NORWEGIAN MINISTRY OF
CLIMATE AND ENVIRONMENT

Meld. St. 20 (2014–2015) Report to the Storting (white paper)

Update of the integrated management plan for the Barents Sea – Lofoten area including an update of the delimitation of the marginal ice zone

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Recommendation of the Ministry of Climate and Environment of 24 April 2015, approved in the Council of State the same day. (Solberg Government)

1 Introduction

Norway is a maritime nation. The seas and coastline have shaped the development of Norwegian society and played an important part in forming the Norwegian sense of identity. Norway's marine areas support a wide range of species and habitats and provide us with valuable resources, some familiar and others that we are still learning about. Many sectors of Norwegian industry and the Norwegian economy are closely linked to the seas, from maritime transport and shipbuilding to fisheries, aquaculture and the petroleum industry.

1.1 Integrated, ecosystem-based marine management

The white paper *Protecting the Riches of the Sea* (Report No. 12 (2001–2002) to the Storting) was the first in which the Government presented a more ecosystem-based and cross-sectoral marine environmental policy using integrated management plans as a tool. At the time, the management system was fragmented, and there was no coherent knowledge base. Since then, integrated management plans have been drawn up for all Norwegian sea areas. The management plans have been published in the following white papers:

- *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).
- *Integrated Management of the Marine Environment of the Norwegian Sea* (Report No. 37 (2008–2009) to the Storting).
- *First update of the Integrated Management Plan for the Marine Environment of the Barents Sea–Lofoten Area*, Meld. St. 10 (2010–2011).
- *Integrated Management Plan for the Marine Environment of the North Sea and Skagerrak* Meld. St. 37 (2012–2013).

The purpose of the management plans is to provide a framework for value creation through the sustainable use of natural resources and ecosystem services in the sea areas and at the same time maintain the structure, functioning, productivity and diversity of the ecosystems. The management plans are thus a tool both for facilitating value creation and food security within sustainable limits, and for maintaining good environmental status.

Figure 1.1 The Barents Sea–Lofoten management plan area.

Source: Norwegian Polar Institute.

The management plans clarify the overall framework and encourage closer coordination and clear priorities for management of Norway's sea areas. They are a clear expression of Norway's willingness and capacity as a coastal state to ensure sound management of its marine areas.

1.2 Background and basis for this update of the management plan

The 2006 integrated management plan for the Barents Sea–Lofoten area and the management plans for the Norwegian Sea and for the North Sea and Skagerrak all included a broad-based, overall description of the relevant sea areas, including ecosystem status and trends, as a basis for determining the measures to be introduced. An update of a management plan has a more limited scope, dealing with a restricted number of issues, knowledge updates or part of the geographical area of the management plan. In the 2011 update of the Barents Sea–Lofoten management plan, there was a special emphasis on descriptions and assessments for the waters off the Lofoten and Vesterålen Islands and Senja. The updates also ensure that the general framework for management of the area continues to be appropriate during the period before an overall revision of the management plan. According to plan, a complete revision of each management plan will be carried out about every 15 years.

In the present update of the management plan, the Government will focus on the northern/Arctic part of the Barents Sea–Lofoten management plan area. Human activity has less direct influence on these waters than on any other part of Norway's sea areas, but at the same time this is the region that is showing the earliest signs of climate change. Changes in the extent of the sea ice are making new areas accessible for human activity, particularly shipping, fisheries and petroleum activities. These changes will make new demands on the administrative authorities.

Updated knowledge about the state of the environment and new measurements of sea ice extent have improved our understanding of the geographical location of the particularly valuable and vulnerable areas in the management plan area. The Government is not proposing to alter the definition of the marginal ice zone as a particularly valuable and vulnerable area used in the earlier versions of the management plan, but will update its delimitation for the purposes of the management plan on the basis of new measurements of sea ice extent.

No changes to the framework for commercial activities in the Barents Sea–Lofoten management plan area are being proposed at present.

In 2020, the Government will publish a white paper presenting an overall revision of the management plan for the entire Barents Sea–Lofoten area. As part of the scientific basis for the revision, the definition used as a basis for determining the delimitation of the marginal ice zone will be reviewed.

The management plans describe changes in the marine environment as a result of climate change. They also describe the influence of human activities in the management plan area on marine ecosystems, including activities that result in greenhouse gas emissions and may contribute to climate change. However, the management plans are not intended as direct climate policy tools. Decisions on policy instruments and measures to reduce greenhouse gas emissions are made as part of other processes, not through the marine management plans.

Value creation from commercial activities is a relatively minor topic in the present white paper. However, this will be a key topic as scientific work on the management plan continues. A great deal has already been done to build up a body of knowledge in connection with the previous update of the Barents Sea–Lofoten management plan in

2011 and a white paper on the petroleum industry published in the same year. This includes knowledge about the potential impacts of petroleum activities in unopened areas along the coast of Nordland and Troms counties, and about the direct and spin-off effects of expanding commercial activities such as tourism and fishery-related enterprises. The results of this work will form an important part of the scientific basis for the revision of the management plan in 2020.

In the previous versions of the Barents Sea–Lofoten management plan, the marginal ice zone is described as a particularly valuable and vulnerable area, delimited using statistical methods of expressing sea ice extent. In recent decades, there has been a clear negative trend in sea ice extent in the Barents Sea. Calculations of the extent of the marginal ice zone have been based on older ice data that are no longer representative of current ice conditions. In the present white paper, the delimitation of the marginal ice zone for the purposes of the management plan is therefore updated using ice data for the period 1985–2014.

The northern part of the management plan area includes the fisheries protection zone around Svalbard and the territorial waters of Svalbard. Activities within the territorial waters of Svalbard are regulated by the Svalbard Environmental Protection Act. Norway has ambitious goals for maintaining a more or less undisturbed environment in Svalbard, set through white papers specifically on Svalbard, most recently in 2009 (Report No. 22 (2008–2009) to the Storting) and subsequent Storting debates on these white papers. Large nature reserves and national parks protect 87 % of the territorial waters and most of the coastline of Svalbard. Management plans are being drawn up or have been adopted for all of these to ensure that the purpose of protecting the areas is achieved. In the northern Barents Sea region, there are close links between terrestrial and coastal species and ecosystems in Svalbard and those in surrounding sea and drift ice areas, and they are interdependent. The territorial limit 12 nautical miles from land around Svalbard is an administrative boundary, but does not reflect an ecological boundary. An integrated management regime is therefore needed that helps to achieve the goals set for areas both within and outside the territorial waters around Svalbard.

1.3 International cooperation

The 1982 United Nations Convention on the Law of the Sea constitutes the basic international legal framework for all maritime activity. The Convention applies to all sea areas, including the Barents Sea and Arctic Ocean. It sets out detailed rules on the rights, duties and responsibilities of states as regards promoting peaceful and sound utilisation of the seas and taking into account the protection of the marine environment and other important interests. Under the Law of the Sea, Norway has jurisdiction over substantial resources. Coastal states also have a clear duty under the Convention to protect the marine environment in their waters, so that Norway has a major responsibility for ensuring sound management of the areas under its jurisdiction.

Under the Law of the Sea, countries also have a duty to cooperate at regional and global level to protect and preserve the marine environment. For the area in focus in this update of the management plan, the most important cooperation forums are the International Maritime Organization (IMO), the Arctic Council, the Convention for the Protection of the Marine Environment in the North-East Atlantic (the OSPAR Convention), the North East Atlantic Fisheries Commission (NEAFC) and the bilateral environmental cooperation and fisheries cooperation between Norway and Russia. In addition, there is substantial research cooperation, for example under the Intergovernmental Panel on Climate Change (IPCC), the International Council for the Exploration of the Sea (ICES) and the International Hydrographic Organization (IHO).

The International Maritime Organization (IMO)

Extreme weather conditions, winter darkness, ice-covered waters, the limited availability of communication systems and the remoteness of polar waters make it challenging to ensure the safety of shipping and avoid damage to the vulnerable environment. In recent years, IMO has intensified its efforts to provide for ship, crew and passenger safety and to improve protection of polar waters. The adoption of the Polar Code is a particularly important step. The Code is internationally binding, and establishes additional requirements for ships that are to operate in Arctic or Antarctic waters. The safety requirements were adopted in November 2014 and the environmental requirements in May 2015. The entire Polar Code is to enter into force from 1 January 2017 and will apply

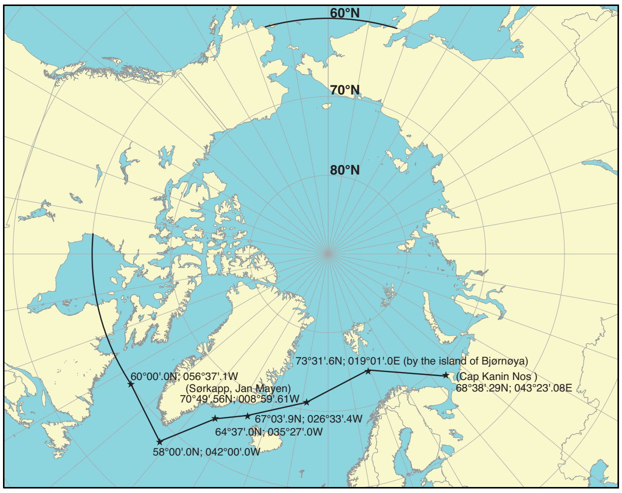

Figure 1.2 Area of application of the IMO Polar Code in Arctic waters.

Source: International Maritime Organization

in the areas defined as polar waters. The Polar Code is further discussed in Chapter 3.

The contribution of shipping to climate change in the Arctic is also on IMO's agenda. Ships generate emissions of soot, or black carbon, which is a short-lived climate forcer that has a particularly strong impact in the Arctic. IMO is seeking to reach agreement on a definition of black carbon emissions and identify methods of measuring these emissions and control measures to reduce them.

The Arctic Council

The Arctic states are engaged in extensive cooperation within the framework of the Arctic Council to promote sustainable, ecosystem-based management of marine areas. Norway has been playing a leading role in this cooperation with the aim of creating greater understanding of the importance of an ecosystem-based approach to management of Arctic waters. A new Arctic marine strategic plan is being drawn up for the Arctic Council ministerial meeting in spring 2015. It includes strategic goals to improve knowledge of the Arctic marine environment, conserve and protect ecosystems, promote safe and sustainable use of the marine environment and enhance the economic and social well-being of Arctic inhabitants, and strategic actions for achieving these goals. The implementation of an integrated, ecosystem-based approach to management is a central element of the plan. This topic was also addressed by the Ecosystem-Based Management expert group, which submitted its recommendations in 2013.

In addition, various Arctic Council working groups are working on the implementation of an ecosystem-based management regime. The Arctic Monitoring and Assessment Programme Working Group (AMAP) has identified Arctic marine areas of heightened ecological significance in the light of a changing climate and more intensive use. At the ministerial meeting of the Arctic Council in spring 2015, updated knowledge about short-lived climate drivers (methane, ozone and black carbon) will be presented. The Protection of the Arctic Marine Environment Working Group (PAME) has conducted an assessment of Arctic shipping and has carried out a project on the use and carriage of heavy oil fuel (HFO). PAME has also assessed the need to designate areas in the high seas area of the Arctic Ocean that warrant protection from the risks posed by shipping, and has identified possible measures to reduce the risk of environmental damage. Moreover, work is in progress on a common framework that countries can use to designate marine protected areas (MPAs) in areas beyond national jurisdiction. Tourism in the Arctic is expanding, and PAME is therefore looking at measures and guidelines to promote sustainable marine tourism. The Emergency Prevention, Preparedness and Response Working Group (EPPR) has prepared a guide to oil spill response in snow and ice conditions, which will be presented at the Arctic Council ministerial meeting in spring 2015. The EPPR is also developing a searchable database of Arctic oil spill response assets. The working group is discussed further in Chapter 3.5.

In 2013, the member states of the Arctic Council signed the Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic, see Chapter 3.5. The operational guidelines for the agreement were developed and are maintained by the EPPR. A framework plan for cooperation on prevention of oil pollution from petroleum and maritime activities in the marine areas of the Arctic is being prepared for the ministerial meeting in April 2015.

The Agreement on the Conservation of Polar Bears

The Agreement on the Conservation of Polar Bears was adopted in 1973 by the five Arctic states Canada, Denmark (Greenland), Norway, the US and Russia (then the USSR). Its purpose is to protect polar bears and their habitat through coordinated national measures taken by the parties to the agreement. The agreement is the key international instrument for cooperation on polar bear

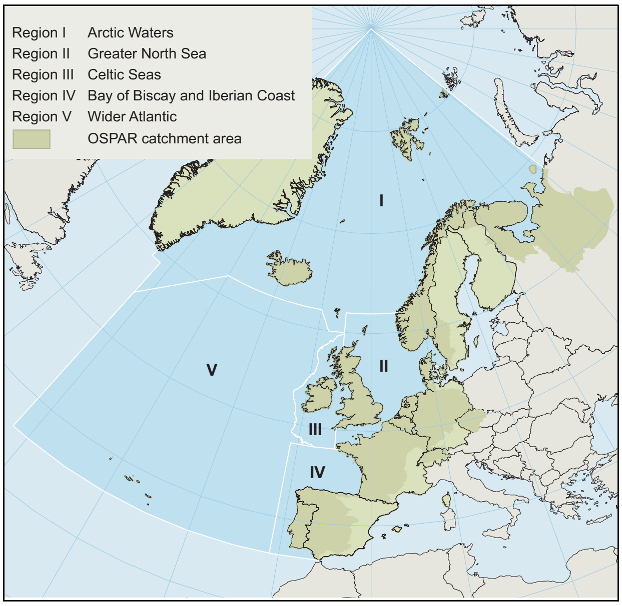

Figure 1.3 The five regions of the OSPAR area.

Source: OSPAR.

protection throughout their range, which in Norway means the northern part of the Barents Sea–Lofoten management plan area, including Svalbard and sea areas that are ice-covered for part of the year. Under the agreement, the parties have an obligation to ensure sound management of polar bear populations on the basis of the best available scientific data. The agreement requires the parties to take appropriate action to protect the ecosystems of which polar bears are a part.

In 2009. the parties to the agreement agreed to develop a circumpolar action plan and national action plans for the polar bear. The Norwegian Environment Agency has drawn up a Norwegian action plan, and the circumpolar action plan is scheduled to be adopted at the meeting of the parties in Greenland in autumn 2015.

OSPAR and NEAFC

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention) unites 15 countries around the North-East Atlantic and the EU as parties in efforts to protect, conserve and improve the state of the marine environment. The OSPAR area is divided into five regions, and there has recently been a special focus on Arctic waters (Region I). OSPAR's role in coordinating the implementation of the EU Marine Strategy Framework Directive is important for parties to the convention that are also EU member states.

The North East Atlantic Fisheries Commission (NEAFC) is a regional fisheries management organisation that is responsible for managing all fish resources in in international waters in the Northeast Atlantic. Its objective is to promote long-term conservation and optimum utilisation of the fishery resources of the Convention Area. The contracting parties are Norway, Russia, the EU, Iceland and Denmark (in respect of the Faroe Islands and Greenland). Its most important tasks are to develop good control and enforcement schemes and promote a more ecosystem-based approach to management in its regulatory area. NEAFC adopts regulatory measures to ensure that fisheries are sustainable, such as TACs and seasonal closures. Regulatory measures are adopted by the contracting parties on the basis of scientific advice from ICES. NEAFC has a comprehensive control and enforcement scheme and also adopts regulatory measures to protect marine ecosystems that are vulnerable to pressures and impacts associated with fisheries.

