainly on scenarios 4 and 7. The analysis for scenario 8 only included discharge point 2.

The scale of the damage will vary depending on whether the contamination affects fish, seabirds, marine mammals or the shoreline. The scale of the consequences of a particular oil spill also depends on the size and duration of the spill, the exposure time for species and habitats, the timing of the discharge and location of the discharge point, the potential exposure of vulnerable species and habitats, including the coastal zone, and the oil type. The presence of species that are vulnerable to oil varies over the year, and thus the damage potential of an oil spill will vary for different species according to the season.

Consequences for seabirds

The simulations run for scenarios 2 and 4 (representative of various types of incidents during petroleum activities) and scenario 7 (4 500 tonnes/day for 14 days) show that the consequences for seabirds vary. For the largest spill volume in these three scenarios (scenario 7), there is generally a probability of high percentage population losses (in the intervals 5–10 %, 10–20 %, 20–30 % and >30 %) for many of the species in the management plan area. For scenario 4, the results show that there is a probability of high percentage population losses for certain important species in the areas and a probability of population losses in the interval 1–5 % for a larger number of species. The consequences are generally smallest for scenario 2, but there is nevertheless a relatively high probability of population losses in the interval 1–5 % for several species. The consequences are smallest for discharge point 7 in Troms II, since it features condensate with a high degree of weathering. The influence area is therefore smaller than for oil.

No demonstrable consequences were found for scenario 2, since in this case the condensate did not reach the shore. However, large spill volumes from this discharge point are still associated with a high probability of population losses for certain species. The results for scenario 7 show that Atlantic puffin is most at risk, since there is an 85 % probability that 1–5 % of the population will die if there is a spill during the summer, while for a winter spill the probability is almost 80 %. The simulations for the nearcoast discharge points in Nordland V and VI show the greatest environmental consequences; even for the smallest discharge volume (scenario 2) there is a high probability of population losses for several of the species analysed (for example up to 90 % probability of a population loss of 1–5 % for puffin, and up to 80 % for common guillemot).

The simulations showed that the consequences of spills from discharge points on the seaward side of the coastal current were smaller for the scenarios involving the smallest spills, but serious for the largest spills. Environmental consequences have not been assessed for the near-coast discharge point in Nordland VII (number 6). The oil drift results indicate that the environmental risk is high, since there is a high probability of oil contamination along long stretches of shoreline and of large volumes of oil combined with the presence of large numbers of vulnerable species and areas of vulnerable habitats in the water column, in the open sea and in the coastal zone. To learn more about the environmental consequences and risk associated with this scenario, it will be necessary to carry out environmental risk analyses using the data from oil drift modelling.

The Lofoten and Vesterålen Islands and the Barents Sea are very important areas for seabirds. The good food supplies in the Norwegian Sea and the Barents Sea support large populations of colony-nesting seabirds along the mainland coast, on Bjørnøya and in Svalbard. Because of the high density of seabirds and their species composition, these areas are vulnerable to oil contamination. Modelling indicates that oil spills at the discharge points used in the environmental risk assessments would mainly affect the large colonies on Røst, Værøy, Fuglenykene and Bleik and adjacent feeding areas. A major spill (scenario 7) would also affect Sør-Fugløy and Nord-Fugløy in Troms, and Lille Karmøy in western Finnmark. This area has large numbers of seabirds during the breeding season, when they are tied to their breeding habitats and therefore stationary. Simulation of the mortality caused by spills shows without exception that the consequences would be far more serious in the breeding season than at other times of year. In autumn and winter the birds are more evenly distributed along the coast, and the probability of high percentage population losses is lower. For all the analysed discharge points, the species that will be most severely affected is the puffin. The largest Norwegian colony is on Røst and could be directly affected by spills in Nordland V and VI. The size and duration of the oil spill and the exposure time for the birds influence the modelling results. In the event of a minor surface spill in Nordland V or VI, there is a probability of a population loss of 1–5 % for puffin. The blowout scenario with the lowest probability, a surface spill of 4 500 tonnes per day for 50 days from discharge point 2 in Nordland VI, would in the breeding season result in a 38 % probability of a population loss of more than 30 % and a 44 % probability of a loss of 20–30 %. The environmental consequences of this scenario have not been analysed for discharge points 1, 3 and 6 in Nordland V, VI and VII. Oil drift modelling shows that spills from these discharge points would affect the shoreline to a greater degree than a spill from discharge point 2, and the environmental consequences would be expected to reflect this. Discharge points 1 and 3 are upstream of the large seabird colonies on Røst, and the probability that these colonies and colonies further north will be affected is expected to be higher. The scenarios that have been analysed show that the shag would be the most severely affected coastal species, especially the colonies on Røst and Lille Karmøy.

The black-legged kittiwake and common guillemot are categorised as critically endangered (CR) and endangered (EN) respectively on the 2010 Norwegian Red List. Simulation of the different scenarios gives varying results for both species. A spill in Nordland V has a relatively serious damage potential. For the kittiwake, the consequences of a spill in Nordland V vary from a 60 % probability of a population loss of 1–5 % (minimum estimate for a spill of 35 tonnes/day for 14 days) to a 20 % probability of a loss of 10–20 % and a 5–10 % probability of a loss of 50 % (a spill of 4 500 tonnes/day for 14 days). Spills of longer duration and corresponding or higher rates would result in a higher probability of greater percentage losses. Since kittiwakes and common guillemots are found at the highest densities in Finnmark, the consequences for these species occupy a less dominant place in the simulation of the consequences for the Lofoten and Vesterålen Islands. However, both species have suffered a serious population decline, which makes them more vulnerable to any increase in mortality. Thus at the local level, oil contamination may have greater negative impacts than immediately indicated by the simulations. Mortality on the scale indicated for the largest scenarios analysed would increase the probability that the populations of kittiwake and common guillemot on Røst will die out. The birds are more evenly distributed along the coast in autumn and winter.

Consequences for the shoreline

The analysis showed that the duration of the spill was of considerable importance for the consequences for shore zone habitats. In general, the most representative spill and blowout scenarios have a probability of minor to moderate environmental damage combined with recovery periods of less than one year and 1–3 years respectively for shore zone habitats. A larger-scale incident of 4 500 tonnes per day for 14 days would have more serious consequences and involve a probability of substantial damage, with a recovery period of 3–10 years for shore zone habitats.

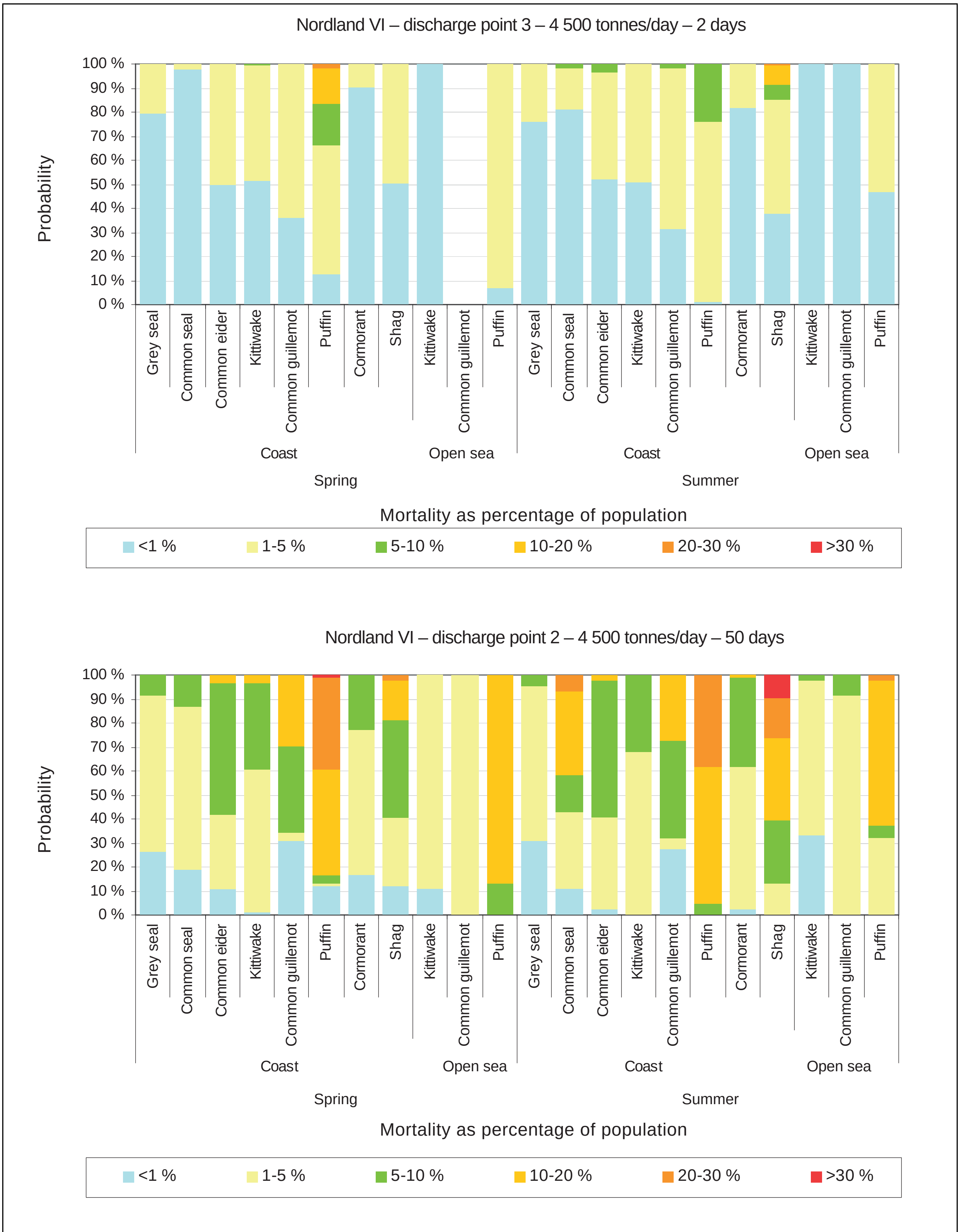

Figure 5.7 Consequences for seabirds and marine mammals. Probability of different levels of population loss for various species. Upper panel: consequences of a spill of 4 500 tonnes/day for 2 days at discharge point 3. Lower panel: a spill of 4 500 tonnes/day for 50 days at discharge point 2.

Source: DNV 2010.

Consequences for fish

To harm aquatic organisms, the oil must be mixed into the water column, which means that a spill on the seabed could have more serious consequences than a surface spill. For these organisms, the length of time between the discharge of fresh oil and the point when the oil no longer releases water-soluble components is of crucial importance for assessing the potential damage. Eggs and larvae, which are the critical stages in fish life cycles, drift passively northwards with the current, and damage at these stages could reduce the year class involved.

Generally speaking, simulation of the various scenarios shows an 85–95 % probability that less than 1 % of a particular year class will be lost. The worst-case scenario shows a loss of 50 % of a year class from a spill in Nordland V. The probability of a loss of this magnitude is calculated to be around 5 % if the spill occurs at the time when fish are most vulnerable. There are other examples, involving smaller spills and larger spills at other times of year, where the consequences are marginal or zero.

The probability of harm to adult fish is mainly related to the uptake of oil components that reduce fish quality. However, adult fish are able to smell oil in the water column and will swim away. There have been cases where fish in fish farms, which cannot escape, have died as a result of the stress caused by their attempts to avoid the polluted water.

In order to assess spatial variation or patchiness in the survival of fish eggs and larvae there is a need for accurate observations of the temporal and spatial distribution of these stages. These data should be used for modelling when and where water masses containing damaging concentrations of oil components coincide with the presence of fish eggs and larvae.

Environmental risk

To assess environmental risk, the varying severity of the environmental consequences modelled must be combined with the probability of incidents that could cause these consequences. The probability of spills from oil and gas activities is discussed in section 5.1.2. In the analyses discussed here, the environmental risk has been assessed for three of the species for which the most serious consequences were found. The three species analysed were puffin (at the time of year when it is tied to the coast), shag and grey seal. The environmental risk was assessed for the most widely representative incident (scenario 4), for one of the large-scale incidents (scenario 7) and for the largest-scale incident (scenario 8). The analysis of scenario 8 is limited to discharge point 2. The results showed that in general the large-scale incidents (scenarios 7 and 8) would have the most serious consequences and have the highest probability of damage in the most serious categories for seabirds, marine mammals and the shoreline. However, the probability of such incidents is low. The results showed that scenario 4 would also have serious consequences and that the probability of such consequences was higher than for scenarios 7 and 8. Thus scenario 4 has the most representative risk level.

According to the analyses, the low probability of an incident plays a larger part in maintaining a low level of environmental risk than the level of environmental consequences.

Apart from the discharge point in Troms II, the analyses focused on the areas off the Lofoten and Vesterålen Islands, where the modelled spills would mainly affect the large seabird colonies on Røst, Værøy, Fuglenykene and Bleik. The results for environmental consequences and environmental risk for the Lofoten and Vesterålen Islands cannot necessarily be extrapolated to other parts of the management plan area.

The analyses of environmental consequences and environmental risks were mainly conducted for scenarios 2 and 7 and certain of the discharge points. In its report on the oil spill in the Gulf of Mexico, the Forum on Environmental Risk Management recommended that environmental risk analyses should also be carried out for the coastal zone and shoreline in the Vestfjorden and the Lofoten and Vesterålen Islands, Troms and Finnmark, and that they should include the larger modelled spill scenarios as well.

Shipwreck off Røst

The results show that a shipwreck off Røst with a total spill of 60 000 tonnes oil over 4 days would result in a high risk of environmental damage. It could lead to major damage to a number of seabird populations, the grey seal population and the shoreline. The largest Norwegian puffin colony is on Røst and would therefore be affected by such a spill. The consequences were estimated at a 30 % probability of a population loss of 30 % for puffin. If a shipwreck were to occur during the spawning-season cod fishery off the Lofoten Islands, it would have immediate and very serious consequences for the fisheries. If it were to occur in a period with high concentrations of cod eggs and larvae, it could also lead to a marked reduction in the year class in question. However, the traffic separation schemes, the emergency tugboat services and other maritime safety measures have helped to reduce the probability of this type of incident.

No analyses have been made for the other parts of the management plan area. The potential consequences of oil spills are generally considered to be the same as before. In 2010–11 the Norwegian Coastal Administration conducted comprehensive environmental risk analyses for maritime traffic along the coast of mainland Norway.

5.3 Preparedness and response to acute pollution: reducing the consequences of spills

The most serious scenario in the scientific basis for the management plan update and the additional modelling described above is a spill with a discharge rate of 4 500 tonnes oil per day lasting for 50 days. However, the environmental risk analyses for the Barents Sea–Lofoten area have not taken into account the effect of preparedness and response measures. The objective is for the preparedness and response to acute pollution to be designed and dimensioned to effectively keep the risk of damage to the environment at a low level.

A natural topic of discussion is how the Norwegian preparedness and response system could be used to reduce the environmental consequences of a spill on this scale and how to incorporate the lessons learned after the accident in the Gulf of Mexico. However, there are many dissimilarities between the Gulf of Mexico and the management plan area, such as climate, ocean currents, water depth, marine life and geology. The high spill rate in the Gulf of Mexico was related to the geological conditions in the reservoir. There is no evidence to suggest that the same geological combination of good reservoir properties, very high reservoir pressure, volatile oil and deep water is to be found in the management plan areas as in the Macondo prospect, and this should be borne in mind when the lessons learned from the accident are being evaluated.

The Gulf of Mexico spill caused the authorities concerned to re-evaluate the assessments of oil spills, including potential causal mechanisms, spill volume, duration, consequences and preparedness and response. The total spill volume in the Gulf of Mexico accident was estimated at almost 800 000 Sm^3 oil and lasted for 87 days. Norway has no experience of dealing with oil pollution on this scale or at these depths.