In recent years, there has been close cooperation between OSPAR and NEAFC. OSPAR is responsible for surveys of the state of the environment for and identifying pressures and impacts on the environment, including those associated with the fisheries, while NEAFC is responsible for establishing measures to deal with the pressures and impacts of fisheries on the environment. In 2014, OSPAR and NEAFC concluded a collective arrangement with the purpose of further strengthening their cooperation.

The management plans and developments in the EU

In 2008, the EU adopted the *Marine Strategy Framework Directive*, which is based on an approach and methods very similar to those of Norway's integrated management plans. Although the directive is considered not to be relevant for incorporation into the Agreement on the European Economic Area (EEA), Norway shares its overall objectives. Moreover, implementation of the directive and its goals on good environmental status will be in Norway's direct interest, since it applies to marine regions that are shared between Norway and the EU. The directive is the environmental pillar of the EU's integrated maritime policy. The objective is for good environmental status to be achieved in the EU's marine waters by 2020. Each member state is required to develop a marine strategy to this end, which must include a programme of measures, to be established by 2015, describing what the country will do to maintain good environmental status or achieve this by 2020. After this, the marine strategies, including the programmes of measures, are to be reviewed every six years, starting in 2018.

Norway and the other EEA EFTA countries consider the directive not to be EEA-relevant because its geographical scope extends beyond that of the EEA Agreement. The EU was formally notified of this conclusion in autumn 2013, and the matter has been under consideration by the EU since then.

The European Commission has invited Norway to take part in the working groups that have been appointed to support implementation of the directive. The directive also specifies that member states should coordinate their strategies with each other and with third countries that share the same marine region. They should as far as possible use the mechanisms and structures of the regional sea conventions as a basis for this. In Norway's marine areas, the OSPAR Convention is the relevant agreement. Through its participation in OSPAR, Norway can follow developments in the EU closely and also have an influence on how the directive is implemented.

The *directive establishing a framework for maritime spatial planning* was adopted in July 2014. It requires member states to establish maritime spatial plans by 31 March 2021. Its objective is to promote the sustainable growth of maritime economies, the sustainable development of marine areas and the sustainable use of marine resources. The maritime spatial plans must identify the spatial and temporal distribution of existing and future activities.

This directive also requires cooperation where possible with neighbouring countries and third countries, for example through regional institutional structures, and Norway is taking part in technical cooperation under the directive. The EU has not identified the directive as a text with EEA relevance, and Norway has not taken a position on this.

Norway's bilateral cooperation with Russia

The main purpose of Norwegian-Russian cooperation on the marine environment is to maintain the clean, rich environment of the Barents Sea. This has developed into cooperation with a view to achieving ecosystem-based management of the whole Barents Sea. The Barents Sea is considered to constitute a single large marine ecosystem extending across the delimitation line between Norwegian and Russian waters. To ensure sound management of the Barents Sea, it is therefore essential to ensure that the management regimes on both sides of the delimitation line are based on shared knowledge and the same principles.

Norway and Russia have enjoyed close bilateral cooperation on environmental monitoring for many years. In the 1960s and 1970s, this started as fisheries cooperation which also included monitoring of environmental conditions. It has now developed into a joint system for monitoring the marine environment, including annual surveys. The monitoring programme includes marine resources, biological and oceanographic parameters and hazardous substances. A unique body of information on the whole ecosystem is being collected through this system.

One long-term goal has been to develop a concept for a management plan for the Russian part of the Barents Sea, based on the Norwegian model. Russia has now decided that the Barents Sea is to be a pilot area for the development of an integrated marine management system for the country as whole. Norway's experience of developing integrated management plans and the results of the bilateral cooperation on the marine environment will be key parts of the process that Russia is now planning. Continuation of the cooperation is therefore being given high priority. In 2015, Norway and Russia will publish an update of the joint environmental status report for the Barents Sea and will use a common platform to present the knowledge base. During winter 2014 and spring 2015, scientists from a number of research institutions in both countries presented a proposal for indicators to be used as a basis for a joint environmental monitoring programme in the Barents Sea in the future.

The Barents Sea is one of the world's most productive sea areas. The most important fish stock here, the Northeast Arctic cod, is also one of the best managed. The healthy state of the stock is due to a combination of favourable natural conditions and very successful and effective cooperation on management of the stock by the Joint Norwegian–Russian Fisheries Commission. Since the mid-1970s, Norway and Russia have practised joint management of the most important fish stocks in the Barents Sea: cod, haddock, capelin and Greenland halibut, and more recently also beaked redfish. A joint management strategy and cooperation on resource control, and in particular steps to combat IUU fishing, have been of key importance. At the annual meetings of the Joint Norwegian–Russian Fisheries Commission, the parties determine total allowable catches (TACs) for each stock and share them between Norway, Russia and third countries. The proportions of the TACs allocated to each country have remained unchanged, and are an important reason for the stability of the cooperation. The parties also agree on reciprocal fishing rights in each other's zones and exchange quotas for both joint stocks and national stocks. The TACs jointly determined by Norway and Russia are based on management strategies agreed by Norway and Russia and on recommendations on catch levels from ICES, which includes both Norwegian and Russian scientists. The TACs are based on a precautionary approach, and the objective is to ensure a high long-term yield. In addition, the parties agree on various technical measures on for instance mesh sizes, minimum sizes, the use of sorting grids in trawl fisheries and criteria for closing areas to fishing because the intermixture of undersized fish is too great. The parties are also engaged in well-developed marine research cooperation, which dates back to the early 1950s. The results of this research form the basis for the management decisions made each year by the Joint Norwegian-Russian Fisheries Commission, and are therefore of crucial importance for the management of the joint fish stocks in the Barents Sea.

In 1994, Norway and Russia entered into a bilateral agreement on combating oil spills in the Barents Sea. The agreement has been implemented in the form of a joint contingency plan and annual joint exercises, the most recent of which took place in the outer Varangerfjord, in the border area between Norway and Russia, in June 2014.

International research cooperation on the marine environment and the Arctic

The changes that are taking place in the Arctic mean that new knowledge is needed, particularly about climate and the environment. This involves complex issues and research needs, and we know that research in the polar areas is highly resource-intensive. Through international cooperation projects, we can bring together enough expertise and resources to generate knowledge on a scale that is not otherwise possible, for example to describe climate processes.

There are some international research programmes and projects under way in the Arctic at present, for example ASOF (an international programme on the oceanography of the Arctic and subarctic seas and their role in climate) and the EU-funded project ICE-ARC (Ice, Climate, Economics – Arctic Research on Change). In the latter, scientists from 11 countries are to look into the current and future changes in Arctic sea ice and the economic and social consequences of these changes in the area. There are currently no major international research programmes on Arctic Ocean ecosystems, but the five coastal states are developing several research programmes on topics including living marine resources and ICES has established a new group called Working Group on the Integrated Assessments of the Barents Sea.

priorities in Arctic research, sharing of data, simplification of the movement of samples across borders, research logistics and funding of possible projects and research in the Arctic.

The Arctic Council's Task Force for Enhancing Scientific Cooperation in the Arctic (SCTF) is working towards a new agreement between the Arctic states to strengthen and promote research cooperation in the Arctic. Various difficulties related to research cooperation in the region have been identified, including restrictions on access to some areas, barriers to moving personnel, equipment and samples across national borders and inadequate coordination, data acquisition and exchange information. The aim is to establish simplified procedures that will allow closer cooperation. The task force will ask for an extension of its mandate at the 2015 Ministerial Meeting of the Arctic Council so that it can initiate formal negotiations on a legally-binding agreement.

Over the years, various forms of collaboration have been established, and these were strengthened during the International Polar Year (IPY). Some of them are being continued, for example through the Norwegian Polar Institute's project Norwegian Young Sea ICE Cruise (N-ICE2015). The project involves close cooperation on climate research with institutions in Europe (Germany, France, Finland, the UK) and North America (US, Canada). All these countries and Russia are also important partners in ecosystem research.

The major international research programmes that operate at pan-Arctic level need to be strengthened. There are opportunities for funding through the EU Framework Programme for Research and Innovation, Horizon 2020, since the programme is also open to the US and Canada. One of the seven societal challenges to be addressed by Horizon 2020 is entitled 'Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy'. Another is 'Climate Action, Environment, Resource Efficiency and Raw Materials'. The Joint Programming approach makes it possible to pool national research efforts, and involves agreement between European countries on joint planning, implementation and evaluation of research programmes in key areas. The Joint Programming Initiatives JPI-Climate and JPI-Oceans are particularly useful networks for establishing close research cooperation.

There are leading climate and environmental and marine research groups in Norway. The Norwegian institutions that are most heavily involved in international research cooperation in the High North and the Arctic are the Norwegian Polar Institute, UiT the Arctic University of Norway, the Institute of Marine Research, the University Centre in Svalbard (UNIS), the University of Bergen/Bjerknes Centre for Climate Research, the Norwegian University of Science and Technology (NTNU), the Nansen Environmental and Remote Sensing Center (NERSC), the University of Oslo, the Northern Research Institute (Norut) and the CICERO Center for International Climate and Environmental Research. The Fram Centre in Tromsø plays a key role in Norwegian climate and environmental research in the Arctic.

In collaboration with the research institutes, the Research Council of Norway has identified the following scientific priorities for Norwegian Arctic research:

- climate research – understanding of the coupled ocean-ice-atmosphere system;
- climate change and ecosystem impacts;
- ocean acidification;
- impacts of hazardous substances;
- short-lived climate forcers (black carbon, methane).

When the new Norwegian ice-class research vessel is put into normal operation in 2018, this will be the start of a new era for Norwegian polar research. The new vessel will provide Norwegian scientists with a state-of-the-art research platform and offer new opportunities for building up knowledge about the northern Barents Sea and the Arctic Ocean. It will be equipped for all research disciplines within biology, climate, oceanography and geology.

A major international project including Norwegian participants is under preparation, in which the Alfred Wegener Institute's research vessel *Polarstern* will be frozen into the ice in the central Arctic Ocean and then drift with the ice for a whole year.

2 Environmental status and particularly valuable and vulnerable areas

As mentioned earlier, the present update of the management plan focuses on updating the boundaries of the ice margin and providing an up-to-date description of the northern part of the management plan area, particularly in view of the rapid changes that are taking place as the sea temperature rises and the extent of the sea ice shrinks. Arctic temperatures have risen rapidly and there has been a marked reduction in sea ice cover in recent years. These trends are apparent throughout the region, and according to the Intergovernmental Panel on Climate Change (IPCC), it is very likely that they are a result of anthropogenic climate change. Some of the most rapid changes in the Arctic are being observed in the Barents Sea area. This chapter describes the observed changes and their implications for the Barents Sea ecosystem, and to some extent also the expected future trends as regards climate and sea ice.

Two advisory groups with participants from relevant public authorities and research institutions have been established to develop the scientific basis for the marine management plans. These are the Forum for Integrated Marine Management, chaired by the Norwegian Environment Agency, and the Advisory Group on Monitoring, chaired by the Institute of Marine Research. In 2014, the Advisory Group presented an assessment of the state of the Barents Sea–Lofoten ecosystem, focusing on changes. The descriptions in this chapter are largely based on their report. The main elements of the scientific basis for this update of the management plan are the updated scientific information in the Advisory Group's assessment report, together with the updated calculations from the Norwegian Polar Institute of the delimitation of the marginal ice zone as a particularly valuable and vulnerable area, and reports on oil spill preparedness and response and shipping in Arctic waters. The Forum for Integrated Marine Management will coordinate the preparation of the scientific basis for the 2020 revision of the management plan.

2.1 Environmental status

The inflow of warm Atlantic water to the Barents Sea ensures that the Norwegian coast and large parts of the Barents Sea are ice-free all year round. Where the Atlantic water meets colder Arctic water, an oceanographic front is formed, called the polar front. Other frontal zones are found along the edge of the continental shelf and in the marginal ice zone. During the winter, the marginal ice zone more or less overlaps the polar front. Frontal zones are highly productive, supporting rich blooms of planktonic algae that are grazed by zooplankton and in turn provide food supplies for fish, seabirds and marine mammals. The Barents Sea is a relatively shallow sea (average depth 230 m) with large very shallow bank areas, so that the whole area is very productive. Biological production in the Barents Sea forms the basis for the large fish stocks that support Norway's fishing industry. Herring, capelin, cod and haddock use the area throughout their lives or for part of their life cycle, and all of these species migrate towards the Norwegian coast to spawn. The most concentrated spawning grounds are near the Lofoten and Vesterålen Islands. From here, eggs and larvae drift northwards along the coast and into the Barents Sea, where the juvenile fish grow and mature. Because of its high productivity, the Barents Sea supports some of the largest concentrations of seabirds in the world. In addition, the northern part of the Barents Sea is an important habitat for a number of marine mammal and seabird species that are not found in areas without ice cover; several of these are of national and international importance.

One characteristic of the Barents Sea is that physical factors such as temperature and ice conditions vary widely between seasons and from year to year, and this has significant effects on the ecosystem. However, there are also some clear trends in environmental conditions, especially as regards temperature and sea ice. Throughout the Arctic, temperatures have been rising twice to

Boks 2.1 Explanation of ice-related terms

Various terms are used in this white paper to describe the marginal ice zone and ice-covered waters:

- *Sea ice* is a general term for ice on the surface of the sea which has originated from the freezing of sea water.
- *Drift ice* is sea ice that moves with currents and wind. Sometimes, sea ice forms in fjords, inlets and between islands near the coast, and remains attached. This is known as *fast ice*.
- The *marginal ice zone* is the transitional zone between concentrated drift ice and open sea. It may vary in breadth from a few hundred metres to tens of kilometres.
- The *marginal ice zone* also refers to a particularly valuable and vulnerable area as defined in the Barents Sea–Lofoten management plan. A further explanation of how this area is delimited is given in Box 2.5.

Figure 2.1 Aerial photo of the marginal ice zone in summer.

Photo: Haakon Hop, Norwegian Polar Institute.

three times as fast as the global average, and the extent of the sea ice has declined markedly in recent decades. Climate models indicate that the warming trend will continue in the Norwegian Arctic. In the longer term, trends in temperature and ice conditions will depend on whether the world is successful in reducing global greenhouse gas emissions. The trend towards higher temperatures and less ice cover in the Arctic also involves positive feedback mechanisms; less snow and ice cover means less incoming sunlight is reflected, and more open water means more solar irradiation is absorbed. Further reductions in sea ice extent in the Barents Sea may have serious consequences for ice-dependent species, which will lose much of their habitat and be displaced further north and east. In addition, Higher sea temperatures are expected to result in a northward shift of more southerly species, and this will also have consequences for the Barents Sea ecosystem.

2.1.1 Rising temperatures and shrinking ice cover

In recent decades, both air and sea temperatures in the Barents Sea area have been rising sharply. One reason for this has been an increase in heat transfer to the Barents Sea with the inflow of relatively warm Atlantic water. Measurements in the southern Barents Sea, where the inflow of Atlantic water take place, show that the sea temperature rose by around 1.5 °C from 1977 to 2013.

The sea ice extent in the Barents Sea varies a great deal between seasons, usually reaching a maximum in April[1] and a minimum in September (see Figures 2.11 and 2.12). Since 1979, there has been a negative trend in sea ice extent in both April and September (see Figures 2.19 and 2.20). The strongest decline in sea ice extent has been in April. At the same time, the thickness of the Arctic sea ice is also changing, from thick multi-year ice to thin first-year ice. This is having major impacts on ecosystems.

[1] The timing of maximum sea ice extent varies depending on the area included. For the Arctic as a whole, March is the month when sea ice extent reaches a maximum, while in the Barents Sea and Fram Strait, the maximum is reached at the end of March/early April, with wide interannual variations.

2.1.2 Impacts on the ecosystem

Climate change

As the temperature has risen and more of the sea surface has become ice-free, the Barents Sea ecosystem has changed. Some species are benefiting from these changes, while others are being negatively affected.

The state of the environment in the Barents Sea is still generally good, but pressures and impacts on species and ecosystems related to climate change are becoming more marked. Climate change is expected to have the most serious negative impacts on species and ecosystems in the northern, Arctic part of the management plan area, including the waters around Svalbard. In these areas, climate change is the greatest threat to biodiversity. Species that are dependent on the sea ice have only limited opportunities to move further north to find suitable habitat as the sea ice melts and ice-covered areas shrink. This is because the sea ice is retreating from the shallow coastal waters and continental shelf around Svalbard to the deeper and less productive Arctic Ocean, which cannot support anything like the same level of biological production and biodiversity.

The impacts of climate change are already becoming apparent in the waters around Svalbard and in the northern Barents sea. Along the west coast of Svalbard, Arctic water has been displaced by temperate Atlantic water which supports a plankton assemblage with a different species composition. This has resulted in major changes in the marine ecosystem, and species such as capelin, herring, cod, salmon and mackerel are now periodically to be found in the fjords in this area. There are also clear signs of a northerly and northeasterly shift in the distribution of fish and whales in the Barents Sea. So far, the most striking example of a 'climate winner' is the cod; the population is now at a historically high level, and cod are being recorded considerably further north and east than ever before.

Ringed seals have almost ceased to breed along the west coast of Svalbard because of the lack of sea ice in whelping areas. Changes in the species composition of plankton and fish communities are also reducing the availability of food supplies for some seabirds and therefore having an impact on their populations.

Further east in Svalbard and the Barents Sea, the changes are less marked, but the number of polar bear dens in the most important denning areas has dropped sharply, probably because there is no longer sea ice in these areas in late autumn, when the pregnant females enter their dens. Shifts in the distribution of habitats and species will continue as a result of climate change and changes in sea ice extent. Key areas of habitat may become unsuitable for certain species, while new areas become much more important for species that have to move to find suitable habitat. More southerly species will gradually be able to displace Arctic species, and changes will spread to other parts of ecosystems. In marine ecosystems, changes can take place rapidly because there are few barriers to the spread of species in response to higher sea temperatures. As the climate continues to warm further, it is to be expected that the changes will become more far-reaching and involve more and more species.

Climate change may also amplify the impacts of other pressures and threat factors. The cold water of the northern Barents Sea has formed a natural barrier to the spread of alien species, but its effect is being weakened by climate change. As a result, there is a greater risk that alien species that are introduced will become established and spread here as well. In the longer term, ocean acidification is also expected to have major impacts on marine ecosystems in the Barents Sea. The greatest impacts are likely to be in the most northerly waters, partly because CO_2 is more soluble in cold water. Ocean acidification will interact with climate change in ways that are difficult to predict, but that may have impacts on plankton and other key species and thus on the structure and functioning of marine ecosystems.

Pollution and marine litter

In the most northerly parts of the Barents Sea, there is little human activity that results in direct releases of pollutants. The persistent, bioaccumulative and toxic substances and radioactive pollution that are registered here have largely been transported from other regions by winds and ocean currents, following global circulation patterns in the northern hemisphere. They originate from densely populated and industrial areas further south. There are many sources, including leachate from landfills, waste water, waste incineration, agriculture and industry. Atmospheric transport is the most rapid route, and substances can be carried to the Arctic by winds in only hours or days, whereas transport with ocean currents may take several years. Pollutants are deposited on snow and ice or in the sea with rain and snow. The concentrations of environmentally hazardous substances that have been measured in sediments and during monitoring of air pollution in the Barents Sea area are generally low. Nevertheless, there is cause for concern because evidence of the spread of new substances whose use is not regulated is constantly being found. High levels of persistent, bioaccumulative and toxic substances have also been found in certain animal groups at higher trophic levels, such as seabirds and marine mammals. A wide range of such substances has been found in seabirds. Little is known about the interactions between different pollutants, but because so many different substances have been found in seabirds, there is concern that they may have health effects. This is the case even in species where the concentrations of individual substances do not exceed levels that are known to have biological effects.

In certain species, such as the glaucous gull and ivory gull, levels of persistent, bioaccumulative and toxic substances are so high that they may directly affect reproduction and survival. In polar bears, levels are high enough to affect the hormone and immune system and reproductive capacity of individual bears. The effects at population level are uncertain. Levels of the internationally regulated persistent organic pollutants (POPs), such as PCBs and DDT, are generally declining in the atmosphere and in some groups of organisms, whereas levels of substances whose use is not regulated or has been restricted only recently (for example organobromine and organophosphorus substances) are stable or rising. Cyclic siloxanes are a new group of substances of concern that have been found in the fauna in Svalbard, but so far little is known about their environmental impacts. There is only limited information about releases of siloxanes from products, but there is reason to believe that personal care products are the largest source. Cyclic siloxanes have been found in polar cod, glaucous gulls, kittiwakes and seals in Svalbard. This indicates that they can be transported over long distances to areas far from emission sources. Atmospheric monitoring has shown that levels of siloxanes in air in Svalbard are 100 to 1000 times higher than those of the 'classical' POPs such as PCBs and DDT. The siloxanes detected in Svalbard have almost certainly been carried with the wind from sources further south in Scandinavia and the rest of Europe.

Levels of most heavy metals (arsenic, cadmium, lead and nickel) measured in the atmosphere and precipitation in Svalbard have declined

Figure 2.2 Beach litter in Svalbard.

Photo: Tor Ivan Karlsen, Norwegian Polar Institute.

considerably since the early 1990s. However, mercury levels have remained more or less stable right up to the present. This is cause for concern, because mercury is an extremely dangerous pollutant that can pose a threat to human and animal health. Mercury is volatile, and is transported by winds and ocean currents into Arctic ecosystems and food webs. Alarmingly high levels of mercury have been found in fish, birds, marine mammals and polar bears in Arctic areas.

The problem of mercury pollution has a number of causes. There are both natural and anthropogenic sources. Although mercury releases caused by human activity have been greatly reduced in Europe and North America, climate change will allow the remobilisation of mercury that has been stored for example in ice and permafrost. Mercury bioaccumulates along food chains, and species at high trophic levels such as fish and mammals are therefore particularly liable to accumulate levels of mercury that can have health effects.

Levels of hazardous substances, including radioactive substances, are generally low in the species used as indicators of seafood safety. The only exceptions are the content of certain POPs in cod liver and POPs and mercury in Greenland halibut from certain areas.

Ocean currents transport large quantities of marine litter, which may sink to the seabed or remain floating on the surface. Beach litter is registered systematically at two sites on the west coast of Svalbard. The Governor of Svalbard also organises beach clean-up campaigns each summer. Marine litter is a threat to animal life, and both seabirds and marine mammals can be injured or become entangled in fishing gear and other litter. In addition, seabirds and other animals ingest litter, either directly or with their prey. Litter can block the gut, weakening or killing animals. There has been a steep rise in the proportion of fulmars in Svalbard that have plastic debris in their stomachs. One study found plastic in the stomachs of 88 % of the 40 fulmars analysed. In 23 % of the birds, the quantity of plastic particles exceeded the ecological quality objective set by OSPAR (less than 10 % of birds have more than 0.1 g plastic in the stomach). Microplastics, meaning plastic objects or fragments below 5 mm in size, are found in large quantities in almost all sea areas across the world. Zooplankton can mistake these tiny particles for food and ingest them, and several studies have concluded that microplastics enter the food chain in this way. A great deal of research is now being done on the effects of microplastic pollution on people and animals.

Ocean acidification

Ocean acidification occurs when the quantity of atmospheric CO_2 dissolved in sea water increases. CO_2 reacts with water to form carbonic acid, making the seawater more acidic (lowering the pH). Higher levels of CO_2 and lower pH in the ocean will also mean that calcium carbonate dissolves more readily in seawater, with particularly severe impacts on living organisms that build calcium carbonate shells and skeletons. Calcifying phyto- and zooplankton species, corals and molluscs are among the organisms expected to be adversely affected. Regular monitoring of ocean acidification in the Barents Sea along a transect from the mainland to Svalbard was started in 2010, and the northeastern Barents Sea was included from 2013. Ocean acidification has not been part of the indicator set for monitoring of the Barents Sea until now, but will be included in the course of 2015. Given the wide natural variability of pH and the short time series, it is difficult to quantify a long-term trend in acidification. However, a comparison of recent and historical data from the Lofoten Basin shows that pH dropped by 0.07 units from 1981 to 2009. In future, ocean acidification may have far-reaching impacts on marine ecosystems. CO_2 is most readily soluble in cold water. Acidification is therefore expected to be most rapid in the Arctic waters north of the polar front.

2.1.3 Specific ecosystem components

Phyto- and zooplankton

The species groups of phytoplankton that are most abundant in the Barents Sea vary between seasons and between years. There is typically an intense phytoplankton bloom in spring to summer when biomass increases dramatically, particularly in the marginal ice zone and near the coast. Production is higher in warmer years with little ice than in cold years with more widespread ice. After a period when there were various observations of more southerly species, no such species were recorded along the permanent monitoring transects in the Barents Sea (Fugløya–Bjørnøya and west of Bjørnøya) in the period 2011–13.

Zooplankton biomass appears to have been fairly stable over the past 10 years, but the relatively small quantitative variations nevertheless

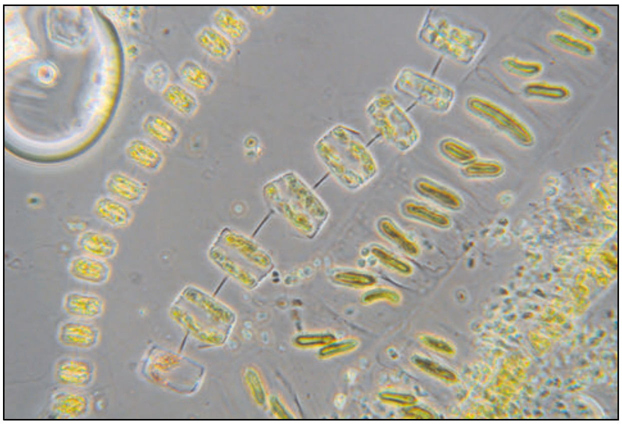

Figure 2.3 Microscopic algae in the marginal ice zone. Common phytoplankton species in a spring bloom.

Photo: Cecilie von Quillfeldt, Norwegian Polar Institute

reflect changes marked enough to have a considerable impact on species that graze on zooplankton. After a gradual decline over the three years 2007, 2008 and 2009, there was a clear rise in the quantity of zooplankton in 2010. Since then, biomass has been more variable. In 2013, zooplankton biomass appears to have been lower than before, although there was little change in spatial distribution from the preceding years. The total quantity of zooplankton was in fact lower than in any year since 1992. Numbers of the copepod *Calanus finmarchicus* have been relatively stable, while numbers of the larger Arctic species *Calanus hyperboreus* and *Calanus glacialis* have declined. However, the variability is within normal limits. The quantity of krill was above the long-term mean in 2013. The quantity of zooplankton is of key importance in marine ecosystems, among other things for trends in the major pelagic fish stocks.

The seabed and benthic fauna

Benthic animals of a variety of species groups live in, on or just above the seabed, and may be motile or sessile. Benthic animals are found in large numbers north of the marginal ice zone (for example brittlestars and various types of corals), on the slopes between the deep water of the Norwegian Sea and the bank area Nordkappbanken (*Geodia* sponges) and on the bank areas (sea urchins and sea cucumbers). There is a sharp boundary (the 'benthic polar front'), which is linked to the marginal ice zone, between a more southerly benthic community in an area including the Bjørnøyrenna channel and a more northerly one in an area including the deeper water of Hopendypet. As the ice retreats northwards as a result of higher sea temperatures, the distribution of commercial fish species will expand. Observations also show that the distribution of the shrimp *Pandalus borealis* is shifting northeastwards. These changes may influence the distribution of various types of fisheries activities in the Barents Sea. Benthic animals are affected by bottom trawling, anchors and chains, invasive alien species (species that graze on the benthos and compete for space and prey), climate change and pollution.

One benthic organism that is considered to be a newcomer in the Barents Sea is the snow crab, which has been spreading westwards in the Barents Sea from further northeast. It is still uncertain whether it was originally introduced by human activity or whether we are witnessing a natural expansion of its range from the Bering Sea and the coast of eastern Siberia. Climate change may have made it possible for the species to expand its distribution in this way. The largest numbers of snow crabs ever registered in Norwegian waters were recorded in the Norwegian part of the central Barents Sea in 2013. However, the main concentration of snow crabs in the Barents Sea is still further east, in Russia's economic zone. Russian scientists estimate that in 2013, the snow crab population was about 10 times the size of the red king crab population. It seems likely that the snow crab will end up with a more northerly distribution than the red king crab, and it will probably be possible for snow crabs to become established in the waters around Svalbard. Both the snow crab and the red king crab are occupying a niche in the Barents Sea ecosystem where there are few competing species, but they have a considerable impact on their prey species. Moreover, native species such as the northern stone crab (*Lithodes maja*), hermit crabs and *Hyas* species are found in relatively small numbers, although there may be considerable concentrations locally. The rising numbers of snow crabs may have substantial impacts on the benthic ecosystem in the Barents Sea, and the species is expected to play an important role in this ecosystem in future.

In 2015, the MAREANO programme is to start mapping a long transect of the seabed from the Bjørnøyrenna channel to the island of Hopen. In time, the results will give us a better picture of variations in biodiversity and biological production in the Barents Sea, including variations across the marginal ice zone.

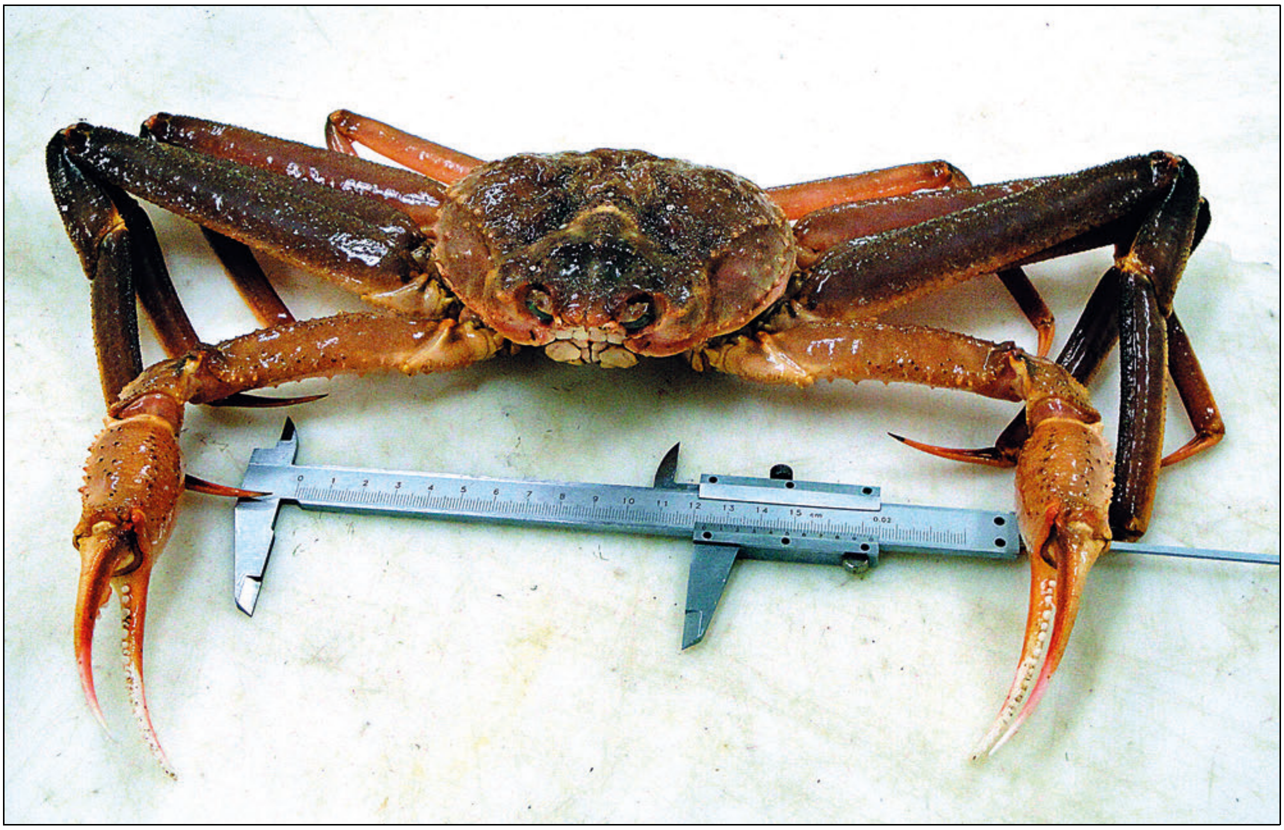

Figure 2.4 Snow crab. The first specimen found near Svalbard.