A large-scale response operation was mounted in the aftermath of the Gulf of Mexico spill. Figure 5.8 shows estimated figures for the fate of the oil. The areas severely affected were small in relation to the size of the spill, and the visible acute environmental impacts were less serious than had been feared. This was because most of the oil either evaporated or was dispersed in the water column. However, a great deal more work is needed to determine the scale of the damage, and we do not know the effects of the large quantities of oil dispersed in the water column or on the seabed. Studies are being carried out on the long-term effects of the uptake of oil and dispersants by organisms.

Recovery of oil from the sea surface

The Norwegian preparedness and response system is mainly based on mechanical recovery of oil from the sea surface by means of booms and skimmers.

A major acute pollution incident in the management plan area that threatens the coastal zone would pose considerable operational challenges related to distance, infrastructure, darkness, weather and availability of equipment and personnel.

In the Gulf of Mexico extensive resources were deployed to contain, disperse and remove the oil and limit the damage, see Box 5.2. In spite of the scale of the response operation, only a small proportion of the total spill (3 %) was recovered from the surface by mechanical means. Since the spill occurred in deep water, much of the oil was dispersed in the water column and not all of it reached the surface. In addition large quantities evaporated and large quantities were chemically dispersed, see Figure 5.8. In Norway the figure for recovery of oil drifting on the sea during governmental clean-up operations has in most cases been 12–15 %, calculated as pure oil recovered in relation to total spill volume. This corresponds in general to international figures for mechanical oil recovery.

Oil dispersion

Chemical dispersion was one of the main measures used to limit the amount of surface oil in the

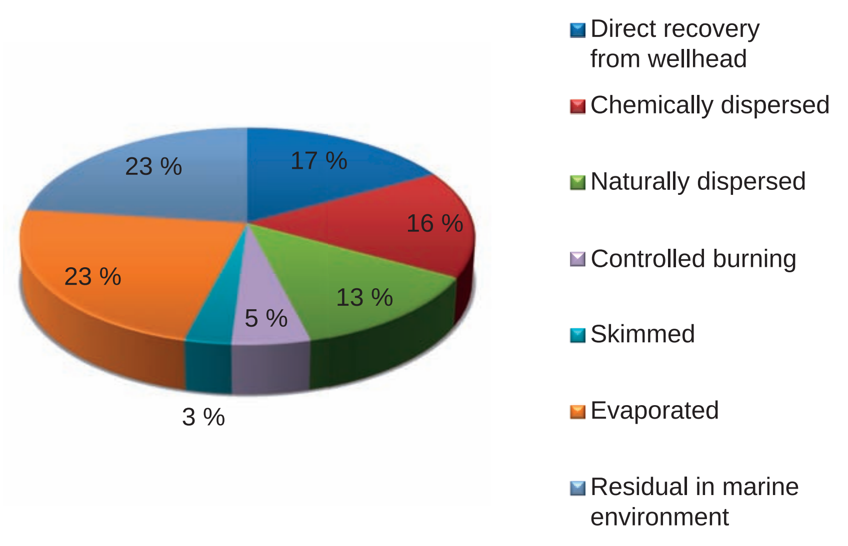

Figure 5.8 Oil budget for the Mexico Gulf accident

Source: Report to the President. National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, January 2011.

Gulf of Mexico. Around 7 000 m^3 dispersant was used. Norwegian operators do not have the logistical or operational capacity to use dispersants on this scale. Norway has total stocks of around 650 m^3 dispersants, mainly held by the oil and gas operators themselves. It is too soon to conclude that the dispersants used in the Gulf of Mexico did not damage the marine environment or that dispersant use gave less overall damage than for example mechanical recovery or in situ burning.

Under the Pollution Regulations, dispersant use should be chosen when it will give less overall damage to the environment than any other method. The Norwegian Coastal Administration is reviewing the possibility of including dispersant use as a response technique in the governmental system. The Gulf of Mexico spill showed that preparedness and response to acute pollution should take into account that it may be necessary to use dispersants and shoreline-cleaning agents in addition to mechanical recovery. Thus it might be advisable to review the framework conditions for the use of different techniques and to seek to improve their effectiveness through R&D.

Natural dispersion and evaporation of oil

The potential damage from a spill is usually reduced by natural dispersion by waves, wind, sunshine and bacteria, and by evaporation of crude oil. A high proportion (23 %) of oil from the Gulf of Mexico spill was estimated to have evaporated. The surface temperature of the sea in the Gulf is around 32 °C, which means that weathering will proceed differently from weathering of a corresponding crude oil in Norwegian waters. The rougher wind and weather conditions in the management plan area would increase the dispersion of the oil through the water column, thereby reducing the risk of acute damage to the shoreline, but the potential for long-term effects of the dispersed oil would be higher.

In situ burning of oil

Controlled burning of crude oil on the sea surface was also used in the Gulf of Mexico. Norwegian operators have very little experience of this method, although it has been tested for oil spills in icy waters.

Shoreline cleaning

The type of accident largely determines how much of the oil is beached. Near-shore spills of heavy fuel oil from ships often make large-scale shoreline-cleaning operations necessary. So far, there have been no incidents where oil spills from oil and gas activities have reached land, but oil drift forecasts based on scenarios and discharge points in areas from Nordland to Troms show that the probability of landfall is high (see section 5.2.2).

Landfall of oil from ships has led to prolonged clean-up operations in Norway, for example after the spill of heavy bunker oil from the *Full City* off

Box 5.5 Status and development of oil spill preparedness and response in the management plan area

Governmental oil spill response (responsible agency: Norwegian Coastal Administration)

The main depots of the Norwegian Coastal Administration in the management plan area are located in Bodø, Lødingen, Tromsø, Hammerfest, Vadsø and Longyearbyen, and there are supplementary depots at Sortland, Skjervøy, Honningsvåg and Båtsfjord. Two of the Administration's oil recovery vessels and six Coast Guard vessels with oil pollution response equipment on board normally operate in the management plan area. The service vessels under the Governor of Svalbard can also be deployed in governmental emergency response. The Norwegian Coastal Administration has a surveillance aircraft for monitoring the spread of oil on the sea surface.

Municipal response

There are seven intermunicipal acute pollution control committees, in which all municipalities from Røst to Sør-Varanger participate. The municipal emergency response equipment consists primarily of light-weight booms and skimmers suitable for use along the shoreline and in coastal waters.

Private-sector response

The petroleum industry is required to maintain a level of preparedness and response that is dimensioned to deal with spills from oil and gas activities. This means that operators must identify their needs and performance requirements with regard to ocean-going response and emergency response in coastal waters and the shore zone as a function of estimated quantities of oil in specified sample areas along the coast. The Norwegian Clean Seas Association for Operating Companies (NOFO) is responsible for planning and implementation of emergency response measures on behalf of the operators. The governmental emergency response system is therefore designed mainly to deal with spills from shipping accidents rather than those from oil and gas activities.

Langesund in summer 2009. It is not unusual for shoreline-cleaning operations to take up to six or seven months, even after the relatively small spills we have experienced.

In the event of a major spill in the management plan area, equipment from all governmental depots along the coast can be deployed, but normally the equipment in local depots in the area will be used. However, the availability of personnel is less reliable in this part of the country than in other, more densely populated, parts of the coast. The infrastructure also poses more problems than in other parts of the country. Thus if extensive shoreline-cleaning operations are needed, the capacity of the municipal emergency response system is likely to be limited.

There are many areas of the coast in the management plan area where it is difficult to deploy personnel and that are not accessible from the seaward side.

Overall effect of oil spill preparedness and response

It is clear from the scientific basis of April 2010 for the management plan update and the report by the Forum on Environmental Risk Management on the Gulf of Mexico accident that it is not possible to give a single straightforward description of what the overall effect of preparedness and response would be in the event of an oil spill in the management plan area. Dealing with a major oil spill in the area would involve considerable operational challenges, especially as regards coordination and monitoring of the response operation, access to personnel and equipment, and the effectiveness of booms, equipment and methods for recovering oil from the sea surface and shoreline in difficult weather conditions, when ice is present and in darkness. These factors will make oil spill response particularly difficult in the whole management plan area.

As in other sectors, governmental preparedness and response to acute pollution in the management plan area is dimensioned on the basis of

Box 5.6 Preparedness and response measures implemented since 2006

Since 2006, both the authorities and the petroleum industry have implemented a number of measures to strengthen the preparedness and response to acute pollution:

Governmental and municipal measures

- Emergency response equipment at all depots has been renewed, replaced and reallocated.
- New Coast Guard vessels carrying oil spill recovery equipment have been phased in, which has increased capacity and mobility for ocean-going response, including equipment carried by the Coast Guard vessel *KV Sortland*.
- The emergency cargo transfer capacity for bunker and cargo oil has been strengthened by the deployment of new equipment.
- The competence of personnel in the governmental system has been strengthened by increasing the frequency of exercises.
- The Climate and Pollution Agency and the Norwegian Coastal Administration have further developed decision-making tools for the use of dispersants as an emergency response measure.
- The knowledge base for environmental risk and preparedness analyses has been strengthened, for example by testing and further developing three-dimensional modelling of oil drift.
- The preparedness and response requirements for the petroleum industry have been tightened, and the licences awarded by the Climate and Pollution Agency contain more specific requirements for dealing with oil spills close to the source and in the drift trajectory towards the coast.
- New regulations concerning the use of vessels in oil spill response have been issued. The aim is to enable vessels that are built, equipped and certified for other uses to be safely deployed in oil spill response operations.
- Guidelines have been developed through a project headed by the Norwegian Coastal Administration for general competence-building for preparedness in coastal waters and shoreline clean-up, with contributions from NOFO, Statoil, the Directorate for Civil Protection and Emergency Planning, the Norwegian Fire Protection Training Institute and the Climate and Pollution Agency.
- The Royal Decree of 17 February 2006 relating to nuclear accident preparedness was made applicable to Svalbard and Jan Mayen from 1 April 2006.

Private sector

- NOFO has increased the number of high seas oil recovery systems, and improved and replaced equipment. It has also identified new technology needs and to this end is implementing a technology programme in cooperation with the Norwegian Coastal Administration.
- In order to comply with the requirements for preparedness and response to acute pollution during planned operations over a limited period (exploration drilling), the operators have strengthened preparedness for coastal waters and the shoreline for certain segments of coast in the management plan area.
- A research programme on beached oil has provided new knowledge about conditions for the use of different beach clean-up techniques, test methods for dispersants and shoreline-cleaning agents, and the weathering and spread of certain types of crude oil on different beach types.
- The preparedness and response system established for the fields on the Halten bank, with a five-hour response time to the Norne field, can be used as the first response for operations in the southern parts of the management plan area. The emergency response system being established for the Goliat field will improve the preparedness level in the northern part of the area.
- A multiannual research programme on oil spills in ice has raised the level of knowledge and improved the basis for decision-making as regards the establishment of preparedness and response for icy waters.

risk analyses. A preparedness and response system cannot be designed on the basis of a worst-case scenario.

5.4 Important gaps in our knowledge

The work on the management plan is based on the assumption that all the relevant authorities contribute expertise in their own sphere of responsibility and compile a scientific basis for the plan. It is important to arrive at a common understanding of risk that is shared by all the authorities and experts, and to this end to further develop the criteria for selecting information relevant to an environmental risk assessment.

The methods for assessing the economic effects of accidents involving acute pollution should be further developed. This will improve the basis for making decisions on investment in prevention, preparedness and response.

There is still a need to improve the methodology for assessing the environmental consequences of acute pollution for fish, seabirds, marine mammals and the shoreline. There are still uncertainties as regards assessments of the consequences for fish, including how to deal with spatial variation or patchiness in survival of fish eggs and larvae. We also need to know more about survival from larvae to adult fish.

The petroleum industry should give priority in R&D to prevention of accidents that may result in acute pollution in general and in Arctic areas in particular. One priority area that has been identified is the development of technical and operational solutions for the management plan area that are adapted to conditions when icing is likely.

6 Assessment of cumulative environmental effects and progress towards goals

6.1 Ecosystem-based management and cumulative environmental effects

Chapters 3 and 4 give an account of the Barents Sea–Lofoten ecosystem and environmental pressures and impacts associated with human activity. In this chapter, cumulative environmental effects on the ecosystem as a whole are assessed as far as possible.

What are cumulative environmental effects?

Any pressure on an ecosystem must be assessed on the basis of the cumulative environmental effects on the ecosystem now or in the future, taking into account the structure and functioning of the ecosystem. Cumulative effects must be assessed for each ecosystem component, for species and habitats, and for the ecosystem as a whole. If a habitat type is under a great deal of pressure in the area in question, one important consideration is whether this is the only area of the habitat type in the country, or whether it is relatively widespread. This approach is in accordance with the requirement to assess cumulative environmental effects and apply the precautionary principle, as set out in the Nature Diversity Act.

Many different pressures and impacts on the Barents Sea–Lofoten ecosystem are discussed earlier in this white paper. Some are associated with human activities in the management plan area, such as fisheries, maritime transport and oil and gas activities. In such cases, the Norwegian authorities are in a good position to implement national measures or take the initiative for international measures to regulate environmental pressures. There are also external pressures, such as climate change and the accompanying rise in sea temperature and melting of the sea ice, ocean acidification and long-range transport of pollutants. In such cases Norway alone is less able to control developments. It is therefore considerably more difficult to predict how important such external pressures will be when assessing cumulative environmental effects at some point in the future.

In addition, the risk of accidents and releases of pollution, which is discussed in Chapter 5, is an important part of the overall picture.

It is difficult to assess cumulative environmental effects when considering a large and complex ecosystem, subject to many different pressures that have impacts on a variety of ecosystem components, which in turn interact with each other. The Barents Sea–Lofoten ecosystem is just such a system. Our understanding of the types of mechanisms involved has improved from 2005 to 2010, but is still not nearly good enough to enable us to understand the entire complex system.

In this chapter, the different components of the Barents Sea–Lofoten ecosystem are considered. The chapter gives an account of the role of each component in the ecosystem and of pressures and impacts associated with human activities in the management plan area (see the discussion of the different industrial sectors in Chapter 4). There is also an account of how the ecosystem is being affected by external anthropogenic pressures such as climate change, ocean acidification and long-range transport of pollutants. As far as possible, the way different pressures affect individual species and habitat types and the ecosystem as a whole has also been evaluated.

At present, we lack sufficient knowledge and good enough methods to make a reliable and complete analysis of all these relationships. The precautionary principle (as set out for example in the Nature Diversity Act) must therefore be included as a consideration in assessments of how the Barents Sea–Lofoten area is to be managed under the relevant legislation.

6.2 Cumulative environmental effects on different ecosystem components

Phytoplankton and zooplankton

The phytoplankton is of fundamental importance to marine ecosystems. These organisms are responsible for primary production, which is the first stage in energy transfer to higher trophic levels (later stages in the food chain). Transport of zooplankton from the Norwegian Sea is of crucial importance for zooplankton production in the Barents Sea during the spring and summer. The zooplankton biomass available in the Barents Sea in autumn influences the growing conditions for species at higher trophic levels in the following year.

There are wide variations between seasons and between years in the species composition and biomass of phytoplankton. Important natural factors that influence and regulate the phytoplankton include nutrients, light, temperature, salinity, sea ice, mixing of the water masses, grazing and sedimentation. Climate change could influence several of these factors and thus result in changes that propagate upwards in food chains. If climate change influences water and heat transport into the Barents Sea, it will also have an effect on the zooplankton biomass in the area, both because it will influence zooplankton transport and because temperature is an important factor for the development of different life stages of the zooplankton.

Planktonic organisms with calcareous skeletons and shells will be particularly vulnerable to ocean acidification. Zooplankton, for example the copepod *Calanus finmarchicus*, have been shown to be sensitive to long-term exposure to even moderate acidification of seawater, which influences both physiology and reproduction. Warming of the oceans may result in less uptake of carbon dioxide, but the surface waters in northern waters will still be colder than further south; CO_2 uptake will therefore be higher in these areas, resulting in acidification of the seawater.