Photo: Jan Sundet, Institute of Marine Research.

Fish stocks

One of the species that has benefited from rising sea temperatures is the cod. The spawning stock of Northeast Arctic cod has been rising since 2001 and is now at a historically high level. In 2012, cod were recorded further north than ever before, at 82° 30'N in shallow water north of Franz Josef Land. During the Norwegian-Russian ecosystem survey in autumn 2013, cod specimens were also found further east than ever before, in the northern Kara Sea. Another important fish species in the Barents Sea is the haddock, which is also now present in large numbers and has expanded eastwards and northwards. The rising sea temperature and availability of more food has made it possible for both cod and haddock to expand into previously cold and less productive areas. The capelin and shrimp stocks – both of these are important prey species for cod – are in good condition. Polar cod numbers have been relatively low in recent years, but the stock estimate is very uncertain. This is a key species in the Barents Sea ecosystem, particularly in the marginal ice zone. Mackerel have also been expanding their range northwards in the last few years, and have been registered as far north as Svalbard.

Monitoring shows that most fish stocks are in good condition, but the stocks of golden redfish and Greenland halibut are at low levels. The directed fishery for golden redfish has been stopped. There have been restrictions on fishing for Greenland halibut for the past 20 years, and there are indications that the stock is increasing. However, stock estimates for the species are uncertain, and have mainly been used as an indication of trends. Work on the methodology is continuing so that better stock estimates can be obtained for Greenland halibut.

Marine mammals

Both the declining extent of the sea ice and the delay in ice formation on the fjords around Svalbard until later in the season have had negative impacts on ice-dependent marine mammals. The has affected ringed seals particularly severely, and pup mortality has risen as a result of poor breeding conditions. A declining ringed seal population affects polar bears in turn, since ringed seals are their most important prey. The effects are most marked in Svalbard's fjords, where ice conditions have been so poor since 2005/2006

Box 2.2 Polar cod as a key species

Figure 2.5 Polar cod.

Photo: Peter Leopold, Norwegian Polar Institute.

Many Arctic food chains are short and simple, with few species and links between them, but large populations of the species that are present. Certain animals are regarded as key species; they play a central role in the ecosystem, and are prey for a variety of other species. The polar cod is one such species, and is very important for energy transfer through the marine ecosystem. It is the main prey species for fish-eating seabirds in the Arctic and an important part of the diet of seals and whales. The cod stock in the Barents Sea feeds on polar cod as well as capelin.

that there has been widespread reproductive failure.

Female polar bears dig maternity dens in late autumn, in banks of snow on land. Monitoring of denning areas on Hopen and Kongsøya islands shows clearly that few females appear in these areas in autumn if the sea ice forms late. The number of days of sea ice cover round all the five most important denning areas has shown a dramatic decline over time since 1979. Data from the annual mark-recapture studies indicate a gradual decline in cub production, but it is uncertain whether this reflects a population-wide trend, or is only happening more locally in the areas covered by the studies. In 2004, the Svalbard–Barents Sea population of polar bears was estimated at between 1900 and 3600 animals. A new survey is to be carried out in 2015.

Since 2005, harp seal pup production has dropped by about 50 % compared with the level in the period 1998–2003.

The main distribution area of baleen whales has shifted further north in recent years, to the northerly shallow waters east of the island of Nordaustlandet and northeast of the Svalbard archipelago. White-beaked dolphins are now being observed far north of the polar front.

Seabird populations

The Barents Sea populations of a number of seabirds constitute a substantial proportion of the European populations, and the total breeding population of seabirds in the Barents Sea is estimated at about 12 million. If non-breeding birds (including juveniles) that use the sea area during summer are included, the number rises to about 20 million. Because the Barents Sea is shallow and highly productive, the distribution of seabirds is not as strongly linked to proximity to the coast as it is in the Norwegian Sea, and large concentrations of seabirds, for example Brünnich's guillemots, are also found in the open sea.

The distribution of seabirds in the Barents Sea is governed mainly by climatic, oceanographic and biological conditions, with a particularly marked gradient from southwest to northeast, from warm, saline Atlantic water in the southwest to cold, less saline Arctic water in the north and east. The polar front is an important feeding area for seabirds, and the distribution patterns of the different seabird species reflect the distribution of the water masses and the location of the polar front. There is a particularly striking difference between the species mix along the Norwegian mainland coast and in the Svalbard area. There are more species, both breeding and wintering, along the mainland coast than further north. Species such as shag, cormorant and gannet were previously found only along the mainland coast (the first gannets bred on Bjørnøya in 2011), whereas glaucous gulls, ivory gulls and little auks only breed on the islands in the northern Barents Sea. The high biological production in the marginal ice zone is important for seabirds at certain times of year, for example just before the breeding season, when species such as Brünnich's guillemot feed there. Other species such as little auk, black guillemot, fulmar and ivory gull also use the marginal ice zone.

Figure 2.6 Brünnich's guillemots.

Photo: Sebastian Gerland, Norwegian Polar Institute.

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 generally easy to count, and they concentrate in large colonies during the breeding season and often in large numbers in productive marine 'hotspots' outside the breeding season. Monitoring seabird populations provides a basis for managing them, and also gives an indication of the availability of food supplies (biomass of prey) in the waters around breeding colonies. Some species have shown a much more dramatic population decline than others; numbers of Brünnich's guillemots on Bjørnøya and in other parts of the Svalbard archipelago have dropped by 25–50 % since the mid-1990s, whereas kittiwake numbers on Bjørnøya and Spitsbergen have remained stable or shown a positive trend in recent years. Regular counts of seabirds as part of the environmental monitoring programme for Svalbard and Jan Mayen (MOSJ) and the mapping and monitoring programme for seabirds, SEAPOP, are carried out along the west coast of Svalbard and on Bjørnøya. There is only limited information on seabirds from the islands of Øst-Spitsbergen and Nordaustlandet, apart from general information on the breeding colonies. It is not possible to give any specific information on the most northerly areas because of a lack of up-to-date figures.

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

Threatened species

The Norwegian Biodiversity Information Centre has been responsible for publishing the Norwegian Red List for species since 2006. The number of species classified as threatened in the Barents Sea–Lofoten area rose between 2006 and 2010. The most important pressures on species and habitats are harvesting, habitat degradation and pollution. In addition, climate change is an important pressure on a number of red-listed species, particularly in the northern parts of the Barents Sea. A new edition of the Red List for species will be published in 2015, and this will show whether the status of the species assessed has changed. The first Red List for ecosystems and habitat types was published in 2011. The red-listed habitat

Box 2.3 Ivory gull

The ivory gull is one of Norway's most ice-dependent species. It is a high-Arctic species, breeding for example in eastern Spitsbergen and Nordaustlandet. There are known to be almost 80 colonies in Svalbard, but not all of them are used every year. Ivory gulls feed on fish and crustaceans in the marginal ice zone, and also on carrion left by polar bears and Arctic foxes. Because of its preferred habitat and diet, the ivory gull is considered to be a good indicator of the impact of declining sea ice extent and changes in sea ice distribution in the Arctic. Its population has shown a severe decline in Canada and southern Greenland, probably because of sea ice changes combined with high levels of contaminants.

The ivory gull is one of the species included in the MOSJ and SEAPOP monitoring programmes. Recent observations support the hypothesis that the species is declining in the Barents Sea area. As the distances between breeding sites and suitable foraging areas increase, the effects on ivory gulls are expected to include poorer condition and lower breeding success, and that the birds are forced to use less optimal foraging areas and prey. Satellite telemetry studies of Norwegian (Svalbard) and Russian ivory gulls indicate that the marginal ice zone is a very important foraging area throughout the daylight months of the year, and especially in spring and autumn.

Figure 2.7 Ivory gull.

Photo: Bjørn Frantzen, Norwegian Polar Institute.

types include three that are found in the deep-water areas of the Barents Sea: coral reefs (vulnerable, VU), coral gardens (near-threatened, NT) and *Radicipes* coral gardens (vulnerable, VU). Various other species, species groups and habitat types have also been assessed for the two red lists, but a lack of information makes it difficult to decide which red list category is appropriate. For example, cold seeps and 42 species of sponges and anthozoans have been placed in the category data deficient (DD). A new classification system for ecosystems and habitat types in Norway has been devised, but it does not include Arctic marine ecosystems associated with sea ice or Arctic coastal waters as separate habitat types. They were therefore not assessed for the Red List of ecosystems and habitat types. However, on the basis of currently available information it seems clear that ecosystems associated with Arctic sea ice are threatened by climate change in the Norwegian part of the Arctic. The classification system for ecosystems and habitat types is being revised, and habitat types associated with sea ice are being considered in this connection.

Alien species

Alien species are species or other taxa occurring outside their natural range (past or present) and dispersal potential through human agency (adapted from the IUCN definition). In global terms, the spread of invasive alien species is regarded as one of the most serious threats to biodiversity. In marine ecosystems, shipping is considered to be one of the main causes of the spread of alien species (through discharges of ballast water and hull fouling). Alien species can alter the natural species composition in an area and thus the local ecosystem. In the Barents Sea, alien species are still mainly found in waters along the mainland coast of Norway rather than in the open sea. The red king crab is the only alien species that is monitored annually in the Norwegian part of the Barents Sea. New estimates show a general population decline since 2004.

The cold, Arctic water of the northern Barents Sea forms a natural barrier to the spread of alien species from further south. However, its effect is being weakened by climate change and rising sea temperatures. As a result, there is a greater risk that any alien species that are introduced will become established and spread in these waters as well. At present, we do not know of any alien species that have been introduced with shipping and have become established in the northern part of the Barents Sea. Only a limited number of alien species have been reported in the Arctic. Of these, the wrack *Fucus evanescens*, the blunt gaper *Mya truncata*, the gooseneck barnacle *Lepas anatifera* and the ascidian *Molgula manhattensis* have been registered around Svalbard.

2.1.4 Overall evaluation

The state of the environment in the Barents Sea–Lofoten area is generally good, but the shrinking extent of the sea ice, the decline in seabird populations and the appearance of new species in the benthic fauna are all cause for concern. The declining extent of the sea ice and the fact that the fjords around Svalbard do not freeze until later in the season has had negative impacts on ice-dependent marine mammals. The problems have been particularly severe for the ringed seal, and pup mortality has risen as a result of poor breeding conditions. A drop in the number of ringed seals affects food supplies for polar bears. The reduction in sea ice extent in the Barents Sea also means that it is further from the whelping areas for harp seals in the White Sea to important feeding areas in the marginal ice zone. This may be a contributory factor in the substantial decline in pup production in the Barents Sea stock of harp seal in recent years.

Variations in plankton biomass have remained within the range found in historical data, although the large Arctic copepod species are showing a northward shift in their distribution. The same is true of the shrimp *Pandalus borealis*. The cod stock is at a historically high level, the capelin stock is stable and healthy, and the haddock stock is also satisfactory. There are clear signs of a northerly and northeasterly shift in the distribution of fish and whales in the Barents Sea. It is uncertain how far into the Arctic Ocean this shift will continue for demersal fish species such as cod and haddock. Together with the declining extent of the sea ice, shifts in the main distribution areas for plankton, fish and marine mammals may alter living conditions for the benthic fauna and seabirds as well.

Concentrations of environmentally hazardous substances in the Barents Sea area are generally low, with the exception of the levels of some substances measured certain fish species and top predators. In some top predators, for example polar bears, levels of persistent, bioaccumulative and toxic substances are high enough to have negative effects on health. A wide range of such substances has been found in seabirds. Little is known about the interactions between different contaminants, but because so many different substances have been found in seabirds, there is concern about possible negative effects. This is the case even in species where the concentrations of individual substances do not exceed levels that are known to have biological effects. Levels of hazardous substances, including radioactive substances, are generally low in the species used as indicators of seafood safety, with the exception of Greenland halibut. Climate change may influence the transport and release of hazardous substances and how they accumulate in fish and other animals.

Harvesting, habitat degradation, climate change and pollution are currently the most important pressures on species and habitat types in the Barents Sea–Lofoten area as a whole. In the northern part of the Barents Sea, climate change as a result of rising global greenhouse gas emissions is the predominant cause of changes that are influencing species and ecosystems. These changes are expected to continue and become more marked, and more severe negative impacts can be expected, particularly for species and ecosystems in the northern parts of the Barents Sea. In future, ocean acidification is also expected to have far-reaching impacts on marine ecosystems.

In 2011, the following conclusions were drawn as regards cumulative environmental effects on marine ecosystems in the Barents Sea–Lofoten area as a whole:

> ‘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. 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 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.'

Since 2011, seawater temperatures have remained high, and this is the most important factor driving environmental change in the Barents Sea, particularly in the more northerly areas. This update of the management plan does not include a new overall assessment of the impacts of activities in various sectors or the cumulative environmental effects on the ecosystems of the Barents Sea. The scientific work in the period up to the revision of the management plan in 2020 will include such an assessment.

In conclusion, the state of the environment in the Barents Sea–Lofoten area is generally good, but considerable ecosystem change is taking place in the northern parts of the area as a result of climate change.

2.2 Particularly valuable and vulnerable areas

Particularly valuable and vulnerable areas are those that on the basis of scientific assessments have been identified as being of great importance for biodiversity and biological production in the entire Barents Sea–Lofoten area. Areas may for example be identified as particularly valuable and vulnerable because they are important habitats or spawning grounds for fish, important habitats for seabirds and marine mammals, or contain coral reefs. Areas were selected using predefined criteria. The main criteria were that the area concerned was important for biodiversity or for biological production. In addition, a number of secondary criteria were evaluated, for example economic, social and cultural importance, and scientific value.

The vulnerability of the species and habitat types in the areas identified has been assessed with respect to fisheries, shipping and petroleum activities, and in addition to climate change and pollution. The vulnerability of an area is considered to be an intrinsic property of the species and habitats to be found there, regardless of whether or not specific environmental pressures are actually acting on them.