At present, human activity only has indirect effects on plankton biomass, through exploitation of species further up the food chain. In future, direct harvesting of zooplankton, for example *Calanus finmarchicus*, could alter the situation.

An oil spill in the marginal ice zone would probably affect biological production locally. It is unlikely that the quantity of plankton in the Barents Sea–Lofoten area as a whole will be negatively affected by pollution, but pollutants could be transferred from plankton to higher trophic levels.

At present, the cumulative environmental effects on plankton are not believed to be having a negative impact on plankton biomass in the Barents Sea–Lofoten area. However, a continuation of current trends – increasing acidification, rising temperature and shrinking ice cover – may have impacts on plankton production, species composition and distribution in the longer term.

Projections for 2025

Cumulative environmental effects on plankton in the future will depend on other environmental trends. Continuing ocean acidification is expected to have negative impacts on calcifying planktonic organisms and on *Calanus finmarchicus*. Changes in temperature and ice cover will also affect the species composition and distribution of planktonic organisms, and trends in stocks of plankton-feeding fish will be an important factor for plankton biomass. If large-scale harvesting of zooplankton is permitted, this will be a new anthropogenic pressure on the plankton biomass, which could have significant effects on the ecosystem. Any harvesting must be based on scientific advice. If adequate information is not available in a specific case, or if there is doubt about the impacts on the environment, decisions must be made in accordance with the precautionary principle.

The seabed and benthic fauna

Most benthic species are stationary and are mainly of local importance for the ecosystem. The benthic species composition reflects local conditions and can therefore be used as an important indicator of environmental quality. Many demersal fish and other animal groups feed on benthic species. Changes in the species composition of benthic communities can affect biological production and thus the food supplies available.

Cold-water coral reefs are large, spatially complex biological structures, which makes them suitable habitats for many sessile and free-swimming organisms. Coral reefs offer a wide variety of microhabitats and thus support high biodiversity. There is also reason to believe that sponge communities are important both for fish and for many invertebrates, but little work has been done on their ecological importance.

Important processes that take place on the seabed include decomposition of organic particulate matter and nutrient regeneration. These processes are crucial for production in the ecosystem. Enzyme activity in microbial processes, and

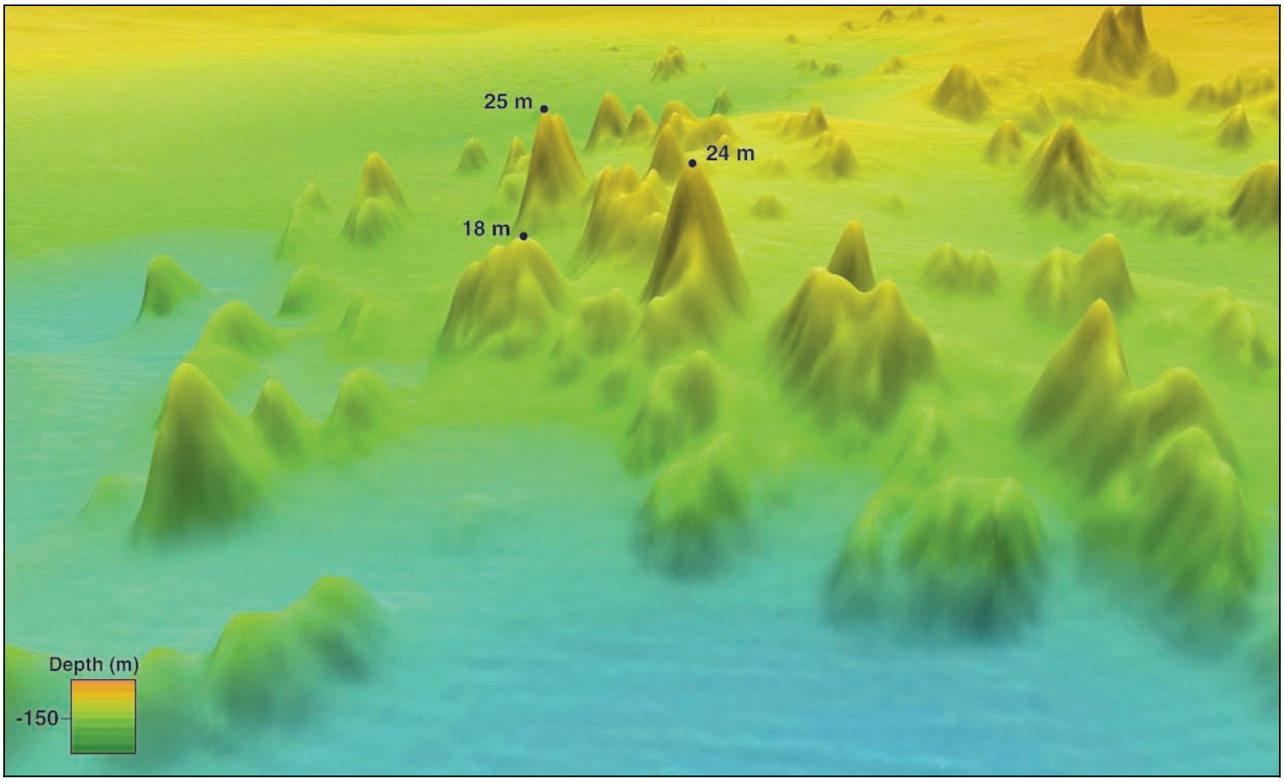

Figure 6.1 3D map showing a group of coral reefs in the Hola area off the Vesterålen Islands. The numbers indicate the height of some of the reefs.

Source: MAREANO/Norwegian Mapping Authority

thus the speed of such processes, is influenced among other things by the temperature on the seabed.

Benthic animals are particularly vulnerable to damage and disturbance caused by fishing gear that is towed along the sea bed. The fauna in relatively fine sediments will be more severely affected than fauna in coarser, more unstable sediments. Pressure from bottom fishing has been reduced from 2005 to 2009. Bottom trawling can kill motile species that live among the sessile species or affect them indirectly by damaging their protective surroundings and exposing them to predators. Bottom trawling also increases the particulate content of the water. This particulate matter settles on benthic communities and results in an increase in sediment-cleansing activities and energy use.

Rising temperatures can result in the expansion of the range of various species northwards. It is uncertain how much impact this will have on the benthic fauna.

An increase in runoff from land and a rise in inputs of sediments from Svalbard's glaciers will have most impact near the river mouths and glacier terminuses.

Pollutants have been detected in benthic animals, but only in low concentrations. There are stable low levels of organic pollutants in sediments and organisms.

Benthic communities are affected by the presence of red king crabs, since these feed on benthic animals. Recent investigations in the Varangerfjorden (2008/09) have shown that the species is causing substantial changes in soft-bottom benthic communities. A comparison with the situation before the red king crab became abundant in the

Figure 6.2 Live corals on the Røst reef.

Source: MAREANO/Institute of Marine Research areas studied (1995) shows a dramatic decline both in the number of species and in biomass. In addition, the investigations confirm that large individuals of bivalves, echinoderms and polychaetes are more or less absent. It is unclear whether these are permanent effects. The Varangerfjorden studies indicate that when the crabs remove the dominant benthic organisms, oxygenation in the sediments is reduced.

There have been no registered changes in pressures and impacts associated with maritime transport.

Expansion of oil and gas activities affects benthic communities and species, but to a limited extent. Studies show that the impacts of deposition of cuttings from drilling with water-based mud are generally limited. Deposition of drill cuttings from tophole sections of wells in the Barents Sea is very local, and the seabed will normally return to its normal state within a few years.

Benthic trawling results in bycatches of various groups of the benthic fauna, which in addition to corals and sponges include arthropods, bivalves, gastropods, polychaetes, echinoderms and sea anemones. More than 400 species belonging to 14 different groups are affected, but the impacts on the ecosystem are not known.

Harvesting of benthic invertebrates such as shrimps and red king crab also has impacts on benthic communities. The shrimp stock is considered to be healthy and is being harvested sustainably. In the past 10 years, the fisheries management authorities have focused increasingly on impacts on benthic communities, and a number of measures have been introduced. Further measures will probably be introduced, and the pressure from the fisheries is therefore expected to be reduced.

A number of different factors with impacts on benthic animals and habitats have been identified. However, no surveys or research have been carried out that provide information on the cumulative effects of all these factors on populations and their distribution.

All in all, climate change and the fisheries are the factors that will have the greatest effects on the species composition and distribution of benthic communities and biological production by such communities. We know little about the importance of the impacts of bottom gear for the status of individual species in the management plan area or in Norwegian waters as a whole. There has been trawling in a number of areas for some decades. In the areas mapped by the MAREANO programme, damage to certain habitat types (coral reefs and gorgonian forests) has been revealed. The programme has also revealed damage to sponge communities, but the scale is uncertain. We know that continued ocean acidification will have a negative impact on corals because they will grow poorly, and this may make them more vulnerable to other pressures such as sediment deposition.

Figure 6.3 Shrimp on a gorgonian coral.

Source: MAREANO/ Institute of Marine Research

It is difficult to draw conclusions about the cumulative environmental effects on the benthic fauna and habitats. In areas where the seabed has been mapped, there is considerable damage from bottom fishing gear, and more damage than could be documented in 2005. However, we know that bottom trawling has been restricted since 2005. In geographical areas that have not been mapped, we lack sufficient information to draw conclusions about cumulative environmental effects and their significance for the ecosystem.

Fish stocks

Different fish species play different roles and are of differing importance in the ecosystem, some as prey and others as predators. Different species may compete for the same food resources. Current knowledge indicates that cod, herring and capelin are the three key fish stocks in the production system harvested in the Barents Sea. Capelin is the most important prey species for cod, and is also important for a number of other predators, including several species of seals, whales and seabirds (see Chapter 3.3.4 for a description of ecological relationships between herring and capelin). In northern parts of the Barents Sea, polar cod is particularly important for many predators.

Many different environmental pressures act on fish stocks, but fishing is the human activity that has the greatest impact. This applies both to species that are targeted by the fisheries and to those that are taken as bycatches. The indicators used for fish stocks in the Barents Sea–Lofoten area are Northeast Arctic cod, capelin, Greenland halibut, golden redfish, beaked redfish, juvenile herring and blue whiting.

One of the objectives of the management of living marine resources is to ensure a high long-term yield. However, European eel, blue skate, spiny dogfish, basking shark, blue ling, golden redfish, porbeagle and beaked redfish are all listed as threatened (in the categories critically endangered, endangered or vulnerable) on the 2010 Norwegian Red List (see Chapter 3.3.7). There is no directed fishery for eel, blue skate, blue ling, porbeagle or beaked redfish in the management plan area. The stocks of golden and beaked redfish and blue ling are at low levels because of earlier overfishing. Management measures have been introduced for all these species, and beaked redfish and Greenland halibut have shown better recruitment and signs of a positive trend in stock size in recent years. There is a directed fishery for beaked redfish in international waters, which is cause for concern, and Norway has repeatedly urged the North East Atlantic Fisheries Commission (NEAFC) to halt this fishery. It is too soon to evaluate the effect of the management measures introduced for coastal cod.

Oil and gas activities can also put pressure on fish stocks, and seismic surveys have been shown to affect fish behaviour. Fish show increased swimming activity, which can be a sign of stress. Fish are also affected by underwater noise from various sources and by operational discharges of pollutants, even at low concentrations. In addition, chronic exposure of fish to low levels of oil components in produced water may result in damage to genetic material, slower maturation and poorer growth. It is uncertain to what extent the levels registered in the environment can result in long-term effects.

Long-range transport of pollutants also has impacts on individual stocks. Studies show that levels of hazardous substances and radioactive substances in the environment are generally low. Species at the highest levels of food chains, such as seals, are an exception to this, as are long-lived deepwater fish species.

Climate change has already resulted in changes in physical conditions and ice cover in the management plan area. These factors will have an increasing impact on the distribution of fish stocks.

Harvesting is a deliberate and managed pressure on fish stocks. Harvest levels are based on advice from the International Council for the Exploration of the Sea (ICES), but negotiations with other countries and other public interests may result in departures from the recommended quotas. In some case, for instance, the fisheries authorities may plan for rebuilding of certain stocks to proceed more slowly, in order to take account of other public interests. This may result in somewhat higher fishing pressure on some stocks than recommended by ICES.

Climate change may cause changes in physical conditions and ice cover, which will have a considerable impact on the distribution of fish species. In the short to medium term, rising temperatures are expected to result in an increase in quantities of fish in the Barents Sea, particularly in northern and northeastern parts. In addition, any pressure that results in changes in the biomass or species composition of the zooplankton may have impacts on fish stocks. It is unclear how ocean acidification will affect lower trophic levels and what effects this may have on other ecosystem components, including fish. The cumulative effects are therefore uncertain.

At present, cumulative environmental effects are not believed to be having a negative impact on the most important fish stocks in the Barents Sea–Lofoten area. However, the cumulative effects on certain smaller but important stocks, such as the two redfish species and Greenland halibut, are too great. The fisheries are putting most pressure on these stocks. However, a continuation of current trends – increasing acidification, rising temperature and shrinking ice cover – may have impacts on the production, species composition and distribution of fish stocks in the longer term.

Seabirds

In the past 10 years, an alarming number of seabird populations in the Barents Sea–Lofoten area have been declining rapidly. The cumulative environmental effects (from climate change and other anthropogenic pressures) today are too great. Seabirds are long-lived, have low reproductive rates and are highly mobile. Most species are closely adapted to the availability of specific food

Figure 6.4 Ivory gulls.

Photo: Hallvard Strøm

organisms that are directly or indirectly affected by harvesting strategies and climate change. At certain stages of their life cycle, seabirds are also closely tied to their habitats, and are particularly sensitive to a wide range of human pressures, including habitat loss, disturbance, pollution (oil and hazardous substances) and hunting.

Seabirds that migrate away from the Barents Sea–Lofoten area for part of the year or part of their life cycle will also be exposed to various environmental pressures outside this area. Seabirds are a link between marine and terrestrial ecosystems, and this factor becomes increasingly important at higher latitudes. It is therefore particularly important in Svalbard, where biological production on land is highly dependent on the marine ecosystem.

Seabirds are exposed to environmental pressures that act both through the physical environment and through their food supplies. The decline in populations and in breeding success has mainly been linked to changes in food supplies. The observed changes in zooplankton biomass and in the migration patterns of important fish stocks may reduce the food supplies available to seabirds within range of their breeding sites. The ivory gull is sensitive to changes in sea ice distribution and is particularly vulnerable.

Climatic conditions affect seabirds both directly and indirectly, for example through changes in food supplies and exposure to hazardous substances. Changes in these conditions that alter the distribution patterns of prey organisms will affect seabird populations, but the effects will vary according to where the different species breed. Seabird populations that are already declining are also particularly vulnerable to any other environmental pressures. The situation has become more serious since 2005. Even low levels of hazardous substances may have negative impacts if other conditions (including food supplies) are unfavourable. However, the extent to which such interactions have had impacts at population level is uncertain. Levels of organic pollutants in glaucous gulls are still alarmingly high.

Activities in many sectors put pressure on seabirds. The fisheries can have an impact on food supplies for seabirds and seabirds may be taken as a bycatch in fishing gear, while oil spills, marine litter and pollutants all have negative impacts on species and habitats. In the near future, offshore energy production may result in further mortality and habitat loss. In addition, climate change may result in changes in the distribution of prey species on which seabirds are dependent. The role of seabirds in marine ecosystems means that they are one of the most vulnerable groups of marine organisms.

Despite considerable improvements in the knowledge base on seabirds, there is still a lack of quantitative information on the causal relationships behind the decline in populations. Poorer food supplies are one explanation, but a lack of knowledge about which pressures result in poorer food supplies means that any assessment of cumulative effects on seabirds and their habitats today and in the future is uncertain.