A number of particularly valuable and vulnerable areas were identified in the Barents Sea–Lofoten area. In the northern part of the Barents Sea, these are the marginal ice zone, the polar front and the sea areas surrounding Svalbard (see Figure 2.8).

The particularly valuable and vulnerable areas, which contain especially valuable environmental components, were mapped and delimited during work on the management plans. The designation of areas as particularly valuable and vulnerable does not have any direct effect in the form of restrictions on commercial activities, but indicates that these are areas where it is important to show special caution. They have been used as a basis for setting an overall framework for activities. To protect particularly valuable species and habitats, it is for example possible to use current legislation to make activities in such areas subject to special requirements. Such requirements may apply to the whole of a particularly valuable and vulnerable area or part of it, and must be considered on a case-by-case basis for specific activities.

2.3 The marginal ice zone

2.3.1 The marginal ice zone as a particularly valuable and vulnerable area

The marginal ice zone is not in practice a sharp boundary between the open sea and concentrated drift ice, but a dynamic transitional zone that varies in width depending on wind and currents. Its geographical location varies a great deal seasonally; the maximum extent of the sea ice is generally reached in April and the minimum in September. There are also considerable interannual variations in both sea ice extent and the position of the marginal ice zone.

The earlier versions of the Barents Sea–Lofoten management plan describe the marginal ice zone as a particularly valuable and vulnerable area. In the 2006 and 2011 white papers, this area was delimited and its variable extent (the area across which it moves during an annual cycle) was shown on maps.

For the purpose of the management plan, the marginal ice zone as a particularly valuable and vulnerable area has been delimited using statistical methods of expressing satellite observations of variations in sea ice extent through the year for a series of years.

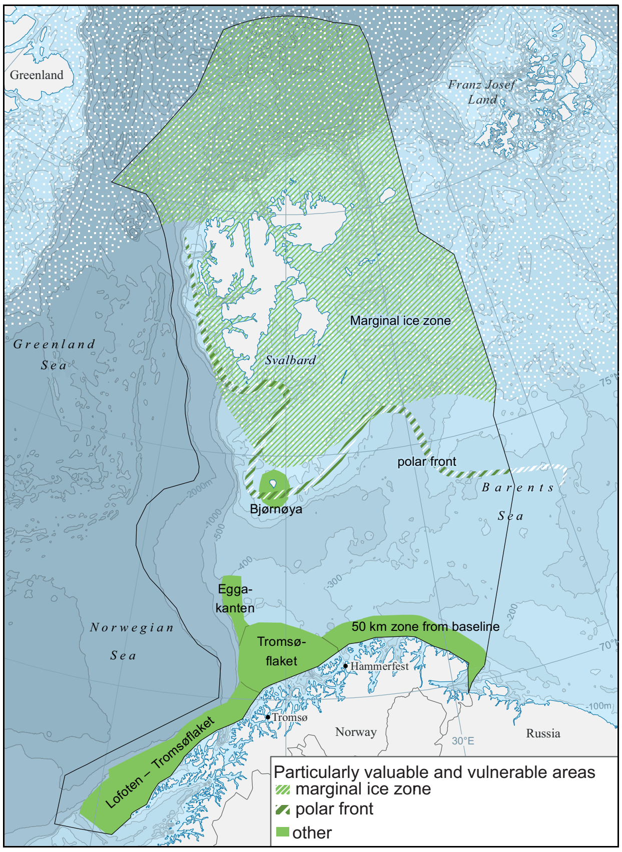

Figure 2.8 Particularly valuable and vulnerable areas in the Barents Sea–Lofoten management plan area. The delimitation of the marginal ice zone has been updated using data on sea ice extent for the period 1985–2014.

Source: Norwegian Polar Institute.

Since 1979, there has been a clear long-term negative trend in sea ice extent at all times of year (see Figures 2.19 and 2.20). The delimitation of the marginal ice zone as a particularly valuable and vulnerable area in the 2006 and 2011 white papers is based on ice data for the period 1967–89. This is no longer representative of current ice conditions. The Government has therefore updated the delimitation of the marginal ice zone as a particularly valuable and vulnerable area using ice data for the period 1985–2014. The updated delimitation of the marginal ice zone is shown on the maps in Figures 2.8 and 2.23.

Thus, the expression 'marginal ice zone' is used both to refer to the natural phenomenon and as the name of the particularly valuable and vulnerable area. Where there is a risk of confusion, the latter is referred to as 'the marginal ice zone as a particularly valuable and vulnerable area'.

2.3.2 The ecosystem of the marginal ice zone

The marginal ice zone is a transitional zone between ice-free and ice-covered sea; it is influenced by waves and swell and there is enhanced ice drift and fracturing of the ice. This zone varies in width from a few hundred metres to several tens of kilometres. The breadth depends on wind direction: a northeasterly wind results in a broad, diffuse marginal ice zone, whereas southerly winds result in a narrower, more clearly defined marginal ice zone. There are also differences between the marginal ice zone during the summer while the ice is retreating and during the winter as more of the sea freezes and the extent of the sea ice increases. The satellite images in Figures 2.9 and 2.10 illustrate the appearance of the marginal ice zone in April, when the sea ice extent reaches its maximum.

At all times of year, the marginal ice zone forms a belt several thousand kilometres long extending through the Barents Sea, and it advances and retreats several hundred kilometres in an annual cycle driven by seasonal variations in sea and air temperatures. The sea ice reaches its maximum extent in spring, usually in April. During the summer, the marginal ice zone gradually moves northwards. By the time the sea ice extent reaches its annual minimum, normally in September, the Barents Sea is generally more or less ice-free and the marginal ice zone is located some way north of Svalbard. There may be wide interannual variations in ice extent. The location of the marginal ice zone in September can vary by several hundred kilometres from one year to another. Interannual variations in ice extent may also be large in the winter and spring months, particularly in the eastern part of the Barents Sea. Figures 2.11 and 2.12 show the actual location of the edge of the marginal ice zone in the Barents Sea for each of the last 10 years up to 2014 in April and September respectively. The figures also show that the updated delimitation of the marginal ice zone as a particularly valuable and vulnerable area encompasses the seasonal variation in sea ice extent measured in the past ten years.

As the ice melts and retreats northwards during the spring and summer, this creates light conditions and nutrient availability in the marginal ice zone that result in a concentrated phytoplankton bloom. The bloom of ice algae in the lowermost part of the sea ice can start up to two months before the phytoplankton bloom, as soon as there is sufficient light in the spring. This prolongs the productive season in areas where there is sea ice,

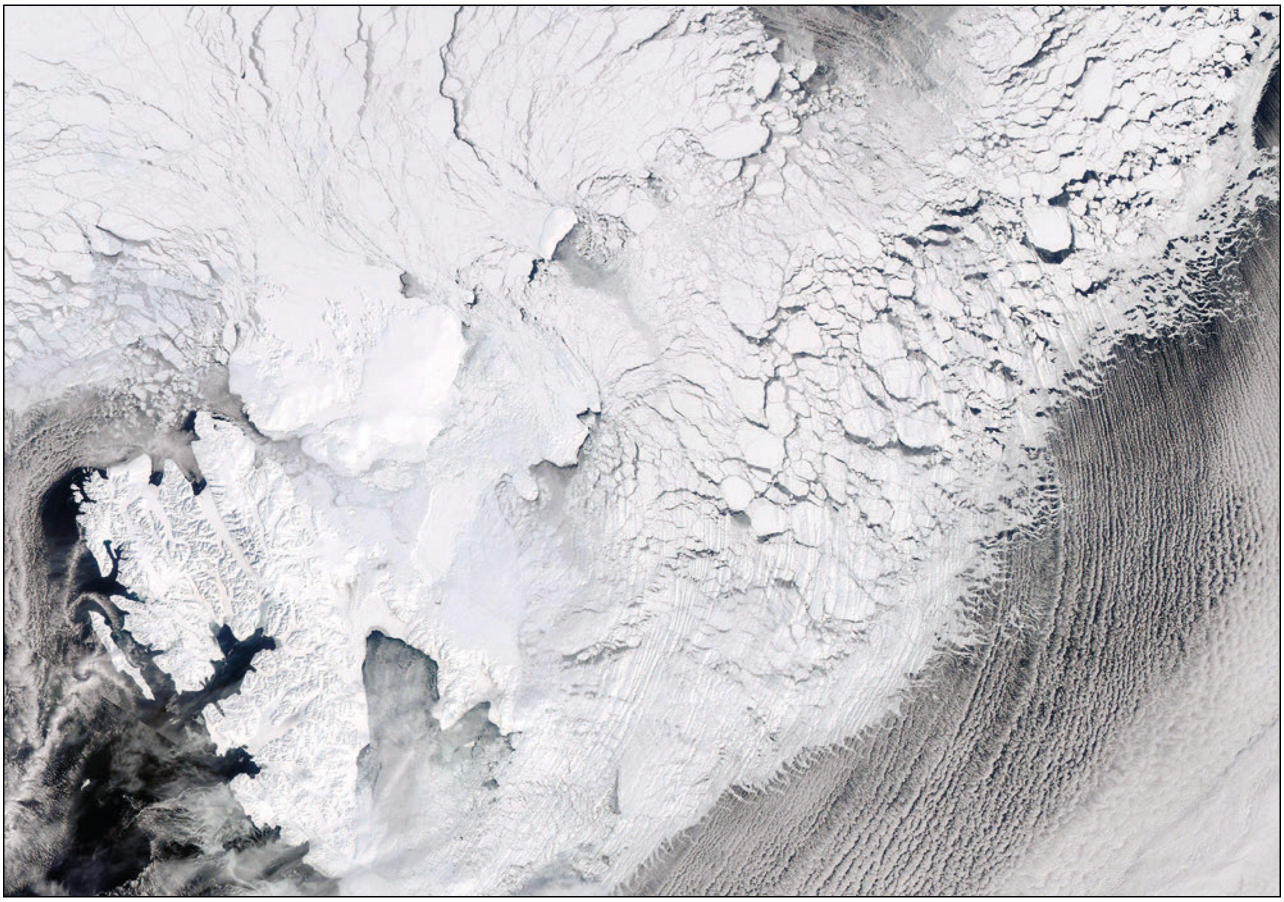

Figure 2.9 Satellite image of ice cover east of Svalbard on 19 April 2013. The image shows a system of large and small ice floes with leads and openings between them that extends far into the drift ice from the fractured outer part of the zone. The fast ice in some of the fjords of Svalbard is also visible. The image also shows clouds, which can be confused with ice.

Source: MODIS, NASA Worldview.

and a number of grazing species have adapted to this situation. The longer productive season together with the importance of the sea ice as a habitat for many species, whether for foraging, shelter or reproduction, make the marginal ice zone a biologically important and valuable area.

From April to September, the productive zone moves northwards through the Barents Sea and provides food for plankton, fish, seabirds and marine mammals. Because the high level of biological production at any time is generally restricted to a zone a few tens of kilometres wide, there may be very high concentrations of grazing species in the marginal ice zone. A number of the species and populations found here are of international and/or national conservation value, are threatened species, species for which Norway has a special responsibility (25 % or more of the European population is found in Norway), or are key species in the Barents Sea ecosystem.

Although biological production is only high in the marginal ice zone in spring and summer, this zone and other areas of sea ice are also a very important habitat for a number of ice-dependent species throughout the year. Mammals to which this applies include the ringed seal, bearded seal, walrus, narwhal and polar bear. Several seabird species also spend most of the year in or near the marginal ice zone.

The maximum southerly extent of the sea ice often coincides with the polar front, but not always. The polar front is the boundary zone where warm, saline Atlantic water carried by the Gulf Stream meets colder, less saline water from the Arctic Ocean. In parts of the area north of the polar front, there is relatively little biological production except for the algal bloom within the marginal ice zone as it moves northwards. As a result, it is variations in the extent of the marginal ice zone that to a large extent govern both biological

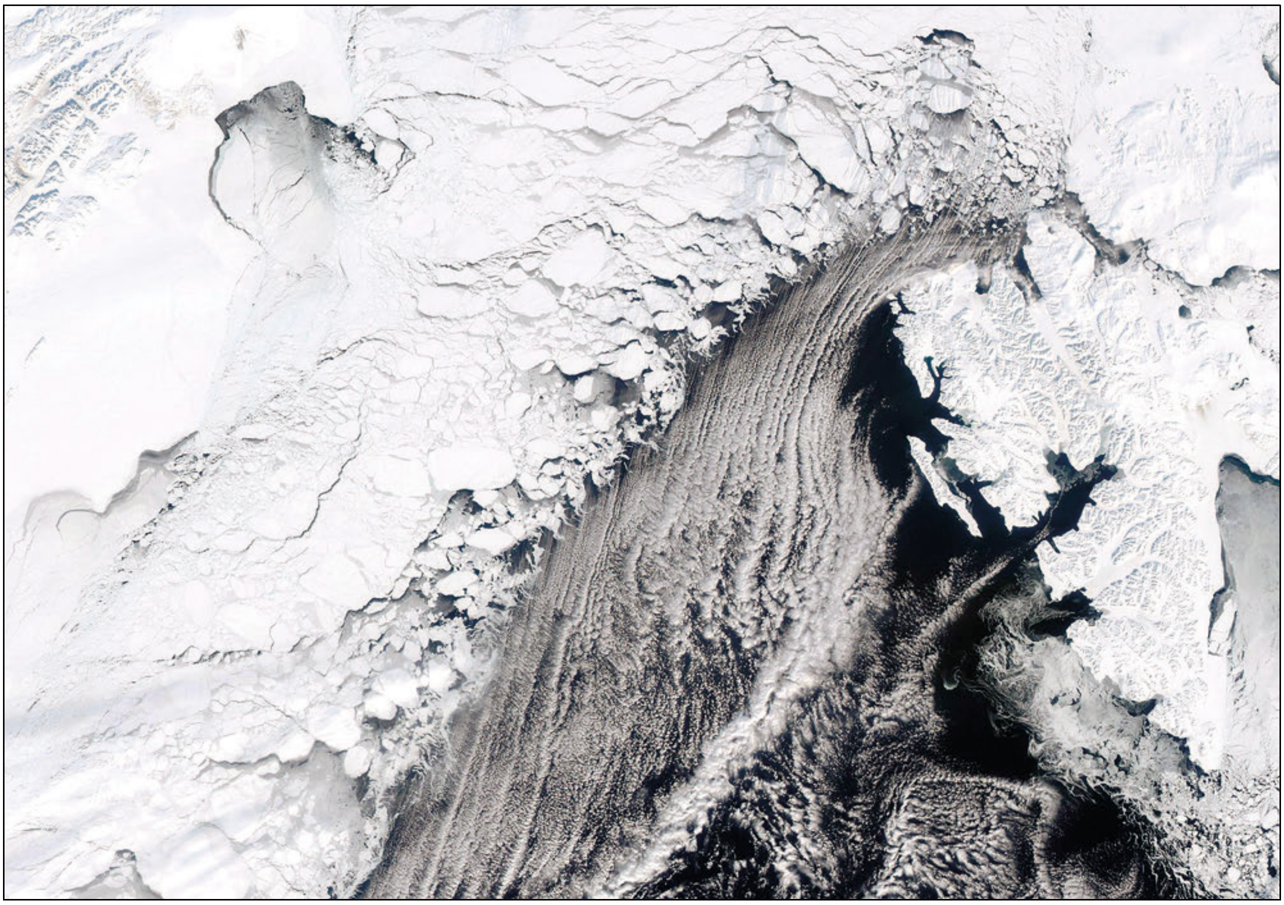

Figure 2.10 Satellite image of ice cover west of Svalbard on 11 April 2013. The image shows a system of large and small ice floes with leads and openings between them that extends far into the drift ice from the fractured outer part of the zone. The fast ice in some of the fjords of Svalbard is also visible. The image also shows clouds, which can be confused with ice.

Source: MODIS, NASA Worldview.

production and the distribution of ice-dependent species in the northern parts of the Barents Sea. Much of the primary production in the marginal ice zone sinks to the seabed, where it can be used by benthic animals, another important component of the ecosystem and part of the diet of seals and seabirds.

Many of the species that live partly in drift ice areas are also dependent on breeding areas on land or on fast ice in the fjords of Svalbard, and on the food supplies available on the seabed in the shallow bank areas traversed by the ice. In the northern part of the Barents Sea and around Svalbard, the sea ice and marginal ice zone are on the surface of shallow waters above the continental shelf, and much of the area is also near to the coast. The combination of a productive marginal ice zone, suitable habitat in and on the sea ice and along the coast, and shallow waters giving access to nutrients on the seabed is crucial for the large numbers of seabirds and marine mammals found in the area. Thus, the sea ice plays a key role in maintaining productivity and diversity in the entire northern Barents Sea ecosystem throughout the year.

2.3.3 Vulnerability

The ecosystem of the marginal ice zone is vulnerable to climate change, hazardous substances and oil spills. Ecological vulnerability is considered to be higher across the whole breadth of the marginal ice zone from the outer limit of the ice and including entire area where light can penetrate through the ice. High concentrations of seabirds and marine mammals can be found in all parts of this zone, often near the open sea. Polar bears congregate particularly deeper into the marginal ice zone, near the transition to more tightly packed drift ice and complete ice cover.

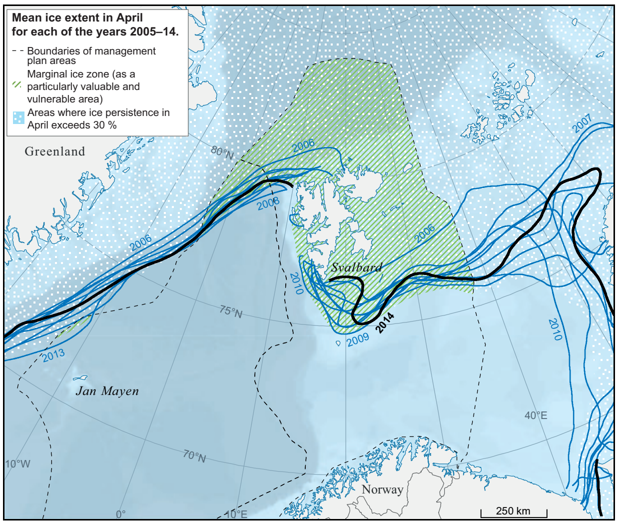

Figure 2.11 Mean ice extent in the Barents Sea in April for each of the years 2005–14. The figure shows the larger interannual variations in sea ice extent in the Barents Sea in April, particularly in the east. The hatched area shows the updated delimitation of the marginal ice zone as a particularly valuable and vulnerable area. The mean ice extent in April has been within this area in each of the past ten years. Together with Figure 2.12, this figure also shows that the delimitation of the marginal ice zone as a particularly valuable and vulnerable area encompasses the seasonal variation in ice extent measured in the past ten years.

Source: Norwegian Polar Institute. Data for monthly mean sea ice extent taken from the US National Snow and Ice Data Center.

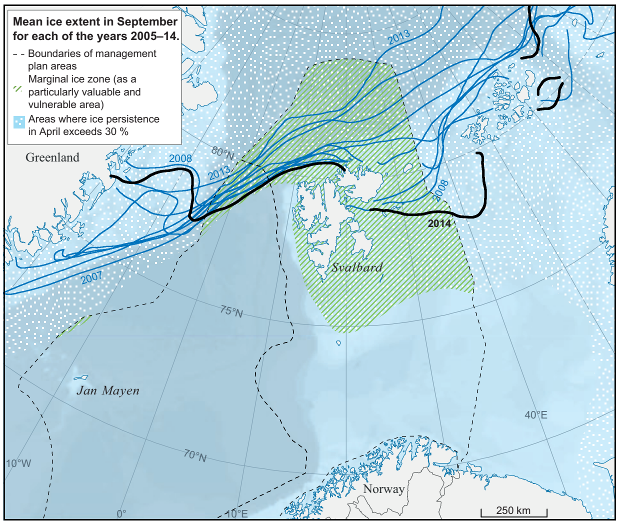

Figure 2.12 Mean ice extent in the Barents Sea in September for each of the years 2005–14. Comparing September 2013 and September 2014 shows how much the summer sea ice extent may vary from one year to another. Together with Figure 2.11, this figure also shows that the updated delimitation of the marginal ice zone as a particularly valuable and vulnerable area encompasses the seasonal variation in ice extent in the past ten years.

Source: Norwegian Polar Institute. Data for monthly mean sea ice extent taken from the US National Snow and Ice Data Center.

Climate change

The ecosystem of the marginal ice zone is highly vulnerable to climate change, which is the greatest threat to Arctic species and ecosystems. Climate change will influence the timing of ice formation and ice melt. This in turn will affect the timing, location and intensity of production in the water column. A reduction in the area of sea ice available will also have an impact on ice-dependent species, and thus on production conditions and biodiversity in areas with a seasonal ice cover. There may also be ecosystem impacts if the timing of the algal bloom in the marginal ice zone changes so that it no longer coincides with the presence of important grazing species, but the consequences are very uncertain. Moreover, changes in ice conditions will have an influence on how much of the algal production under the ice and in the marginal ice zone sinks to the seabed, where it provides nutrition for benthic communities.

The areas covered by sea ice are shrinking rapidly throughout the Arctic. According to the IPCC, the average sea ice extent in the Arctic declined by about 4 % per decade in the period 1979–2012. In summer, the decline has been about 12 % per decade. According to the IPCC, it is very likely that anthropogenic climate change has contributed to Arctic sea ice loss, and that this loss will continue. The IPCC's modelling results indicate that further reductions in sea ice extent in future will be critically dependent on trends in global greenhouse gas emissions. Projections range from a 94 % reduction in summer sea ice extent towards the end of this century in a scenario with high emissions to a 43 % reduction in a scenario with low emissions. The projected reductions in winter sea ice extent are much smaller, ranging from 34 % to 8 %. The results using the high-emission scenario show that the Arctic Ocean will be almost ice-free in September by around the middle of this century. As Figure 2.16 shows, the level of uncertainty in these results is high. In addition to changes in sea ice extent, changes in the thickness and structure of the ice

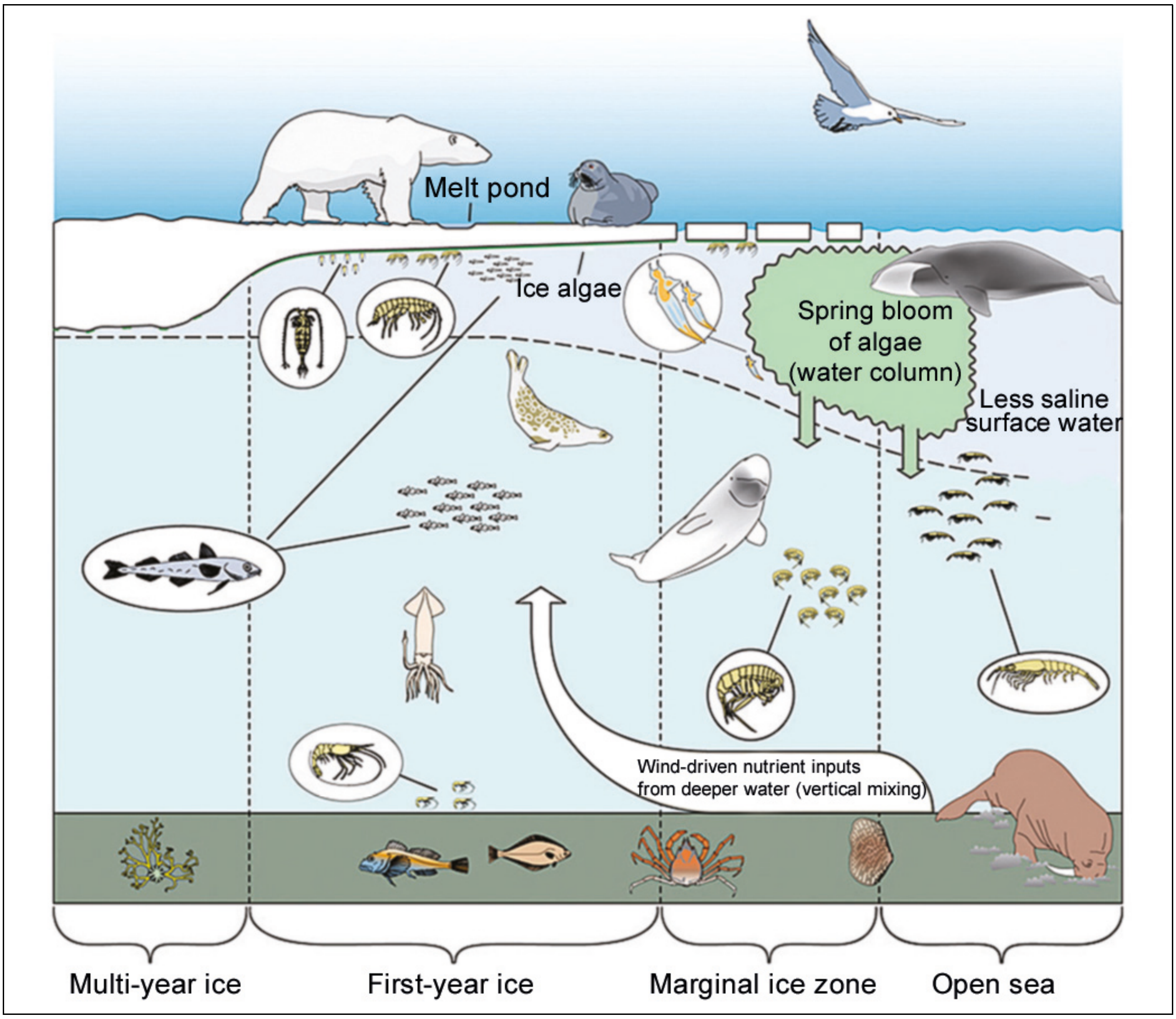

Figure 2.13 The ecosystem in the marginal ice zone during the spring bloom.

Source: Norwegian Polar Institute.

have important implications for production conditions and ice-dependent species.

The Barents Sea is one of the parts of the Arctic where the sea ice is retreating most rapidly. And in contrast to the situation in other parts of the Arctic, sea ice extent is also declining rapidly in winter here (see Figure 2.19). Calculations show that within the parts of the Barents Sea that have a seasonal ice cover, the ice-free period (from the date when the ice disappears in spring and early summer to the date when it re-forms in autumn and winter) has increased considerably since 1979. During this period, the date for the disappearance of the ice in spring has become progressively earlier, by 17 days per decade. The date when the ice re-forms has become later, moving back 24 days per decade. These are far greater changes than in other parts of the Arctic, and according to the climate models they are expected to continue. This poses a serious threat to ice-dependent species such as the polar bear, which can only survive for limited periods without sea ice.

Climate change is already having clear impacts on the ecosystem of the sea ice and marginal ice zone in the Barents Sea. These changes are further described in Chapter 2.1.2.

In its most recent assessment report, the IPCC concluded that in the long term, there is a very high risk of major change in Arctic marine ecosystems. In addition to changing the distribution of species and habitats that are spatially and temporally associated with the sea ice and marginal ice zone, climate change will reduce the area of suitable habitat available to many ice-dependent species. In the longer term, a number of these may

Box 2.4 Plants and animals in the marginal ice zone

In spring and early summer, there is intense primary production under the ice and in the water column in the marginal ice zone. As the ice melts in spring, a stable water surface layer develops containing high nutrient levels after the winter, and light penetrates the water, triggering a phytoplankton bloom.

Ice algae, which live in or on the ice itself, are also important primary producers, like the phytoplankton in the water column. The ice algae are adapted to low light levels, and their bloom starts before that of the phytoplankton. This prolongs the productive season in the marginal ice zone.

Quantities of grazing zooplankton species rise in response to the high primary production, and species that can make use of the abundant food supplies concentrate in the marginal ice zone.

As organisms die, a proportion of the biological production sinks down through the water column to the seabed, and provides the basis for rich benthic communities in ice-influenced areas.

The marginal ice zone provides abundant, predictable food supplies that are of crucial importance for the total annual energy budget (survival and reproduction) of many Arctic species. It is an important habitat and foraging area for key species in the Arctic ecosystem, such as capelin and polar cod. These two species are important prey for seabirds and marine mammals, and the marginal ice zone is therefore also an important staging area for many migratory birds and mammals, for example kittiwake, black guillemot, ivory gull, polar bear, ringed seal, narwhal, beluga and bowhead whale.

In late summer, 80–90 % of the world population of ivory gulls congregate in the marginal ice zone in the northern Barents Sea. Polar bears are found at higher densities along the outer edge of the marginal ice zone than further north. The pelagic seal species whelp on the sea ice in the marginal ice zone in early spring, closely synchronised with the algal spring bloom.

Several of these species are red-listed in Norway or internationally, and the dense concentrations of many species, sometimes in very small areas, increase the vulnerability of the marginal ice zone in periods when production is high.

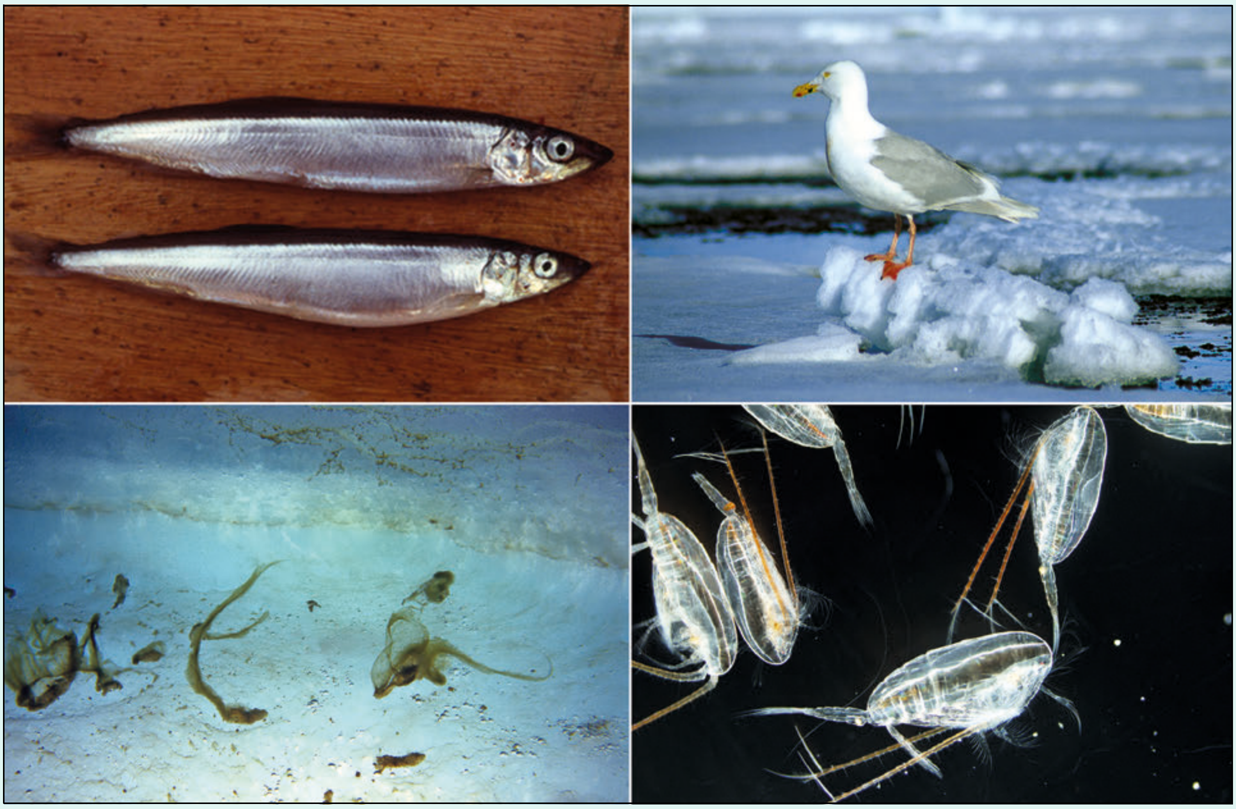

Figure 2.14 Species found in the marginal ice zone: capelin, glaucous gull, ice algae and the copepod *Calanus glacialis* (zooplankton).