Many of the clearest trends for Norwegian seabirds in recent decades appear to be a result of a reduction in the amounts of important prey available, particularly small schooling fish species. Many of the challenges we are facing in this area can only be resolved through closer scientific cooperation between seabird ecologists, fisheries biologists and oceanographers.

Nordic report

In 2010, the Nordic Council of Ministers published the report *Action plan for Seabirds in Western-Nordic areas*. In addition to the action plan, the report contains a review and assessment of pressures and impacts on seabirds in the Northeast Atlantic, based on information from national and international experts. The report highlights three pressures that are important for many seabird species in large parts of the study area. These are climate change/rising sea temperatures, competition with fisheries and oil pollution. The report identifies food shortages caused by competition between seabirds and fisheries as an important cause of the problems many seabird populations are experiencing in areas where fisheries and seabirds compete for the same species . These problems are also apparent in the Barents Sea. However, seabirds and fisheries do not necessarily compete for the same fish resources at the same time and in the same place. There is often a time lag, and competition may be indirect. We still need more knowledge to understand the mechanisms involved and quantify the relationships.

The Nordic report also points out that all seabird species are vulnerable to oil spills, particularly because the waterproofing of their plumage is affected by even very small amounts of oil. Oil pollution may also have toxic effects on birds, especially when they preen and ingest oil, and also through ingestion of contaminated prey. Bycatches and pollutants other than oil are also identified as specific pressures that are of importance for fewer species and/or locally in the Western Nordic area, including Norwegian areas.

Projections for 2025

The expected continuation of climate change will continue to have impacts on seabirds, in the period up to 2025 as well. Pressure from hazardous substances is expected to remain more or less unchanged from today, and seabirds will be under pressure from several other human activities. Bycatches of seabirds are expected to decrease as new technology is taken into use, and closer cooperation between seabird experts and marine scientists will result in better knowledge of seabirds and their food supplies. In the longer term, climate change and perhaps ocean acidification may nevertheless result in an increase in the cumulative environmental effects on seabirds as a result of human activity. Ocean acidification will not be a direct threat to seabirds, but will have indirect effects because of its impacts on food supplies for seabirds.

Marine mammals and polar bears

Various species of whales and seals, in addition to polar bears, are part of the Barents Sea–Lofoten ecosystem. Seals dominate in numbers and whales in biomass. Some whale species spend part of the year in the management plan area, migrating between feeding grounds in polar waters and mating and calving areas in more temperate waters (for example minke whale, fin whale and humpback whale), while others may remain in the Barents Sea–Lofoten area all year round (for example beluga whale, narwhal and bowhead whale). Most of them are top predators, but some baleen whales are secondary consumers, feeding on krill and other larger plankton organisms. Between them, whales feed on organisms that make up a large part of the ecosystem (the sea snail *Limacina helicina*, krill, shrimps, crabs and other crustaceans, various fish species, bivalves, gastropods, cephalopods and seals). Polar bears are top predators in the Arctic ecosystem. The remains of their prey, such as seals, provide an important food supply for animals such as Arctic foxes, ivory gull and glaucous gull.

Marine mammals are subject to various types of environmental pressures. The bowhead whale, narwhal, hooded seal and common seal are all listed as threatened (in the categories critically endangered, endangered or vulnerable) on the 2010 Norwegian Red List. The Svalbard populations of walrus, common seal and polar bear are listed as vulnerable. None of these populations is hunted in the management plan area or Svalbard, but there is some hunting of common seal along the mainland coast of Norway.

In 2005, the catch of minke whales was limited and the impact on the stock was small. In 2009, the catch was further reduced. The harp seal catch in 2005 was limited and had little impact on the stock. Sealing activity was further reduced in 2009, partly because of a decline in pup production in the White Sea in recent years. A hooded seal catch is taken in the West Ice.

Recent data show more definitely that in some areas, the bycatch of common porpoise is so high that it puts considerable pressure on the population. In these areas, the local population of porpoises is only maintained by migration of animals from other areas. The bycatch and harvest of common seals have not been sustainable, and a management plan has now been drawn up for the species. The management regime for the coastal seals has recently been changed, and in future more sustainable management is expected, based on how much of each population can be harvested.

The report from the advisory groups mentions that studies from other sea areas have shown that noise can have impacts on marine mammals. New knowledge means that noise, particularly especially from propellers, is now considered to be a greater problem for marine mammals than was previously believed.

Rising activity levels in maritime transport and the oil and gas industry may also put more pressure on marine mammals, for example through an increase in noise levels and the risk of collisions. Pressure from fisheries and hunting is expected to remain unchanged or decline.

In general, changes in ice cover or the position of front zones where biological production is high may have a considerable impact on the populations of species that are strongly dependent on these areas for breeding or feeding. Species that are already affected by climate change, such as the polar bear, will be particularly vulnerable if pressure from pollutants increases. Climate change will have a direct impact on the availability of suitable habitat for ice-dependent species (Arctic seals, ringed seal, polar bear). For other species, it may result in changes in the availability of prey.

Since 2005, the first possible impacts of climate change on ice-dependent marine mammals have become apparent in the Barents Sea. These impacts are expected to become more marked in the period up to 2025.

Ice-dependent and other species have to be considered separately when cumulative environmental effects on marine mammals today are being assessed. The cumulative effects on ringed seal, harp seal, hooded seal and polar bear are too great, and appear to be primarily a result of rising temperatures. For species that are not ice-dependent, such as the large whale species in the area, there are no apparent adverse effects at present. However, hunting and bycatches respectively are having local negative impacts on the common seal and porpoise populations. A continuation of current trends – increasing acidification, rising temperature and shrinking ice cover – is expected to have increasing impacts on the production, species composition and distribution of marine mammals in the period up to 2025. The scale of these effects will depend on the pace of climate change, and particularly trends in sea ice extent and quality. The impacts of climate change will be additional to those of a rising volume of shipping and an increase in oil and gas activity.

Threatened species

The above review shows that a number of species in different components of the Barents Sea–Lofoten ecosystem are threatened. These are listed in Box 3.6 in Chapter 3.3.7.

The cumulative environmental effects on these populations in the management plan area are discussed under the different ecosystem components. The main distribution area of several of these species coincides with the management plan area. The cumulative effects in this area will therefore be very important for the status of these species in Norway as a whole.

6.3 Cumulative environmental effects on the Barents Sea–Lofoten area

It is a complex and difficult task to make an assessment of the combined effects of all human pressures on the ecosystem as a whole. It involves evaluating human pressure on each ecosystem component and taking into account how impacts in one area may have domino effects on other ecosystem components. Domino effects may increase the vulnerability of species and habitats. In a larger area such as the whole management plan area, it is also necessary to take into consideration the fact that pressures and impacts may vary from one part of the area to another.

When assessing the cumulative effects on parts of an ecosystem, it is therefore important to consider their implications for other parts of the same system. In the present context, it is particularly important to assess the effects on key species in the Barents Sea–Lofoten ecosystem. If the cumulative effects on a particular species group or an area have negative impacts on populations of key species such as the copepod *Calanus finmarchicus*, herring or capelin, this will be far more significant for other species in the ecosystem than if less central species are affected.

Many different factors have already been mentioned that make it a challenging task to assess cumulative environmental effects on the entire Barents Sea–Lofoten ecosystem today and in the future. The lack of reliable information means that the precautionary principle will have to be applied to a varying degree as a guideline for management of the area.

Experience from the fisheries sector shows that a management regime based on the precautionary principle is needed, as set out in the Marine Resources Act, to take into account that there may be synergistic interactions between factors that we do not know about. Climate change will have impacts on both ecosystems and human society. The possible effects of the large-scale climate change we are currently witnessing will be additional to other pressures on an area, and there will be geographical variations in how this affects vulnerability.

In the management plan area, cumulative environmental effects are considered to be greatest for the following elements of the ecosystem: corals, sponges and sea pen communities, seabirds, ice-dependent seal species and those fish stocks that are in poor condition. The decline in common guillemot and kittiwake populations is particularly worrying.

Some trends in the Barents Sea–Lofoten area suggest that the ecosystem is changing. The reasons for the decline in seabird populations are complex, but a reduction in the amount of important prey species available has been advanced as one of the most important explanations. Populations of pelagic species such as common guillemot, puffin and kittiwake have been declining for a long time.

The major fish stocks are in good condition and are being harvested sustainably, but certain smaller stocks are still at low levels. Bottom trawling also has impacts on the benthic fauna. Substantial damage to coral reefs and sponge communities has been documented in several areas. These organisms have functions that are important for other ecosystem components, for example as nursery areas for fish, but we know too little about the relationships. Damage to the benthic fauna may have serious domino effects on other parts of the ecosystem.

In recent years there has been a decline in the extent of sea ice in the Barents Sea and surrounding areas as a result of climate change. A considerable decline in breeding success in ice-dependent seal species is one of the first clear effects of climate change on the ecosystem in the Barents Sea and surrounding areas.

Given normal circumstances and the current level of activity, harvesting is expected to have the greatest impact on fish stocks of all the activities in the management plan area, while maritime transport and oil and gas activities are expected to have little impact (Table 6.1). However, activity in these sectors is growing and may result in increasing pressure.

In the years ahead, the cumulative effects of climate change, ocean acidification and long-range transport of pollutants will probably increase and have more serious implications than the impacts of different human activities in the Barents Sea–Lofoten area. Because of uncertainties and poor documentation of several factors, it is not possible to draw definite conclusions on the cumulative effects on the ecosystem of all human activities combined. However, a combination of several significant environmental pressures in the same area at the same time increases the risk of negative impacts. For example, a permanent change in sea temperature (see Figure 6.5) and pH could result in change on such a scale that the ecosystem reaches a tipping point and there is an irreversible regime shift. This means that there are major, permanent changes in the structure, functioning and productivity of the ecosystem. The consequences of such changes are difficult to predict, but may be far-reaching.

Pressure on one ecosystem component will often have implications for other parts of the system as well. For example, direct physical damage to coral reefs can result in poorer ecological conditions for other organisms that depend on the coral reef as their habitat, such as demersal fish species and crustaceans. This can reduce the value of a coral reef and its role for the biodiversity and ecological functioning of the area.

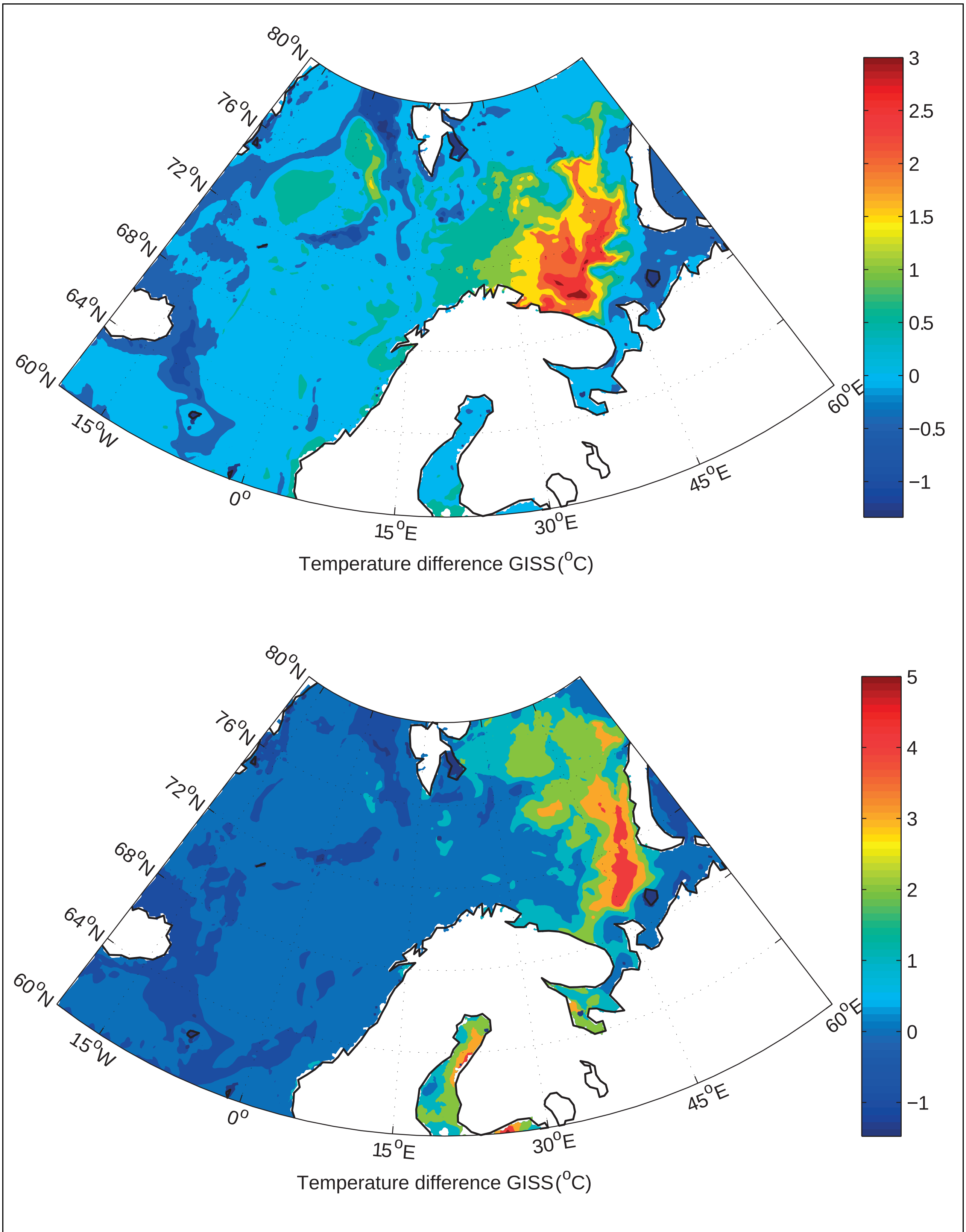

Figure 6.5 Results of simulations of changes in sea temperature in March (top) and September (bottom), showing the difference between the period 2046–65 and the control period 1981–2000.

Source: Institute of Marine Research

Ocean acidification as a result of a higher concentration of CO_2 in seawater may result in damage to calcium-dependent species. This would affect phytoplankton, zooplankton and benthic animals such as corals, crustaceans, echinoderms and molluscs. Coral reefs are key habitats for fish and invertebrates, and planktonic organisms are essential food for fish, seabirds and whales. Harm to these plant and animal groups may result in major changes in the ecosystem.

There are indications that the distribution of plankton in the management plan area may alter as a result of climate change, which could have important effects on other ecosystem components. Fish and other organisms that feed on plankton will move to follow their food supplies. The implications will be more serious for species groups such as seabirds, which are more closely tied to their habitats at certain times of year. Seabirds may experience food shortages because their prey organisms move too far away from the colonies, which means that the adults are unable to provide enough food for their young, and seabird populations decline.

In an ecosystem-based management regime, management of human activities must be based on the limits within which ecosystem structure, functioning and productivity can be maintained. The examples above show that a pressure or impact on one part of the ecosystem may have domino effects on others, and that the mechanisms involved may be very complex. Such effects will be particularly important if environmental pressures result in changes in the population or distribution of key species such as *Calanus finmarchicus*, herring or capelin. Some of the mechanisms involved are known, for example interactions between different fish stocks. However, there are still gaps in our knowledge of important aspects of ecosystem functioning that are needed in the development of an ecosystem-based management regime, and these must be taken into account in management of the ecosystem.