Photos: Haakon Hop (capelin, ice algae), Tor Ivan Karlsen (glaucous gull), Allison Bailey (*Calanus*), Norwegian Polar Institute.

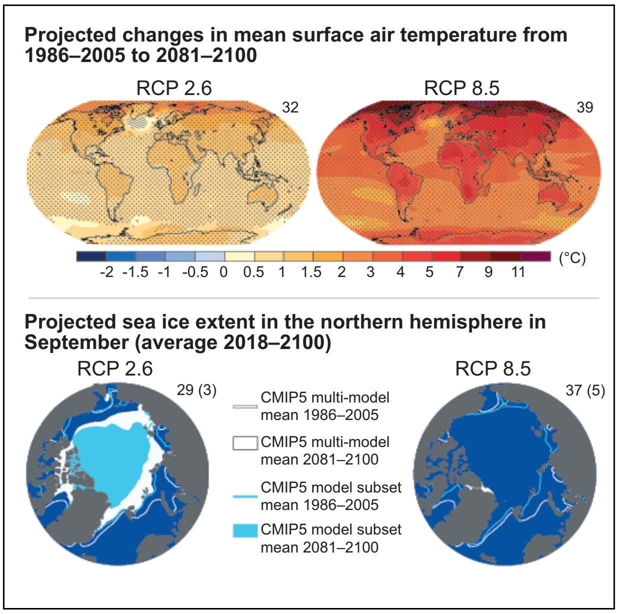

Figure 2.15 Projected changes in mean surface air temperature and sea ice extent towards the end of this century. The right-hand maps show projections for a scenario with continued high levels of greenhouse gas emissions. In this case, the Arctic Ocean is expected to be more or less ice-free in September by the middle of this century. The left-hand maps show projections for a scenario involving deep, rapid cuts in global greenhouse gas emissions. In this case, modelling indicates that there will probably still be sea ice in the Arctic Ocean in summer towards the end of this century.

Source: IPCC.

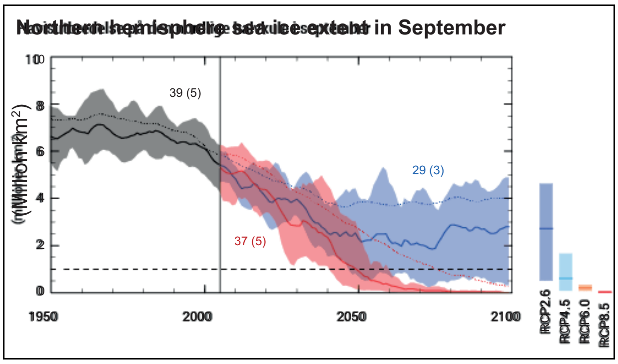

Figure 2.16 Projected changes in Arctic sea ice extent in summer up to the end of the 21st century. Projections based on a scenario with continued high levels of greenhouse gas emissions are shown in red, and projections based on deep rapid cuts in emissions are shown in blue. Solid lines show projected mean values, and the shaded areas show the uncertainty intervals. The horizontal dashed line represents more or less ice-free conditions. It can be seen from the figure that if emission remain high, the Arctic seas are expected to be almost ice-free by the middle of this century.

Source: IPCC.

disappear from larger and larger areas of the Arctic, and the Barents Sea is one of the areas where this is expected to happen most rapidly. There will be less and less suitable habitat for ice-dependent species in the Barents Sea. Such species only have limited opportunities to move further north to find new areas where conditions are suitable. This is because the sea ice is retreating from the shallow coastal waters and continental shelf around Svalbard to the deeper and less productive Arctic Ocean, which cannot support anything like the same level of biological production.

The impacts of long-range transport of pollution, ocean acidification and human activity in the management plan area are additional to the negative impacts of climate change on many species and ecosystems. As the impacts of climate change increase, the cumulative environmental effects on these species and ecosystems will intensify. Climate change may also make ice-dependent species and ecosystems more vulnerable to other environmental pressures. The rapid pace of climate change thus poses considerable challenges for the management of activities that may have impacts on species and ecosystems in the marginal ice zone and drift ice.

Hazardous substances

Even in the undisturbed Arctic environment, far from major sources of pollution, living organisms are exposed to hazardous substances. The fauna of the marginal ice zone is particularly at risk from persistent, bioaccumulative and toxic substances. This is mainly because such substances are transported to the Arctic with northerly winds and ocean currents and then deposited on the sea ice. However, local sources such as historical pollution or oil and chemical spills may also be significant. Modelling results from the Marine Pollution Monitoring Programme (2012) suggest that the sea ice shields the seawater from atmospheric inputs of pollutants in winter, but that they are released into the surface water when the ice melts. This can result in higher concentrations of pollutants along the ice edge in spring, where they may be absorbed by marine animals and plants. This is a serious concern because some substances bioaccumulate very effectively along Arctic marine food chains. In addition, the low temperatures in

Figure 2.17 Polar bears in the marginal ice zone in the Barents Sea.

Photo: Ann Kristin Balto, Norwegian Polar Institute.

the Arctic mean that degradation processes are slower and substances persist longer in the environment. Some Arctic mammals, such as polar bears and ringed seals, are particularly vulnerable to contaminants because their life strategy includes prolonged fasting periods. During these periods, the animals draw on their fat reserves, causing a rise in the concentrations of fat-soluble contaminants in other parts of their bodies and their migration into vital organs such as the liver, endocrine glands and brain. Mammals also transfer contaminants to their young during lactation. Through these mechanisms, hazardous substances are transferred from generation to generation and remain in the environment for prolonged periods. So far, little is known about how climate change will influence the impacts of hazardous substances on marine ecosystems.

Oil spills

In the event of an oil spill, oil pollution in the marginal ice zone could affect the large numbers of seabirds and marine mammals that congregate there, and also the plankton, ice algae and fish larvae in the water column and under the ice. Polar bears, which can be found at high densities in the marginal ice zone, could also be affected in areas polluted by an oil spill. The large concentrations of seabirds and marine mammals make the ecosystem in the marginal ice zone particularly vulnerable to oil spills. There are still major gaps in our knowledge of the damage oil pollution could do to the ecosystem in the marginal ice zone, but its vulnerability is considered to be high. This ecosystem plays a key role for much of the marine life in the Barents Sea, and a large spill in the marginal ice zone could have serious impacts. The impact assessment for the Barents Sea southeast showed that a prolonged oil spill with large amounts reaching the marginal ice zone could be particularly serious for marine mammals associated with this zone. Generally speaking the probability of major spills from petroleum operations is small. The risk of oil spills from shipping and petroleum activities is discussed in Chapter 3.

Oil that is frozen into the ice can be transported with the ice as it drifts, and will be a chronic source of pollution in areas where the ice melts.

Because of the high biological production and diversity in the marginal ice zone, oil pollution in

Figure 2.18 Harp seals on the ice in the marginal ice zone.

Photo: Andrea Taurisano, Norwegian Polar Institute.

this area could affect the habitats of a large number of species and species groups. There are still major gaps in our knowledge of the damage oil pollution could do to the ecosystem in the marginal ice zone, but its vulnerability is considered to be high. The impacts could be particularly severe in the event of a major oil spill across a large are of the marginal ice zone in spring or summer, when production in the water column is very high and large numbers of seabirds and marine mammals may be concentrated in limited areas.

Seabirds that come into contact with oil are liable to freeze to death because their plumage loses its insulating properties when contaminated with oil. Many animal species are very vulnerable to oil throughout the year or at specific times of year, and are usually killed by oil contamination. This applies particularly to seabirds during the moult, seal pups and moulting seals. Other species may survive limited oil contamination. Zooplankton and the early life stages of fish are also vulnerable to oil pollution. Petroleum products contain a large number of different substances, and different products vary widely in composition, toxicity and potential for harm. Oil spills can cause either acute or chronic and potentially lethal physiological and biochemical damage, depending on the concentrations to which individual animals are exposed and the duration of the exposure.

Many factors determine whether a major oil spill has serious long-term impacts, including the time of year when it happens and the stage of animal species' annual cycle (reproduction, feeding, etc) that is affected. Chapter 3.5 describes the special challenges involved in providing an oil spill preparedness and response system for icy waters.

2.3.4 Delimitation of the marginal ice zone as a particularly valuable and vulnerable area in the earlier versions of the management plan

In the 2006 and 2011 white papers on the management plan, the marginal ice zone was identified and described, and its variable extent was shown on maps. This zone includes the entire area of sea that normally has a seasonal ice cover, across which the marginal ice zone moves in the course of an annual cycle between the maximum and minimum extent of the sea ice.

In the management plan, the marginal ice zone has been delimited in the same way as in a report on identification of particularly valuable areas in the Barents Sea–Lofoten area, published in 2003, which formed part of the scientific basis for the 2006 management plan. In this report, the boundary of the marginal ice zone followed a line where sea ice was present on 30 % of the days in April, based on satellite observations of ice extent from the period 1967–89 (excluding 1976). The criterion used to determine whether ice was present was an ice concentration exceeding 15 %, meaning that ice covers more than 15 % of the sea surface. This frequency measure (how often ice is present in a particular month) is called 'ice persistence', and in the short term it expresses the probability of finding sea ice in the period of the year for which the calculations have been made.

This method for delimiting the marginal ice zone as a particularly valuable and vulnerable area is based on statistics on the presence of sea ice for a preceding period, in this case 1967–89. The particularly valuable and vulnerable area encompasses the whole area within which the marginal ice zone will normally be found as the sea ice extent varies between its annual maximum and minimum (see Figures 2.11 and 2.12). It thus covers the areas that are of greatest significance for biological production and biodiversity associated with the marginal ice zone during the course of a year.

Like the other particularly valuable and vulnerable areas, the marginal ice zone contains environmental components that are considered to be particularly valuable, and its delimitation as a valuable and vulnerable area has been fixed. In the case of the marginal ice zone, the delimitation cannot be based on a snapshot of where the ice edge is on a particular date, but must be determined on the basis of statistics on the movement and variable extent of the marginal ice zone during the year and on interannual variations in sea ice extent.

On the basis of a scientific assessment, the boundary of the marginal ice zone is considered to follow the line where there is sea ice on 30 % of the days in April. This criterion means that in the years where the sea ice extent is greatest, there may be sea ice south of the boundary of the marginal ice zone when the ice extent is near its annual maximum (see Figure 2.21).

2.3.5 Update of the delimitation of the marginal ice zone as a particularly valuable and vulnerable area

In the past 30 years, there has been a clear long-term negative trend in sea ice extent both in the Arctic as a whole and in the Barents Sea. In the Barents Sea, this decline has been observed both in summer and in winter. This can be clearly seen in Figures 2.19 and 2.20, which show trends in mean sea ice extent in the Barents Sea in April and September since 1979, based on satellite observations. The figures also show the considerable interannual variability in sea ice extent. This variability is explained by natural fluctuations, while anthropogenic climate change is believed to be the main reason for the long-term negative trend.

With the observed reduction in sea ice, the mean position of the marginal ice zone at any specific time of year is moving steadily further northwards and eastwards. This also means that the ecosystem of the sea ice and marginal ice zone and the vulnerable species and habitats associated with it are shifting in the same direction.

In the earlier versions of the management plan, the extent of the marginal ice zone as a particularly valuable and vulnerable area was delimited using ice data from the period 1967–89. This was a period when there was considerably more

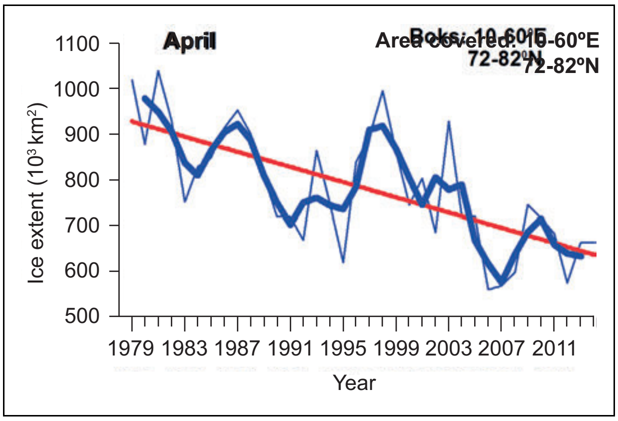

Figure 2.19 Mean sea ice extent in the Barents Sea in April, the month when sea ice extent reaches its maximum. The graph shows monthly means for each year (thin blue line), rolling average values for three-year periods (thick blue line) and the linear trend for the whole period (red line). There are large interannual variations, but also a negative trend in sea ice extent in April throughout the period. The lowest value for sea ice extent was measured in April 2006.

Source: Norwegian Polar Institute.

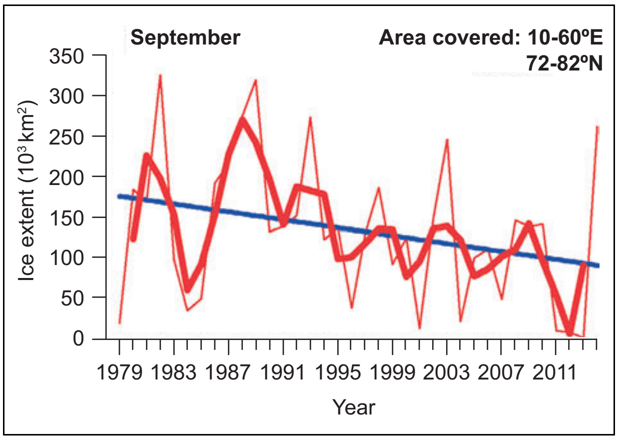

Figure 2.20 Mean sea ice extent in the Barents Sea in September, the month when sea ice extent reaches its minimum. The graph shows monthly means for each year (thin red line), rolling average values for three-year periods (thick red line) and the linear trend for the whole period (red line). There is a negative trend in sea ice extent in September throughout the period, but also large interannual variations.

Source: Norwegian Polar Institute.