Priority should therefore be given to cooperation across sectors in systematic studies of synergistic effects on the ecosystem. For example, more knowledge is needed about how ocean acidification and climate change will affect the transport of hazardous substances, their metabolism and uptake, and their effects on species, food chains and ecosystems. Another area that needs to be studied is how climate change will influence fishing patterns through changes in the distribution of fish stocks or expansion of the areas accessible to fishing vessels as the extent of the sea ice shrinks. And we need to know more about the possible direct impacts of climate change and ocean acidification on fish stocks and their prey and predators, and how it will be necessary to adjust the harvest.

As described in Chapter 3, the state of the environment in the Barents Sea–Lofoten area today is generally good. However, the cumulative effects on the ecosystem will probably increase in the years ahead, and it is important to monitor developments closely.

The particularly valuable and vulnerable areas that have been identified fulfil key functions for the entire ecosystem of the management plan area. It is especially important to prevent the cumulative environmental effects from becoming too great in these areas, where this could have major consequences. Several of the particularly valuable and vulnerable areas are relatively close to the coast and support rich fish stocks and high biodiversity. There is therefore considerable human activity in these areas, particularly fishing and other harvesting. Special caution should therefore be exercised in establishing new activities in these areas.

Table 6.1 Changes in the impacts of human activity on different ecosystem components and their state in 2009. The table uses data for 2009, reported in the scientific basis for the updated management plan.

Ecosystem component	Pressure	Change in impact from 2005 to 2009	State 2009
Physical environment	Fisheries	No change registered	Temperature above long-term mean in 2009 after declining from maximum in 2006. Sea ice extent somewhat higher in 2009 than in preceding years, but still low.
	Maritime transport	No change registered	
	Petroleum activities	No change registered	
	External pressures	Rising temperature and increasing ocean acidification	
Plankton	Fisheries	Larger fish stocks mean higher grazing pressure on plankton	
	Maritime transport	No change registered	
	Petroleum activities	No change registered	
	External pressures	Rising temperature and increasing ocean acidification	Zooplankton biomass lower in 2009 than the three preceding years.
Benthic fauna and benthic communities	Fisheries	Considerable reduction in number of trawl hours means considerably less physical impact than in 2005. Improved documentation shows impacts in 2005 were greater than previously believed.	Benthic biomass varies considerably from year to year. Snow crab numbers have risen in the last few years, whereas red king crab numbers have dropped. Some benthic animals (e.g. corals, sponges, sea pens) show impacts of trawling.
	Maritime transport	No change registered	
	Petroleum activities	Higher level of activity, but no change registered	
	External pressures	No change registered	
Fish stocks	Fisheries	Illegal, unreported and unregulated (IUU) fishing reduced Stocks of commercially important species have risen after more than 20 years' work to build up a sustainable management regime	Major fish stocks are at high levels and are being harvested sustainably. Some smaller stocks still low because of earlier overfishing. Fishing pressure still considered to be too high for two species (golden redfish and coastal cod).
	Maritime transport	No change registered	
	Petroleum activities	Greater seismic activity with short-term scare effects on fish	
	External pressures	No change registered	

Table 6.1 cont.

Ecosystem component	Pressure	Change in impact from 2005 to 2009	State 2009
Seabirds	Fisheries	No change registered	Severe decline in several seabird populations. Decline was limited to the south-western part of the management plan area for many years, but Svalbard populations are now declining as well.
	Maritime transport	No change registered	
	Petroleum activities	No change registered	
	External pressures	Pollutants: levels of certain substances declining, others relatively stable	
Marine mammals	Fisheries	Harvest reduced More data has resulted in higher estimates of common porpoise bycatch in certain areas	Reproductive failure in populations of ice-dependent seal species because of low sea ice extent in years preceding 2009. For some species, harvest and bycatch levels are not sustainable. Minke whale is harvested sustainably.
	Maritime transport	Estimates for effects of noise revised upwards in response to new data More knowledge of risk of collisions	
	Petroleum activities		
	External pressures	Rising temperature Pollutants: declining concentrations of PCBs, stagnation for DDT	
Vulnerable and endangered species	Fisheries	Impacts on benthos believed to be reduced since 2005, but new data shows damage from trawling to be greater than earlier surveys showed.	Threatened/near-threatened species in the management plan area belong to various species groups. The following seabirds are on the 2010 Norwegian Red List and a substantial proportion of the Norwegian population is found within the management plan area: common guillemot, Brünnich's guillemot, black guillemot, puffin, razorbill and kittiwake
	Maritime transport	No change registered	
	Petroleum activities	No change registered	
	External pressures	No change registered	
Alien species	Fisheries	Reduction in red king crab numbers	Estimates of total red king crab population somewhat lower for 2009 than for 2008. Uncertain whether snow crab has spread naturally or been introduced to Barents Sea. Numbers are rising.
	Maritime transport	No change registered	
	Petroleum activities	No change registered	
	External pressures	Rising temperature	

Table 6.1 cont.

Ecosystem component	Pressure	Change in impact from 2005 to 2009	State 2009
Safe seafood	Fisheries	No change registered	Generally low levels of pollutants in seafood in the management plan area, but maximum level for sum dioxins and dioxin-like PCBs found to be exceeded in Greenland halibut and cod liver. Greenland halibut: EU maximum levels for placing on the market exceeded in fish taken northwest of Trænabanken and along the edge of the continental shelf off the Lofoten Islands. Cod liver: levels close to the EU maximum found in fish from certain localities.
	Maritime transport	No change registered	
	Petroleum activities	No change registered	
	External pressures	No change, but more information obtained	
Ecosystem as a whole	Synergistic effects	Fisheries: less impact on fish stocks and benthic fauna. Up to 2009: little known about impacts of maritime transport and petroleum activities, but believed to be small. External pressures: rising temperature and shrinking ice cover over the past 30 years. Trend is continuing. Uncertainties and poor documentation of several factors make it impossible to draw reliable conclusions about the cumulative effects of human activity on the ecosystem as a whole.	State of the ecosystem generally good, low pollution levels. Important exceptions are serious decline in populations of several seabirds, low levels of certain fish stocks as a result of earlier overfishing and reproductive failure in ice-dependent seal species in recent years. The latter may be the first observable effect of climate change on the ecosystem in the management plan area.

6.4 Progress towards objectives and targets

The management plan is a tool for both facilitating value creation and maintaining the high environmental value of the area. The Government's overall objectives are as follows:

– management of the Barents Sea–Lofoten area will promote sustainable use of the area and its resources to the benefit of the region and the country in general;
– the management regime will ensure that activities in the area do not threaten the natural resource base and thus jeopardise opportunities for future value creation;
– the management regime will facilitate economically viable commercial activities and as far as possible promote value creation and employment in the region;

- management of commercial activities in the area will be coordinated to ensure that the various industries are able to coexist and that the overall level of activity is adjusted to take account of environmental considerations;
- harvesting of living marine resources will promote value creation and secure welfare and business development to the benefit of the country as a whole;
- living marine resources will be managed sustainably through the ecosystem approach;
- petroleum activities will promote value creation and secure welfare and business development to the benefit of the country as a whole;
- steps will be taken to facilitate the profitable production of oil and gas on the basis of health, environment and safety requirements and standards that are adapted to environmental considerations and the needs of other industries;
- favourable conditions will be provided for safe, secure and effective maritime transport that takes account of environmental considerations and promotes value creation in the region.

In the 2006 management plan, the Government set objectives and targets for the period up to 2020 for various issues, including hazardous substances and radioactive substances, operational discharges, litter, safe seafood, management of the risk of acute pollution, management of particularly valuable and vulnerable areas and habitats, species management and conservation of marine habitat types.

The objectives and targets in the management plan are intended to express its purpose in more specific terms. A number of them will also give substance to the management objectives for species and habitat types in the Nature Diversity Act for activities and measures in specific sectors, and the management principle and fundamental considerations set out in the Marine Resources Act .

The 2006 management plan set out the objectives and targets listed below as a basis for management of the Barents Sea–Lofoten area up to 2020. In addition, relevant national goals will apply. The rest of this chapter lists the objectives and targets and provides a brief account of progress towards them.

6.4.1 Biodiversity

The Government has set the following objective for biodiversity in the Barents Sea–Lofoten area:

> *Management of the Barents Sea–Lofoten area will ensure that diversity at ecosystem, habitat, species and genetic levels, and the productivity of ecosystems, are maintained. Human activity in the area will not damage the structure, functioning, productivity or dynamics of ecosystems.*

Under this objective there are targets for specific areas, which are discussed below.

Management of particularly valuable and vulnerable areas and habitats

> *Activities in particularly valuable and vulnerable areas will be conducted in such a way that the ecological functioning and biodiversity of such areas are not threatened.*
>
> *Damage to marine habitats that are considered to be threatened or vulnerable will be avoided.*
>
> *In marine habitats that are particularly important for the structure, functioning, productivity and dynamics of ecosystems, activities will be conducted in such a way that all ecological functions are maintained.*

The target of conducting activities in particularly valuable and vulnerable areas in such a way that their ecological functioning and biodiversity are not threatened has been achieved for some of these areas (marginal ice zone, polar front, waters around Svalbard). In other areas (area off the Lofoten Islands to the Tromsøflaket, the Tromsøflaket, Eggakanten, the 50-km zone along the coast of Finnmark) it is uncertain whether the target has been achieved. Some smaller fish stocks are at low levels because of earlier overfishing. However, even when rebuilt, these smaller stocks will only make up a small proportion of the fish resources in these areas measured as biomass. In addition, trawling has caused damage to coral reefs, sponge communities and sea pens. The target of avoiding damage to marine habitats that are considered to be endangered or vulnerable has not been achieved, but a considerable reduction in the number of trawl hours has been registered, which means that the physical impacts of fisheries have been reduced since 2005. In autumn 2009, an area called «Korallen» northwest of Sørøya island in Finnmark was protected against bottom trawling under the Marine Resources Act. It is unclear whether human activity in particularly valuable and vulnerable areas also explains the severe decline that has been observed in a number of seabird populations.

Species management

> *Naturally occurring species will exist in viable populations and genetic diversity will be maintained.*
>
> *Harvested species will be managed within safe biological limits so that their spawning stocks have good reproductive capacity.*
>
> *Species that are essential to the structure, functioning, productivity and dynamics of ecosystems will be managed in such a way that they are able to maintain their role as key species in the ecosystem concerned.*
>
> *Populations of endangered and vulnerable species and species for which Norway has a special responsibility will be maintained or restored to viable levels as soon as possible. Unintentional negative pressures on such species as a result of activity in the Barents Sea–Lofoten area will be reduced as much as possible by 2010.*
>
> *The introduction of alien organisms through human activity will be avoided.*

The target that naturally occurring species will exist in viable populations has been achieved for cod, haddock, saithe, capelin, herring and marine mammals. Other fish stocks (golden redfish, beaked redfish, Greenland halibut and coastal cod) have been at low levels and have therefore not reached their full reproductive potential. This target has not been achieved for seabird populations. In 2005, there was extensive illegal, unreported and unregulated (IUU) fishing of Northeast Arctic cod. Norway took the initiative for cooperation with other countries to reduce fishing pressure. This was successful, and IUU fishing has been greatly reduced. Norway has well-established arrangements for cooperation with Russian fisheries authorities on the management of Northeast Arctic cod through the Joint Norwegian–Russian Fisheries Commission. This includes everything from determining total allowable catches to setting gear restrictions. In 2006, the Commission adopted a harvest control rule to ensure sustainable management of the cod stock, which has been evaluated by the International Council for the Exploration of the Sea (ICES) as being in accordance with the precautionary approach and the goal of maintaining a high long-term yield. In 2010, ICES found that the size of the spawning stock was satisfactory and that it was being harvested sustainably. Thus, as of 2010 the management regime appears to be successful.

Given the condition of the stocks and on the advice of the Institute of Marine Research and ICES, protection measures have been introduced for coastal cod to limit both commercial and recreational fishing. The first of these were introduced in May 2004, and they have since been expanded and adjusted. ICES has recommended that no coastal cod should be harvested until a plan for rebuilding the stocks has been established. As one step in the establishment of a sound management regime for cod in coastal areas, the Ministry of Fisheries and Coastal Affairs adopted a plan for rebuilding coastal cod stocks north of 62°N in spring 2010. This sets out changes in conservation measures to take effect from 2011.

The target of managing species that are essential to the structure, functioning, productivity and dynamics of ecosystems in such a way that they are able to maintain their role as key species in the ecosystem is considered to have been achieved for capelin, cod and juvenile herring (these are defined as key species).

The target of maintaining populations of threatened species and species for which Norway has a special responsibility or restoring them to viable levels as soon as possible has not been achieved. Populations of many such species are not considered to be viable at present. The target of avoiding the introduction of alien species through human activity has not been achieved. The Ballast Water Convention has not entered into force, and rules have not yet been drawn up to prevent the spread of organisms on ships' hulls. Regulations for the management of ballast water in Norwegian waters have been adopted. There is uncertainty as regards the nature and level of risk associated with alien species and which species are in fact being introduced to the management plan area. Norway is managing the red king crab in accordance with a white paper on the subject (Report No. 40 (2006–2007) to the Storting). The current management regime is to be evaluated to see whether it is preventing further spread of the species. The snow crab is expanding its range in the Barents Sea, but it is uncertain whether this species is introduced or has spread naturally to the area.

Conservation of marine habitat types

> *A representative network of protected marine areas will be established in Norwegian waters, at the latest by 2012. This will include the southern parts of the Barents Sea–Lofoten area.*

Norway's network of marine protected areas will consist of marine protected areas that are included in the marine protection plan and other relevant processes.

6.4.2 Pollution

The Government has set the following objective for preventing and combating pollution in the Barents Sea–Lofoten area:

> *Releases and inputs of pollutants to the Barents Sea–Lofoten area will not result in injury to health or damage the productivity of the natural environment and its capacity for self-renewal. Activities in the area will not result in higher levels of pollutants.*

Under this objective there are targets for specific areas, which are discussed below.

Hazardous substances and radioactive substances

> *Environmental concentrations of hazardous and radioactive substances will not exceed the background levels for naturally occurring substances and will be close to zero for man-made synthetic substances. Releases and inputs of hazardous or radioactive substances from activity in the area will not cause these levels to be exceeded.*

Levels of hazardous substances and radioactive substances, including various man-made substances, measured in the management plan area are generally low. However, some animal species at the top of food chains have accumulated high levels of pollutants. The target that concentrations of these substances will not exceed the background levels for naturally occurring substances and will be close to zero for man-made synthetic substances has not been achieved so far.

Operational discharges

> *Operational discharges from activities in the area will not result in damage to the environment or elevated background levels of oil or other environmentally hazardous substances over the long term.*

Environmental monitoring shows that there are generally no elevated concentrations of hydrocarbons or metals in sediments, and that the benthic fauna at all measuring stations is undisturbed. There should be no discharges to the sea from oil and gas activities. The rules on operational discharges from ships are so strict that no observable damage is expected as long as the rules are followed. However, illegal releases of pollutants from ships do occur. The possibility of damage from such incidents cannot be excluded, but the scale of such releases and their impacts are unknown.

Litter

> *Litter and other environmental damage caused by waste from activities in the Barents Sea–Lofoten area will be avoided.*

In the management plan area, marine litter is at present only systematically registered on selected beaches in Svalbard. There have been no systematic observations of marine litter on the shoreline of mainland Norway in the period 2005–09. Litter is still a problem along the coast in the management plan area. This target has not yet been achieved.

6.4.3 Safe seafood

The Government has set the following objective for safe seafood in the Barents Sea–Lofoten area:

> *Fish and other seafood will be safe and will be perceived as safe by consumers in the various markets.*

Levels of various hazardous substances in polar cod, shrimps and capelin, and in muscle meat of cod are not a problem, but average values for the sum of dioxins and dioxin-like PCBs in cod liver in samples from certain localities are close to the statutory maximum level for human consumption set by the EU and Norway. These maximum limits came into effect after 2005. Measurements show that levels are close to the maximum permitted concentrations in both coastal and non-coastal areas of the Barents Sea. Reliable documentation is required to assess progress towards the objective for safe seafood. At present the data are insufficient, but sampling over time and baseline studies of the different food species will provide the necessary documentation. Documentation has already been obtained for Norwegian spring-spawning herring, Greenland halibut and mackerel and will shortly be available for cod and saithe north of 62°N. At present, there is considered to be a risk that maximum permitted levels of contaminants in fish for human consumption may be exceeded in several species and products, including Greenland halibut and cod liver.

6.4.4 Risk of acute pollution

The Government has set the following objectives for management of the risk of acute pollution in the Barents Sea–Lofoten area:

> *The risk of damage to the environment and living marine resources from acute pollution will be kept at a low level and continuous efforts will be made to reduce it further. Activity that involves a risk of acute pollution will be managed with this objective in mind.*
>
> *Maritime safety measures and the oil spill preparedness and response will be designed and dimensioned to effectively keep the risk of damage to the environment and living marine resources at a low level.*

In 2005, the risk of incidents that might result in acute pollution from oil and gas activities was assessed as low in the management plan area. In the period 2005–10, a range of processes and projects that can reduce the risk level have been identified. However, risk management in certain areas needs to be improved, and some factors have been identified that could result in a higher risk level. All in all, however, no information has been obtained during the period that indicates that the 2005 assessment should be changed. Maritime traffic in the area has increased, but at the same time various measures have been introduced to reduce the probability of accidents that could result in acute pollution. Various measures have been introduced to strengthen preparedness and response to acute pollution from petroleum activities and shipping, but further work is needed to achieve the objectives.

An increase in traffic of nuclear-powered vessels and the possibility of new activity in connection with floating nuclear power plants has resulted in a higher probability of an incident leading to releases of radioactivity. On the other hand, various risk-reduction measures have been initiated or completed by Russia. Norway has played an active role in and supported this work. In addition, Norway's nuclear emergency response system has been strengthened and expanded to include Svalbard and Jan Mayen. The probability of an accident is low, and this will continue to be the case. However, the environmental consequences of an accident would be serious.

7 New measures for the conservation and sustainable use of ecosystems

The 2006 management plan for the Barents Sea–Lofoten area (Report No. 8 (2005–2006) to the Storting) set out a number of measures to ensure integrated, ecosystem-based management of the area, reduction of pollution, and protection of biodiversity. This white paper describes how the measures are to be continued, supplemented and updated. The Government's assessments and conclusions are based on new knowledge about the environment and natural resources, current trends, and projections relating to the environment, industries, socioeconomic conditions and risk levels.

The management plan clarifies the overall framework and encourages closer coordination and clear priorities for management of the Barents Sea–Lofoten area. It increases predictability and facilitates coexistence between different industries. New data, particularly on benthic conditions and seabirds, confirms and strengthens the scientific basis for identification of the particularly valuable and vulnerable areas specified in the 2006 management plan. These are areas that are important both locally and for ecosystem functioning in the entire management plan area. Surveys have built up knowledge about oil and gas resources in the waters off the Lofoten and Vesterålen Islands and Senja.

In the 2006 management plan, the Government stated that it considered the state of the environment in the Barents Sea–Lofoten area to be generally good, and this is still the case today. In the Government's view, and on the basis of existing knowledge, the main tasks in the period between now and 2020 will be related to long-range transboundary pollution, climate change and ocean acidification, the decline in seabird populations, the risk of acute oil pollution, and further development of the different elements of an ecosystem-based management regime.

Human activity in the management plan area is expected to increase in future, and the cumulative environmental effects of different activities, climate change and ocean acidification on ecosystems in the area are uncertain. The pace of climate change and ocean acidification is higher than previously expected. This may result in more marked cumulative environmental effects in the years ahead, and means that it is important to introduce management measures that increase the resilience of the ecosystem. The Government will continue the development of an integrated ecosystem-based management regime for the Barents Sea–Lofoten area through the present update of the management plan and the measures described here during the period before an overall revision of the plan in 2020.

7.1 Management and protection of habitat types

7.1.1 Protection of the benthic fauna

A range of vulnerable benthic fauna types have been registered during mapping of the seabed under the MAREANO programme; these include coral reefs, gorgonian forests, sponge communities and sea pen communities. The introduction of measures to protect benthic habitats that are or may be of great importance for the Barents Sea–Lofoten ecosystem must be assessed regularly. Vulnerable and threatened habitat types have been registered during mapping of the seabed, and damage caused by bottom gear that is towed along the seabed has also been recorded. There are thought to be important coral, sponge and sea pen communities in certain areas that have not yet been mapped. The edge of the continental shelf north of the section that has already been mapped is one area where there is a high probability of finding coral reefs and other benthic communities. Giving priority to mapping such areas will make it possible to avoid damage to coral reefs and other important habitats that are intact at present.

The Government will:

– ensure that mapping of the seabed in the Barents Sea–Lofoten area continues, with the target of completing this by 2020;

- give priority to mapping of the seabed along the edge of the continental shelf and in other areas where there is a high probability of finding coral habitats or other vulnerable benthic organisms or habitat types;
- introduce general legislation for Norwegian sea areas requiring vessels that use bottom trawls and other gear that is towed along the seabed to leave the area where they are fishing if bycatches of sponges and corals exceed specified quantities;
- ensure that updated maps and other information on coral reefs and other vulnerable benthic animals are available;
- establish routines for regular evaluation of measures and routines to protect reported or mapped coral habitats, sponge communities, sea pen communities and other vulnerable benthic organisms or habitat types.

7.1.2 Marine protected areas

The establishment of marine protected areas is an important spatial management tool in an integrated marine environmental policy. Under the Convention on Biological Diversity, a target has been set for at least 10 % of coastal and marine areas to be protected by 2020. The ongoing work on marine protected areas under the Marine Resources Act and on the marine protection plan will be the most important contributions towards Norway's achievement of this target.

The Government will:
- draw up a strategy for achieving targets for the protection of marine areas under the Convention on Biological Diversity.

7.2 Management and protection of species

7.2.1 Protection of seabirds

Norway has a special responsibility for the management of several seabird species because their Norwegian populations make up a substantial proportion of the European or North Atlantic populations. The Norwegian seabird populations are much the largest in the Northeast Atlantic region. More than 2 million pairs of seabirds breed along the coast from the Lofoten Islands to the Russian border – this is 80 % of all seabirds in Norway (excluding Svalbard and Jan Mayen). Røst and Gjesvær house the largest seabird colonies in continental Europe. Seabirds are monitored through the SEAPOP programme.

Populations of several seabird species are declining in the Barents Sea–Lofoten area. The common guillemot and black-legged kittiwake are showing a particularly serious decline, especially in the southwestern part of the management plan area. The situation for the common guillemot is so serious that it may only be a question of time before it is lost as a breeding species from many colonies along the Norwegian coast. The situation has been better further north in the Barents Sea, but the Brünnich's guillemot population is now declining in this area, and there are signs of a decline in the kittiwake population as well. Further knowledge is needed on the reasons for the declining numbers, and action must be taken if it is found that pressure from human activities is causing problems for seabirds.

The Government will:
- further develop systematic monitoring of the most important seabird populations;
- build up knowledge of the reasons for the decline in seabird populations;
- ensure that management of living marine resources is based on ecosystem considerations;
- establish a working group of seabird experts and marine scientists to investigate the links between the decline in many seabird populations and their food supplies, and suggest measures to improve food availability for seabirds;
- survey the scale of bycatches of seabirds by fishing vessels;
- review methods and technological solutions for reducing bycatches of seabirds and the extent to which they are being used;
- consider the introduction of specific requirements relating to gear and catch methods in fisheries or areas where bycatches of seabirds are a problem.

7.2.2 Sustainable harvesting

The objective of Norwegian fisheries management is that all fisheries should be sustainable. The Norwegian fisheries management regime is today considered to be one of the best in the world. The major fish stocks in the Barents Sea, which are important in both economic and ecological terms, are at sustainable levels. However, certain other stocks are currently not in a very healthy condition. Special management strategies are proposed for these stocks in order to rebuild them and ensure that they can be harvested sustainably in the future. In some cases, particularly for economic reasons, it will be necessary to permit harvesting on a scale that will prolong the time needed to rebuild a particular stock.

Fisheries have an impact on marine ecosystems. Satisfactory knowledge of individual stocks and their interactions with other species in the food chains and other parts of the ecosystem is essential to ensure sustainable harvesting of living marine resources. The most important fish stocks in the Barents Sea are shared between several nations, and annual quotas for each country are negotiated on the basis of advice from the International Council for the Exploration of the Sea (ICES). It is only possible to harvest sustainably from healthy ecosystems, and these in turn are dependent on biodiversity. It will therefore be important to increase the proportion of commercially exploited stocks that are surveyed, monitored and harvested in accordance with sustainable management strategies. This approach must be reflected in Norway's efforts to ensure that the International Council for the Exploration of the Sea (ICES) can set precautionary reference points for the spawning stocks of all harvested species and stocks.

The Government will:

– further develop systematic monitoring and management of living marine resources in accordance with the Marine Resources Act;
– continue steps to rebuild fish stocks that are in poor condition, particularly coastal cod, golden redfish, beaked redfish and blue ling.

7.3 New framework for petroleum activities in the Barents Sea–Lofoten area

In the 2006 management plan, the Government stated that it considered the state of the environment in the Barents Sea–Lofoten area to be generally good, and this is still the case today. In the Government's view, and on the basis of existing knowledge, the main tasks in the period between now and 2020 will be related to long-range transboundary pollution, climate change and ocean acidification, the decline in seabird populations, the risk of acute oil pollution, and further development of the different elements of an ecosystem-based management regime.

The Government will continue to use the system of management plans for sea areas. An overall framework for petroleum activities will be established in the management plan for each sea area.

In assessing the framework for petroleum activities in the Barents Sea and the waters off the Lofoten Islands, the Government has taken into account the importance of these areas in environmental and fisheries terms and their potential importance in terms of petroleum resources. On this basis of this assessment, the Government will maintain oil and gas exploration activities, and will give the oil industry access to areas of potential interest within an environmentally sound framework. We will generate more knowledge of the northeastern part of the Norwegian Sea, carry out an environmental impact assessment for the southern part of the Barents Sea, and pave the way for petroleum production in the areas that have been opened.

The Government has agreed that the following framework for petroleum activities is to apply within the Barents Sea–Lofoten management plan area:

1. *The north-eastern Norwegian Sea (Nordland I, III, IV, V, VI and VII, and Troms II)*
   – There will be no petroleum activities in the open parts of Nordland VI during the current parliamentary period. Nor will any new blocks be announced during this period. The need to update the knowledge base for the opened areas will be considered in connection with the development of knowledge about the unopened areas.
   – No impact assessment will be carried out under the Petroleum Act for Nordland VII and Troms II or the unopened parts of Nordland IV, V and VI during the current parliamentary period.
   – The MAREANO programme is to complete the survey of the Nordland VI seabed in 2011, and then continue with the other areas that have not yet been mapped.
   – The SEAPOP programme will complete its survey of seabird populations and intensify monitoring in this area, and improve knowledge of how these populations are affected by human activity.
   – The Ministry of Petroleum and Energy will build up knowledge about potential impacts of petroleum activities in the unopened parts of Nordland IV, V, VI, VII and Troms II. This knowledge would be useful if it is decided to carry out an impact assessment of petroleum activities in these areas and as

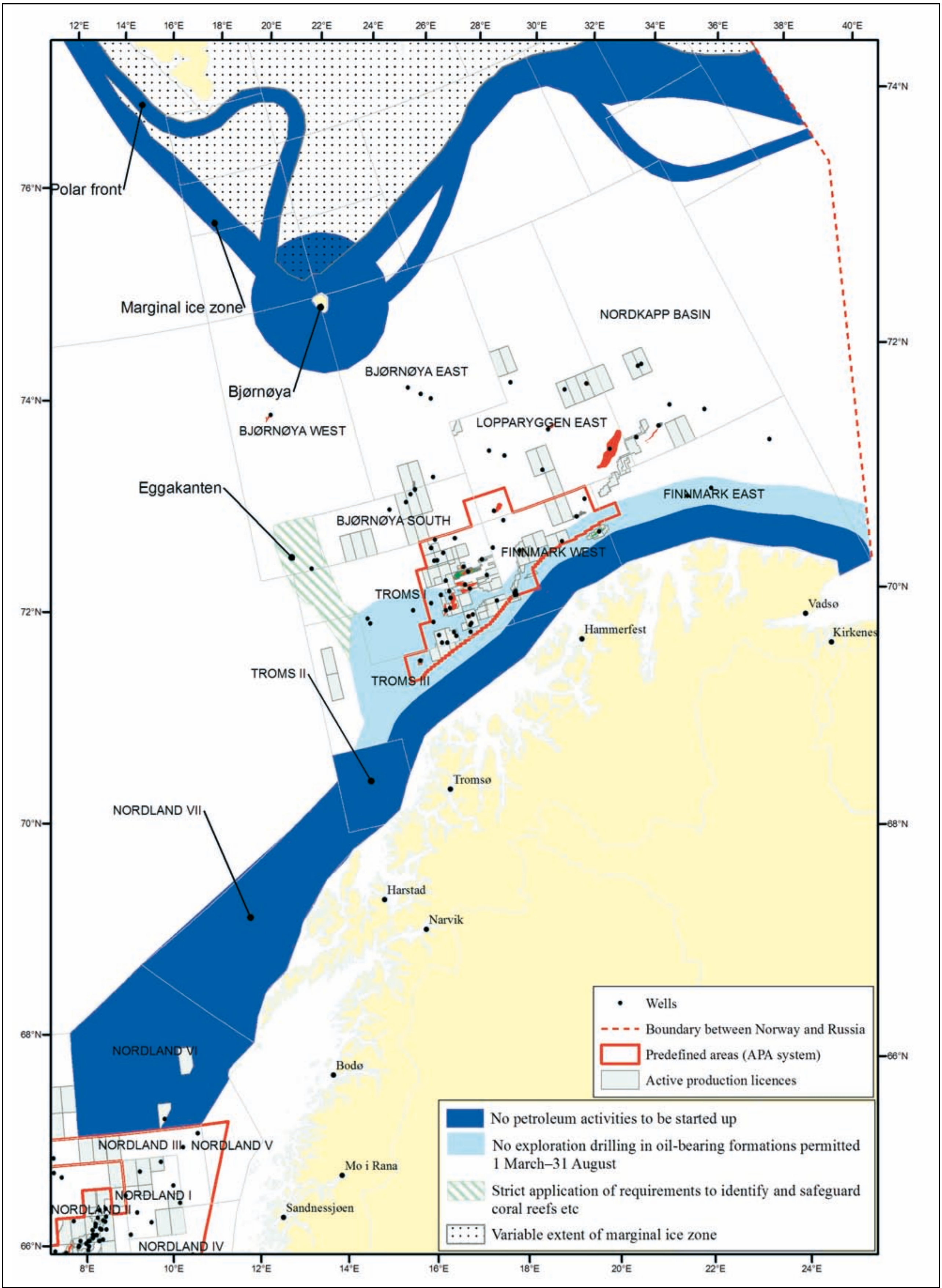

Figure 7.1 Framework for petroleum activities in the Barents Sea–Lofoten area.

Source: Norwegian Petroleum Directorate

a basis for the next update of the management plan. This work will start soon.
It will examine the direct and spin-off effects on society and the business sector of such activities as tourism and fisheries. The topics for consideration will be decided in consultation with regional and local authorities, the authorities in the relevant sectors, and research institutions. It will also be necessary to strengthen knowledge about the petroleum resources in the unopened parts of Nordland IV and V through seismic surveys and the collection of other geological data under the auspices of the Norwegian Petroleum Directorate and in dialogue with the fisheries industry and the fisheries authorities. The Petroleum Directorate will collate this data and relevant seismic data from Nordland VI, VII and Troms II, and offer data packages for sale.

- The Ministry of Trade and Industry, the Ministry of Fisheries and Coastal Affairs, the Ministry of Local Government and Regional Development and the Ministry of the Environment will develop knowledge of the direct and spin-off effects of expanding commercial activities such as tourism and fishery-related enterprises. The knowledge acquired will be useful for the next update of the management plan. This work will start soon. It will examine the spin-off effects on society and the business sector, and the topics for consideration will be decided in consultation with regional and local authorities.
- The system of awards in pre-defined areas (APA) will be extended to include all the blocks in open parts of Nordland I, III, IV and V. This will apply from APA 2011. The environmental and fisheries-related requirements set out in the management plan for the Norwegian Sea will be applicable.

2. *The Barents Sea*
   a. *Previously disputed area west of the delimitation line*
      - When the Treaty concerning Maritime Delimitation and Cooperation in the Barents Sea and the Arctic Ocean has been ratified by both Norway and Russia, the Government will initiate an impact assessment under the Petroleum Act, with a view to granting production licences for the previously disputed area west of the delimitation line in the southern part of the Barents Sea (south of 74°30' N). If this is justified by the conclusions of the impact assessment, the Government will present a white paper recommending that these areas should be opened for petroleum activity.
      - The MAREANO programme will map the seabed in the previously disputed area west of the delimitation line, in accordance with the treaty on maritime delimitation between Norway and Russia.
   b. *Along the coast of Troms and Finnmark to the Russian border*
      - No petroleum activities will be initiated in the current parliamentary period within a zone stretching 35 km outwards from the baseline from the Troms II petroleum province along the coast to the Russian border.
      - No exploration drilling will be permitted in oil-bearing formations in the zone 35–65 km from the baseline in the period 1 March–31 August.
   c. *Tromsøflaket bank area*
      - The restrictions given in 2 b) for the coastal zone also apply to the Tromsøflaket.
      - No exploration drilling will be permitted in oil-bearing formations on the Tromsøflaket outside 65 km from the baseline in the period 1 March–31 August.
   d. *The Eggakanten area along the edge of the continental shelf*
      - There is a general principle that new production licences must include requirements for surveys to identify any coral reefs or other valuable benthic communities that may be affected by petroleum activities and ensure that they are not damaged. This will be particularly strictly applied in the Eggakanten area. In vulnerable areas, special conditions may be included in licences to avoid damage.
   e. *The marginal ice zone and the polar front*
      - No petroleum activities will be initiated in the areas along the edge of the marginal ice zone and the polar front in the current parliamentary period.
   f. *Bjørnøya*
      - No petroleum activities will be initiated within a 65-km zone round Bjørnøya in the current parliamentary period.

3. *Discharges to the sea*
   – Discharges to the sea from petroleum activities will be regulated in the same way in the management plan area as on other parts of the Norwegian continental shelf.
4. *Other environmental and fisheries-related requirements*
   – The management plan will be used as a basis for determining environmental and fisheries-related requirements in new production licences. Until the next update of the management plan, no additional environmental and fisheries-related requirements will be introduced for petroleum activities in the Barents Sea–Lofoten area.

7.4 Measures to reduce pollution and marine litter

7.4.1 Preparedness and response to acute pollution

Since 2006, oil spill response technology and expertise has been further developed, and several steps have been taken to strengthen preparedness and response to acute pollution in the management plan area. Preparedness and response is evaluated regularly, for instance on the basis of lessons learned from accidents and government clean-up operations. Experience gained from the operation to deal with the Gulf of Mexico blowout in 2010 (discussed in Chapter 5.1.2 and 5.3) is also relevant in this context.

Legislative requirements and inspection and enforcement by the authorities play an important role for safety standards in the oil and gas industry. The operating companies are responsible for planning and command during oil spill response operations on the continental shelf. Through the Norwegian Clean Seas Association for Operating Companies (NOFO), an agreement with the Norwegian Coastal Administration on limited use of public resources has been adopted. A review is in progress of the need to elaborate some of the existing requirements for the preparedness and response that operating companies must maintain.

To provide an effective emergency response system, adequate vessel resources must be available for use during operations. Fishing vessels and other suitable vessels that are not primarily built as oil spill response vessels are an important resource in this context. To ensure crew safety, new regulations have been drawn up on the equipment and use of such vessels in operations to deal with acute pollution. Both the operating companies and the Norwegian Coastal Administration will conclude agreements with vessels to ensure rapid mobilisation in the event of an accident.

The availability of sufficient material and personnel is important for preparedness and response in coastal waters and along the shoreline. The effectiveness of different methods of dealing with oil spills, including mechanical recovery, the use of dispersants, in situ burning and various beach clean-up techniques, will be further evaluated and reviewed in the light of experience gained in the Gulf of Mexico.

Experience gained during oil spill response operations in Norway shows that operations management and close coordination between the actors involved is of crucial importance when dealing with acute pollution. The establishment of a national contingency plan system to further clarify the roles of public and private actors during operations is therefore important. The US experience of «unified command», an incident command system involving both competent authorities and the polluter, is relevant in this context. Incident command and the organisation of response operations will be improved by the introduction of a common response model for use in dealing with major incidents where the fire, civil defence and acute pollution authorities are all involved.

The Government will:

– encourage the further development of technology for detecting and mapping acute pollution;
– encourage the development of knowledge on chemical dispersants, to provide a better basis for assessing whether to use dispersants as a response method during government-run operations;
– encourage the further development of knowledge on the effects of response measures and the weathering properties of relevant oil types as a basis for preparedness and response planning;
– establish a national preparedness and response system and introduce unified command to improve coordination, understanding of the roles of different actors and incident command;
– survey the personnel and other resources available for prolonged operations in the management plan area;
– survey preparedness and response needs in coastal waters and the shore zone;
– promote the further development of methods of oil recovery and beach clean-up for operations in Arctic conditions, and develop guidelines for beach clean-up operations;

- look more closely at the requirements relating to the municipal response system and inspection and enforcement by the authorities;
- develop response strategies and improve knowledge of the environmental impacts of in-situ burning, the use of dispersants and other response techniques.

7.4.2 Long-range transport of pollutants – international cooperation

Long-range transport of pollutants with air and ocean currents is the main source of pollution in the management plan area. Various organic pollutants released throughout the world are deposited in the Arctic, and changes in the levels of global releases can be detected in this region. Many of these substances are only slowly biodegradable and can therefore accumulate in living organisms and be concentrated along food chains. Impacts of such pollutants have been found in animals at the top trophic level of food chains in most of the Arctic. The immune system of a number of species, including polar bears, glaucous gulls, Arctic char and harp seals, has probably been weakened. Inputs to the Arctic of substances that were first used many years ago, such as PCBs and DDT, have been declining for a long time, but this positive trend has now stagnated. This could be because the substances are still in use in some areas, or it might be due to climate-related factors. In addition, new substances are constantly being detected in the Arctic environment. It often takes time to identify the environmental impacts of new substances, and it can be difficult to find suitable analytical methods. Norway has recently established an environmental specimen bank, which will play an important role by making it possible to re-analyse samples when new analytical methods are developed or new pollutants are identified. The samples stored here will also be important for the establishment of reference and background levels for new pollutants.

Long-range transport of pollutants is one of the key challenges that must be addressed to maintain the Barents Sea as a clean and rich sea.

The Government will:

- ensure that efforts to reduce the use and discharge of hazardous substances are given high priority in development cooperation and in cooperation with Russia;
- play an active part in work under international agreements, including the global Stockholm Convention on Persistent Organic Pollutants and the regional Convention on Long-Range Transboundary Air Pollution, and in ensuring strict regulation and the inclusion of more substances;
- give priority to the negotiation of a global instrument on mercury under the United Nations Environment Programme (UNEP);
- carry out surveys and screening studies to identify new pollutants in the Arctic;
- ensure that samples from studies in the management plan area are stored in the environmental specimen bank.

7.4.3 Marine litter

Marine litter is a problem that has attracted a great deal of attention internationally.

Within the framework of cooperation under the Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention), the goal is to «substantially reduce marine litter in the OSPAR maritime area to levels where properties and quantities of marine litter do not cause harm to the coastal and marine environment». To achieve this, the parties to the OSPAR Convention have agreed on a series of measures. A pilot project to monitor marine litter on beaches in selected countries has had positive results, and OSPAR is now planning to establish a coordinated monitoring programme for marine beached litter by 2014.

A report on the scale and impacts of marine litter in Norwegian coastal and marine areas was published by the Climate and Pollution Agency and the Directorate for Nature Management in February 2011. This concludes that we currently have only limited knowledge about the exact scale and sources of marine litter in Norway, but that we nevertheless know enough to establish that this is a serious environmental problem in Norwegian waters as well. Much of our knowledge comes from beach litter surveys, studies of seabird stomachs, video images of the seabed and studies of microplastics in the Skagerrak. The report also proposes measures to reduce the problem.

A system of reference beaches where beach litter is regularly monitored should be established. Tromsø municipality has received a grant for a pilot project, which was carried out in 2010. This is the first time a survey of this kind has been carried out in Norway, and it is expected to provide useful experience for further efforts to combat marine litter.

The Government will:
- survey the scale of the marine litter problem in the management plan area and its impacts, and consider action to deal with it;
- monitor beached litter in selected areas;
- carry out a project to evaluate waste streams (types and amounts) from ships to land-based reception facilities.

7.5 Strengthening the knowledge base

7.5.1 Mapping the seabed

The MAREANO programme maps depth and topography, sediment conditions, habitats and pollutants in Norwegian waters. The seabed surveys generate a great deal of new information on the distribution of habitats and species and on the pressures due to human activity. This can be used to improve the management regime and provide better protection for vulnerable habitat types. Criteria for setting priorities for future work have been further developed. In further mapping of the Barents and Norwegian Seas, the Government is giving priority to areas where there are or may be important species and habitat types or natural resources that may be affected by existing or new human activities.

The Government will:
- continue the MAREANO programme for mapping of the seabed in Norwegian waters.

7.5.2 Mapping and monitoring seabird populations

SEAPOP is a mapping and monitoring programme for seabird populations in Norwegian waters. Its purpose is to obtain and maintain baseline information on seabirds and thus help to improve management of the marine environment. It focuses particularly on the collection of data that make it possible to model the effects of human activity and distinguish between these and natural variations. This will make it possible to improve the management and protection of seabirds. It is important to continue knowledge development through programmes that investigate such causal relationships.

The Government will:
- intensify mapping and monitoring of seabirds in Norwegian waters, along the coast and in Svalbard and Jan Mayen through the SEAPOP programme.

7.5.3 Mapping and monitoring pollution

The coordinated monitoring programme for the Barents Sea–Lofoten area has provided a better overview of the pollution status of the management plan area. The established monitoring programmes for pollutants are important in building up knowledge about pollution and hazardous substances in Norwegian seas and seafood. Such knowledge is needed both for management of ecosystems and species and to make it possible to document that consumption of seafood from Norwegian waters is safe.

The Government will:
- further develop pollution monitoring programmes;
- continue to map and monitor contaminants in marine species.

7.5.4 Climate change and ocean acidification

Climate change and ocean acidification are the most serious challenges that will have to be addressed in the time ahead. Ocean acidification may have major impacts on ecosystems at our latitudes. It is therefore of crucial importance to obtain more information on trends in acidification and the impacts of acidification on individual species, on biodiversity and on the biological availability and uptake of hazardous substances. More knowledge is also needed about the synergistic effects of interactions between ocean acidification and climate change.

To meet these needs, it will be essential to put in place a long-term programme with adequate coverage to monitor changes in ocean acidity and the impacts of these changes. This is needed both to gain an overview of the scale of the problem and to provide projections of future trends.

New challenges will arise as regards the management of previously ice-covered areas that become ice-free as a result of climate change. The Government will address these challenges by obtaining the necessary knowledge before new activities are initiated in such areas.

The Government will:
- intensify monitoring of ocean acidification and climate change;
- build up knowledge of the pace and impacts of climate change, which processes create irreversible change, how resilient the Barents Sea–Lofoten area is to change, the impacts of ocean acidification on marine ecosystems, and how

these developments contribute to the cumulative environmental effects on ecosystems;

- intensify knowledge development on the impacts of ocean acidification and climate change, focusing on developing and using good impact indicators;
- ensure that adequate knowledge on ecosystems and ecological goods and services is obtained before new activities are initiated in previously ice-covered areas.

7.5.5 Synergistic effects of interactions between pollutants, climate change and ocean acidification

There is little information available on the synergistic effects of interactions between hazardous substances or between hazardous substances and other factors such as ocean acidification and climate change. The latter will be a key topic in future work, and is an area where there is an urgent need for knowledge.

The Government will:

- take steps to generate knowledge on the ecological relationships between different parts of marine ecosystems;
- develop more knowledge on the cumulative environmental effects of different environmental pressures (such as climate change, ocean acidification and hazardous substances) and human activities (including fisheries, shipping, oil and gas activities);
- ensure that knowledge is developed on the synergistic effects of interactions between ocean acidification, climate change and pollutants;
- develop knowledge on the synergistic effects of interactions between different hazardous substances.

7.5.6 Environmental risk analysis

Further work is needed on the development of criteria for selecting scenarios to be used in environmental risk analysis of potential oil spills.

The knowledge base on the consequences of oil spills for fish stocks has been further developed, and data on several factors that determine environmental impacts and environmental risk have been updated. However, the methods for analysing the environmental consequences and environmental risk of acute oil pollution for fish, seabirds, marine mammals and beaches need to be further developed and improved. Work should be continued on developing methods of calculating the loss of recruitment to year classes of fish that handle spatial variations in survival from larvae to adult fish in a biologically sound way. More precise knowledge of annual variations in migration paths and spawning areas has been mentioned as one factor that could reduce the uncertainty of environmental risk analysis.

The Government will:

- ensure that knowledge development in the field of environmental risk is continued.

7.5.7 Development of indicators

So far, most of the indicators that have been developed tell us something about the state of the ecosystem, for example about population sizes or the distribution and concentrations of hazardous substances in marine animals and plants. Knowledge of the state of the environment has not been linked to any great extent to the pressures on the ecosystem and the impacts these have on different components of the ecosystem. To develop a more complete indicator set, an initiative to develop pressure and impact indicators is proposed. The development of biological effect monitoring is a key part of cooperation under the OSPAR Convention, and is expected to generate new knowledge that will be useful in developing biological effect monitoring in Norwegian sea areas. An indicator set that includes pressure and impact indicators as well as state indicators will improve the evaluation of targets. It is also important to ensure that changes registered through the environmental monitoring system are followed up by appropriate action if the indicator values indicate deviations from the desired state.

The Government will:

- continue the work of developing representative indicators, reference values and action thresholds for the monitoring system under the management plan;
- develop impact and pressure indicators that can also be used to assess progress towards targets;
- ensure that if action thresholds for indicators are exceeded, this elicits an assessment of the appropriate action to take.

7.5.8 Cooperation with Russia on the marine environment – establishing a basis for an integrated Norwegian-Russian environmental monitoring programme for the Barents Sea

Cooperation on the marine environment is the most important element of environmental cooperation between Norway and Russia, and is intended to play a part in protection of the marine environment of the Barents Sea.

An increase in environmental pressures in the Barents Sea is expected, particularly in connection with the expansion of oil and gas activities, fisheries and maritime transport. The impacts of both climate change and ocean acidification may increase. The cumulative environmental effects may be substantial, which will increase the need for Norway and Russia to coordinate their efforts. Within the framework of Norwegian-Russian cooperation on the marine environment, work is now in progress on establishing a basis for an integrated Norwegian-Russian monitoring programme for the entire Barents Sea. This will be based on the joint Norwegian-Russian environmental status report for the Barents Sea, which was presented in 2009. An integrated environmental monitoring programme would put the authorities in the two countries in a better position to meet the needs and challenges involved in making the transition to an integrated, ecosystem-based monitoring system for the Barents Sea. An integrated monitoring programme for the Barents Sea will be a natural continuation of Norway's work with management plans for its sea areas. It can also make a valuable contribution to the formulation of a corresponding plan for the Russian part of the Barents Sea. The Government intends to further develop its cooperation with Russia on the marine environment, and will focus on developing the necessary knowledge base and an integrated and as far as possible joint approach to sound management of the Barents Sea.

The Government will:

- cooperate with Russia on the establishment of an integrated Norwegian-Russian monitoring programme for the Barents Sea, particularly with the aim of assisting in the development of a Russian management plan for the Russian part of the Barents Sea.

7.5.9 Dissemination activity

The website miljøstatus.no is a national channel for dissemination of environmental information. Steps have recently been taken to ensure that the information it provides on marine management is tailored to user needs. The website is the joint responsibility of the environmental authorities, and the Climate and Pollution Agency has the overall editorial responsibility. For the topic «marine and inland waters», special cooperation agreements have been drawn up with the Institute of Marine Research, the Norwegian Coastal Administration and the Geological Survey of Norway. These enable important actors to upload information directly to miljøstatus.no. Close cooperation has been established as a basis for providing comprehensive information on work on the management plans.

The Government will:

- disseminate information on the management plans and their development on the website www.miljøstatus.no and in other ways.

8 Economic and administrative consequences

This white paper discusses the further development of policy instruments and specific new measures. Management of Norway's sea areas will be based on the best possible knowledge, and the intention is to strengthen the knowledge base for ecosystem-based management of the Barents Sea–Lofoten area through mapping, monitoring and research.

The economic and administrative consequences of the measures proposed in the white paper can be predicted with varying degrees of accuracy, but as the proposals are implemented, the consequences for public and private actors will be assessed in the usual way as set out in the Instructions for official studies and reports and the preparation of legislation.

Follow-up of measures that require allocations will be considered by the Government in the ordinary budgetary processes, and presented in the budget propositions of the ministries concerned. The Government will also evaluate the measures in the management plan in relation to other priorities. Follow-up of measures in the years to come will depend on economic developments and the budget situation.

The following is a preliminary assessment of the economic and administrative consequences of the proposals put forward in this white paper.

8.1 Assessment of measures for integrated ecosystem-based management

Integrated monitoring system for the Barents Sea–Lofoten area

The costs relating to the further development of the monitoring system for the Barents Sea–Lofoten area will be considered in more detail in connection with the annual budget proposals. A great deal of the work of developing the monitoring system will take place within the framework of the research and monitoring already being conducted in the management plan area.

The Marine Pollution Monitoring Programme plays an important role in building up knowledge about pollution and hazardous substances in Norwegian waters. Such knowledge is valuable both for management of ecosystems and species and for assessing the safety of seafood from Norwegian waters. Allocations to the programme will be considered further in connection with the annual budget proposals.

Mapping programmes

The Government intends to continue to improve the level of knowledge by continuing the MAREANO programme for mapping of the seabed in Norwegian waters. Such surveys generate new information on the distribution of habitats and species and on the pressures and impacts associated with human activity, and are necessary for developing tools that will ensure sustainable use of such areas.

In 2011, NOK 52.5 million was set aside in the budget for the MAREANO programme. The Government will consider the annual allocations for further implementation of the programme in connection with the annual budget proposals.

The Government will continue mapping and monitoring of seabirds in Norwegian waters, along the mainland coast and in Svalbard and Jan Mayen through the SEAPOP programme. The annual allocations for further implementation of the programme will be considered in connection with the annual budget proposals.

Knowledge about climate change and ocean acidification

Allocations for measures to improve knowledge on climate change and ocean acidification will be considered in connection with the annual budget proposals.

Knowledge about synergistic effects of different factors on the ecosystem

There is little information available on the synergistic effects of interactions between hazardous substances and between hazardous substances and other factors such as ocean acidification and climate change. Nor do we know the cumulative effects of the hazardous substances to which marine organisms are exposed. Ocean acidification and climate change also have effects on marine organisms, and there are considerable gaps in our knowledge about the synergistic effects of climate change, ocean acidification and hazardous substances. Knowledge-building in this field requires environmental monitoring and research, and the Government will consider priorities in this field in connection with the annual budget proposals.

Protection of the benthic fauna

The Government believes that there is a need for special protection measures for vulnerable benthic fauna, and restrictions on bottom trawling, which can damage vulnerable habitats on the seabed, are being proposed. This will be profitable and sustainable over the long term because it will protect areas that are important for marine biodiversity and that have important ecological functions, for example as spawning and nursery areas for commercial fish stocks.

Framework for petroleum activities

On the basis of seismic data collected in the period 2007–09, the Petroleum Directorate has surveyed and estimated the recoverable petroleum resources in 50 prospects in Nordland VI, Nordland VII and Troms II. The projected present value of the benefits of the development as a whole is approximately NOK 105 billion, based on an assumed oil price of USD 80, rising to USD 97 in 2030. However, knowledge of the geology of the sea areas off the Lofoten and Vesterålen Islands and Troms is still limited, and the estimates of undiscovered resources are very uncertain.

Preparedness and response to acute pollution

The Government conducts regular evaluations of preparedness and response to acute pollution, for instance on the basis of lessons learned from accidents and clean-up operations. Experience gained from the operation to deal with the Gulf of Mexico accident is also relevant in this context.

8.2 Administrative consequences

The Government will take steps to simplify and improve the system for involving all interested parties. The possibility of replacing the Reference Group with improved arrangements for ensuring the participation and engagement of interested parties will be considered, and comprehensive information on work on the management plans will be published on the website www.miljøstatus.no. These efforts are expected to put less pressure on the public and interested parties.

The remaining measures are not expected to have administrative consequences of any significance.

The Ministry of the Environment

r e c o m m e n d s :

that the Recommendation from the Ministry of the Environment concerning the update of the Integrated Management Plan for the Marine Environment of the Barents Sea–Lofoten Area dated 11 March 2011 should be submitted to the Storting.

Appendix 1

Key background reports for the update of the management plan for the Barents Sea–Lofoten area

- Scientific basis for updating the management plan for the Barents Sea–Lofoten Area (drawn up for the interministerial steering group for the management plan by the Management Forum for the Barents Sea–Lofoten Area, the Forum on Environmental Risk Management and the Advisory Group on Monitoring, April 2010)
- Accident in the Gulf of Mexico: assessment by the Forum on Environmental Risk Management, 2010
- Economic analysis of future expansion of oil and gas activities in the Barents Sea–Lofoten Area (Report No. 20, Vista Analysis 2010)
- Marine ecosystem services in the Barents Sea–Lofoten Area – description, assessment and valuation (Report No. 144 531 – 01, SWECO 2010)
- Study of local and regional spin-off effects in connection with the updating of the integrated management plan for the Barents Sea–Lofoten Area (3rd edition, Asplan Viak/Nordland Research Institute 2010)
- Descriptive analysis of population and industrial structure in North Norway (Ministry of Local Government and Regional Development, June 2010)
- Commercial importance of the fishing and aquaculture industry in the Barents Sea–Lofoten Area (Report No. 17, SNF, Institute for Research in Economics and Business Administration 2010)

Background documents for the scientific basis:

- Report of the Advisory Group on Monitoring 2010 (*Fisken og havet*, Special issue 1b, Institute of Marine Research 2010)
- Report on a workshop on acute oil pollution and fish stocks (Report No. 4861, Akvaplan-niva AS 2009)
- Effects of seismic surveying on fish distribution and gill-netting and longlining catch rates off the Vesterålen Islands in summer 2009 (*Fisken og havet* No. 2, Institute of Marine Research 2010)
- Petroleum activities. Consequences of acute pollution for fish (Report No. 0527, Det Norske Veritas 2010)
- Oil drift modelling in the Barents Sea–Lofoten Area, OS3D (Report No. 0241, Det Norske Veritas 2010)
- Oil drift modelling in the Barents Sea–Lofoten Area, StormDrift, (Report No. 1, StormGeo 2010)
- Consequences of oil spills for seabirds, marine mammals and the shoreline (Report No. 0539, Det Norske Veritas and Norwegian Institute for Nature Research 2010)
- Consequences of petroleum activities and acute pollution from shipping and the petroleum industry for the fisheries (Report No. 200029–3, Acona Wellpro and Akvaplan-niva 2010)
- Consequences of petroleum activities and acute pollution from shipping and the petroleum industry for tourism in the Lofoten and Vesterålen Islands (1st edition, Asplan Viak 2010)
- Description of environmental technology (Norwegian Petroleum Directorate 2010)
- Oil spill response system (report SINTEF F 15407, SINTEF/Acona Wellpro 2010)
- Oil and gas resources in the waters off the Lofoten and Vesterålen Islands and Senja (Oljedirektoratet 2010)
- Valuation of the consequences of acute pollution for society, (Project No. 999023, Petroleum Safety Authority Norway/Proactima 2010.)
- Proposed scenarios for modelling the consequences of offshore oil spills in the Barents Sea–Lofoten Area (Project no. 999023, Petroleum Safety Authority Norway/Proactima 2010.)

In addition, a number of reports were produced as a basis for the 2006 management plan. All the background reports for the 2006 and 2011 white papers are available on the Ministry of the Environment's website (in Norwegian only).

Appendix 2

Elements of the monitoring system for environmental quality

Table 2.1 Indicators, reference values and action thresholds

Indicator	Reference value	Action threshold
Ocean climate		
Extent of ice cover in the Barents Sea	Mean values 1979–2008	
Temperature, salinity and nutrients along fixed transects	Mean for whole measurement period	
Transport of Atlantic water into the Barents Sea	Mean for whole measurement period	
Marginal ice zone		
Phytoplankton biomass in the marginal ice zone (indicator under development)	Mean over the last 10 years	
Phytoplankton		
Timing of spring bloom (indicator under development)		
Phytoplankton biomass expressed as quantity of chlorophyll a	Mean over the last 10 years	
Species composition[1]	Historical data	
Zooplankton		
Zooplankton biomass	Mean distribution over the last 10 years	
Species composition[1]	Historical data	
Fish stocks that are not harvested		
Biomass and distribution of juvenile herring[2]	Historical data	
Biomass and distribution of blue whiting	Historical data	
Fish stocks that are harvested		
Spawning stock of cod	Precautionary reference point	Estimated spawning stock is below the precautionary reference point
Spawning stock of capelin	Precautionary reference point	Estimated spawning stock is below the precautionary reference point

Table 2.1 cont.

Indicator	Reference value	Action threshold
Spawning stock of Greenland halibut	Precautionary reference point (not known)	Estimated spawning stock is below the precautionary reference point
Spawning stocks of fish stocks that are being rebuilt to sustainable levels (golden and beaked redfish) (indicator under development)	Precautionary reference point[3]	Estimated spawning stock is below the precautionary reference point
Benthic organisms		
Species composition and quantity of benthic organisms and fish taken during research bottom trawling	Under development	Under development
Distribution of coral reefs, soft corals and sponge communities[4] (indicator under development)	Distribution and state of known sites	Significant rise in the extent of damage or reduction in distribution in areas that are monitored
Occurrence of red king crab	Distribution of red king crab	Spread of red king crab to new areas
Seabirds and marine mammals		
Spatial distribution of seabird communities	Average population numbers, last 10 years, and historical data	
Population trend for common guillemot	Average population numbers, last 10 years, and historical data	Viable population level when population is below this: or a population decrease of 20 % or more in five years, or failed breeding five years in a row
Population trend for Atlantic puffin	Average population numbers, last 10 years, and historical data	Viable population level when population is below this: or a population decrease of 20 % or more in five years, or failed breeding five years in a row
Population trend for Brünnich's guillemot	Average population numbers, last 10 years, and historical data	Viable population level when population is below this: or a population decrease of 20 % or more in five years, or failed breeding five years in a row
Population trend for black-legged kittiwake	Average population numbers, last 10 years, and historical data	Viable population level when population is below this: or a population decrease of 20 % or more in five years, or failed breeding five years in a row
Breeding success and adult survival in selected seabird species	Breeding success at a normal level for the species, sufficient to maintain a normal level of adult survival. Adult survival at a normal level for the species, sufficient to maintain a normal level of breeding success	Average breeding success over a three-year period insufficient to counteract natural adult mortality. Average decline in adult survival more than 20 % over two years.

Table 2.1 cont.

Indicator	Reference value	Action threshold
Spatial distribution of marine mammals	Average population numbers, last 10 years, and historical data	
Bycatch of common porpoise	Average for the first three years of comparable monitoring	Rise in bycatch compared with the reference value
Alien species		
Records of alien species	Historical data	Alien species recorded during monitoring
Vulnerable and endangered species		
Red-listed species[5]	Viable population level and historical data on population levels	Population of selected species is below the level considered to be viable
Pollutants (see Figure 2.1)		
Pollutants in fish, polar bears, seabirds, marine mammals and benthic animals	Natural background level	Rise in pollutant concentrations continuing for specified number of years, or sudden large rise from one sample to the next in an area, to above natural background level
Pollutants in sediments	Natural background level	Rise in pollutant concentrations continuing for specified number of years, or sudden large rise from one sample to the next in an area, to above natural background level
Inputs via rivers	Natural background level	Rise in pollutant concentrations continuing for specified number of years, or sudden large rise from one sample to the next in an area, to above natural background level
Atmospheric inputs	Natural background level	Rise in pollutant concentrations continuing for specified number of years, or sudden large rise from one sample to the next in an area, to above natural background level
Levels of radioactivity in sediments, seaweed and fauna along the coast	Natural background level	Rise in radioactivity level continuing for specified number of years, or sudden large rise from one sample to the next in an area, to above natural background level
Beached litter	No litter	Unacceptable amounts of litter on shoreline

1 Samples for determination of species composition are taken along the Fugleøya–Bjørnøya transect.
2 Juvenile herring mature in the Barents Sea, but are fished in other waters.
3 Precautionary reference points must be determined for species for which they are not available at present.
4 This indicator cannot be used until surveys of coral reefs and sponge communities have been made.
5 For a list of species considered to be vulnerable or endangered in the area, see Box 3.6 on species on the 2010 Norwegian Red List

Pollution indicator	Abiotic							
	Sediments	Atm. inputs	River inputs	Seaweed	Mussels	Shrimps	Capelin	Polar cod
Metals and metal compounds								
Hg	f	f	f		f	f	f	f
Pb	f	f	f		f	f	f	f
Cd	f	f	f		f	f	f	f
Cu	f	f	f		f	f	f	f
As	f	f	f			f	f	f
TBT	f				f			
Organic pollutants								
PAHs	f	f				u	u	m
THC	f				u			
PCBs	f*	f	f		f	f	f	f
HCB	f*	f			f	f	f	f
BFRs	u	u			m	f	f	f
PFCs	u	u				f	f	f
Dioxins and dioxin-like PCBs		m				f	f	f
Dioxins and furans						f	f	f
Pesticides								
DDT	f*	f			f	f	f	f
Toxaphene		m			u	f	f	f
Chlordane		f				f	f	f
HCH	f*	f	f		f	f	f	f
Radioactive substances								
Radioactivity	f			f	f	f	f	f

f = Measurements available for several years (minimum 3) and one or more sites/areas
u = Some data available (under development)
m = Not monitored at present, recommended
Atm. inputs = measurements of atmospheric inputs
* = Measurements from coastal waters only

Figure 2.1 Current and proposed pollution indicators, showing current and recommended sample types

Published by:
Norwegian Ministry of the Environment

Internet address:
www.government.no

Cover illustration: Ørnulf Opdahl's watercolour *Hav (Ocean)*,
photographed by Silje Gripsrud

Printed by:
07 Aurskog AS 05/2012

MILJØMERKET
241 Trykksak 379