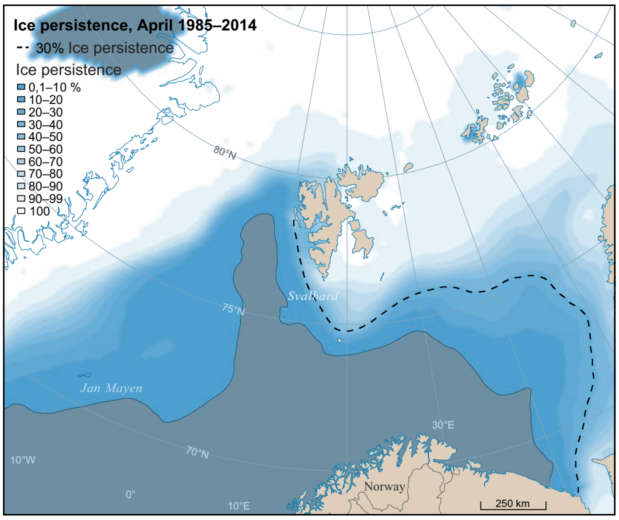

Figure 2.21 Ice persistence in April for the period 1985–2014. Sea ice extent normally reaches its annual maximum in April. Ice persistence is the percentage of days on which sea ice is present in a specific area within a specified period of time, and is further explained in the text.

Source: Norwegian Polar Institute.

ice cover in the Barents Sea than is the case today. The calculations are therefore not representative of current ice conditions.

Particularly valuable and vulnerable areas should be delimited so that their boundaries reflect the areas that are of greatest importance for biodiversity and for biological production. The delimitation of the marginal ice zone as a particularly valuable and vulnerable area has therefore been updated using new ice data, so that it reflects ice conditions up to the present day.

The updated delimitation of the marginal ice zone is based on the same criteria as those used in the 2006 and 2011 versions of the management plan, so that the boundary of the marginal ice zone follows a line joining areas where sea ice is present on 30 % of the days in April. In other words, the marginal ice zone is still delimited using a minimum ice persistence of 30 %. As in the original calculations, the presence of ice means that the ice concentration – the proportion of the sea surface covered by ice – is more than 15 %. Ice data from satellite images for the 30-year period 1985–2014 have been used for the calculations. The new ice data used as a basis for updating the delimitation of the marginal ice zone are generally of better quality than the older data. A 30-year period was used to reduce the sensitivity of the updated delimitation to short-term fluctuations in ice conditions from year to year. The standard normal period used in climatology and meteorology is also 30 years. Figure 2.21 shows mean ice persistence in different parts of the Barents Sea in April for this 30-year period. Figure 2.22 shows the corresponding map for September, when sea ice extent reaches its annual minimum.

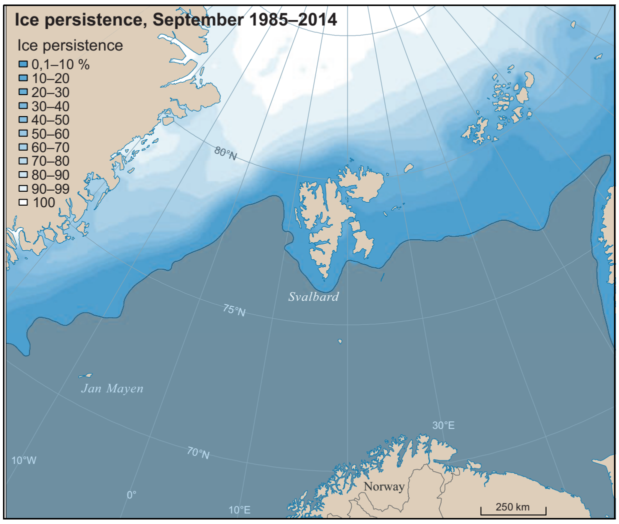

Figure 2.22 Ice persistence in September for the period 1985–2014. Sea ice extent normally reaches its annual minimum in September. Ice persistence is the percentage of days on which sea ice is present in a specific area within a specified period of time, and is further explained in the text.

Source: Norwegian Polar Institute.

The calculations updating the delimitation of the marginal ice zone were performed by the Norwegian Polar Institute, and the new boundary is shown on the maps in Figures 2.8 and 2.23. The updated delimitation reflects changes in ice conditions between the periods 1967–89 and 1985–2014. The ice data used to update the delimitation are from the US National Snow and Ice Data Center, and consist of daily satellite-based measurements of ice concentration in 25x25 km grid squares. As shown by Figure 2.23, the updated boundary of the marginal ice zone runs north of the areas in the Barents Sea that have been opened for petroleum activities. However, special management measures may also be needed south of this boundary to reduce the risk of impacts on the marginal ice zone.

2.3.6 Future updates and further work on the management plan

The delimitation of the marginal ice zone as a particularly valuable and vulnerable area will next be updated in connection with the revision of the management plan for the Barents Sea–Lofoten area in 2020. As part of the scientific basis for the revision, the criteria defined as the basis for delimiting the marginal ice zone will be reviewed.

It is also necessary to consider the implications of the northward retreat of the marginal ice zone in connection with the delimitation of other particularly valuable and vulnerable areas around Svalbard, and for evaluating whether they still cover the most valuable and vulnerable parts of the northern Barents Sea. This is important because climate change is resulting in rapid change in ecosystems, and patterns of human activity are also changing.

In the earlier versions of the Barents Sea–Lofoten management plan, both the polar front and the sea areas surrounding Svalbard are identified and described as particularly valuable and vulnerable areas. There is some overlap between these areas and the marginal ice zone.

The polar front is the zone where warmer Atlantic water meets cold, less saline water from the Arctic Ocean. It is a transitional zone where primary production and biodiversity are high. When the ice has advanced to its maximum extent in spring, the marginal ice zone often coincides to a large extent with the polar front. The location of the polar front, like that of the marginal ice zone, is being influenced by climate change. In the eastern parts of the Barents Sea, the polar front has receded further north and east. An assessment of whether the delimitation of the polar front as a particularly valuable and vulnerable area needs to be updated will be made when the management plan is revised in 2020.

The *sea areas surrounding Svalbard, including Bjørnøya*, have been identified and described as particularly valuable and vulnerable areas in the Barents Sea–Lofoten management plan. Only the area around Bjørnøya has been delimited on maps in the management plan. The scientific work in the period up to the revision of the management plan in 2020 will include an assessment of how the particularly valuable and vulnerable area around Svalbard can be delimited.

In the period up to the revision of the management plan in 2020, it will also be necessary to further develop the set of indicators for assessing environmental status, for example by including indicators for ice-dependent marine mammals.

Box 2.5 Definition of the marginal ice zone as a particularly valuable and vulnerable area

The marginal ice zone as a particularly valuable and vulnerable area is defined so that it encompasses the whole area within which the marginal ice zone will normally be found as the sea ice extent varies between its annual maximum and minimum. The boundary of the marginal ice zone is considered to follow the line where sea ice is present on 30 % of the days in April, using a time series of satellite observations of ice extent for the 30-year period 1985–2014. The criterion for determining whether ice is present is an ice concentration exceeding 15 %, meaning that ice covers more than 15 % of the sea surface. This is in accordance with international standards. This frequency measure is called ‘ice persistence’, and in the short term it expresses the probability of finding sea ice in the period for which the calculations have been made (see Figures 2.21 and 2.22). The delimitation of the marginal ice zone as a particularly valuable and vulnerable area is shown in Figure 2.23.

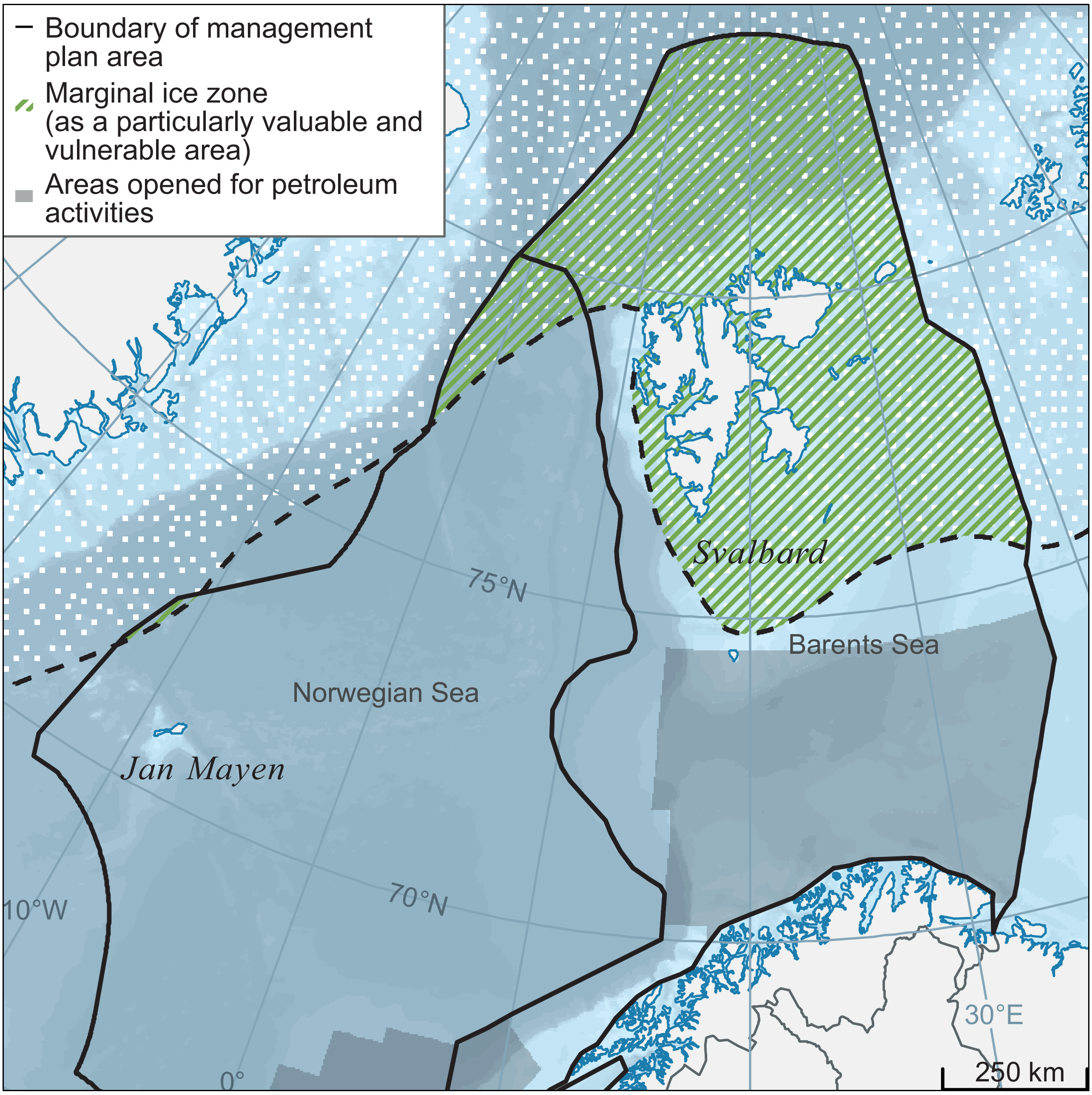

Figure 2.23 Updated delimitation of the marginal ice zone as a particularly valuable and vulnerable area based on ice data for the 30-year period 1985–2014.

Source: Norwegian Polar Institute.

3 Commercial activities in the northern part of the management plan area

3.1 Introduction

Human activity has less direct influence on the Arctic part of the Barents Sea–Lofoten management plan area than on any other part of Norway's marine areas. However, changes in ice conditions are making more of the area accessible to various activities, and larger areas are also becoming accessible as a result of technological advances. Patterns of activity are therefore expected to change. This will make new demands on the management of the most northerly areas.

Fisheries, maritime transport and petroleum activities are the most important activities in the area. In this chapter, actual fisheries activities are discussed in the section on fisheries, while fishing vessels are dealt with in the section on maritime transport. Statistics on maritime traffic in the northern part of the management plan area concern traffic north of the boundary of Arctic waters as defined in the IMO Polar Code. The chapter also contains a section dealing with the risk of acute pollution and the special challenges relating to oil spill preparedness and response in icy waters.

Box 3.1 Research on the environmental impacts of new commercial activities in the north

In 2014, a new flagship research programme, 'Environmental impacts of industrial activity in the north' (MIKON) was started up at the Fram Centre in Tromsø. The programme is intended to strengthen the knowledge base for the authorities' efforts to limit the 'footprint' of industrial activity in north, and to ensure that new industrial activity takes place within a sound environmental framework. Research takes into consideration both existing activities and new developments that are expected in the future.

Given developments in the High North, including a growing volume of maritime transport and expansion of resource extraction activities, Norway must maintain a presence and exercise its sovereignty in the region. Norway's interests and particular responsibilities in the High North also require military capacity. The functions of the Coast Guard and satisfactory search and rescue capacity are particularly important in this connection. The main function of the Coast Guard is to exercise sovereignty and authority, and operations in northern waters are given priority.

3.2 Fisheries

There is a long tradition of large-scale fisheries in Norway's northern sea areas. In the Barents Sea and the northern part of the Norwegian Sea, both Norwegian and foreign vessels harvest from large stocks of Northeast Arctic cod, haddock and saithe, capelin and Norwegian spring-spawning herring, and shellfish such as prawns.

Norway has a modern, efficient ocean-going fishing fleet that operates both off the mainland coast and in the northern seas. Purse seiners and pelagic trawlers fish Norwegian spring-spawning herring along the coast in autumn and winter, and target the capelin stock when it moves to the spawning grounds along the coast of Finnmark in winter. Larger trawlers and vessels engaged in longlining and gill netting catch cod, haddock, redfish, Greenland halibut and prawns in the Barents Sea. In 2013, the landed value of catches from Norwegian fisheries in Arctic waters was about NOK 13 billion.

Most of Norway's commercial fish stocks are shared with other countries. In accordance with international obligations, we therefore cooperate on stock sharing, determining annual total allowable catches (TACs) and other management measures. For stocks in the northern part of the management plan area, the main cooperation forums are the Joint Norwegian-Russian Fisheries Com-

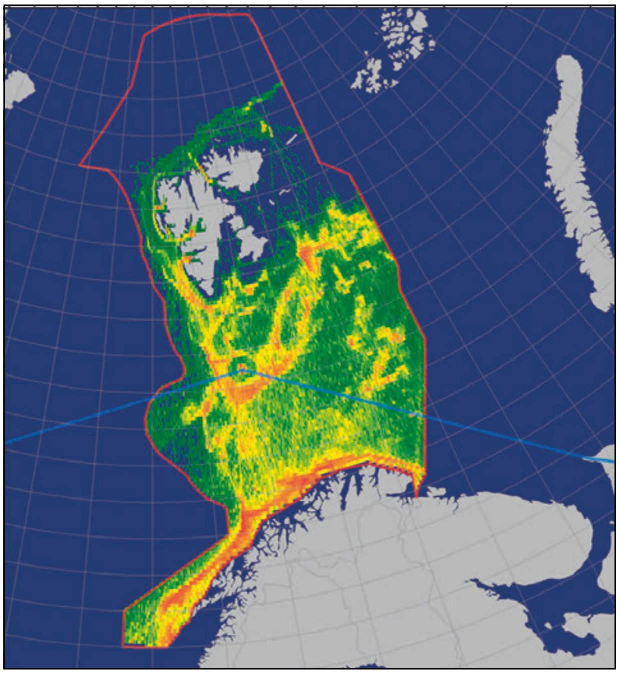

Figure 3.1 Traffic density map for fishing vessels in the management plan area in 2014. The blue line marks the boundary of Arctic waters as defined by the Polar Code.

Source: DNV GL. The figure is based on AIS data from the Norwegian Coastal Administration.

mission and the North East Atlantic Fisheries Commission (NEAFC). In addition, Norway has an extensive national system of regulatory control measures, including monitoring and control carried out by the Coast Guard.

Box 3.2 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.

Norway and Russia practise joint management of the most important fish stocks in the Barents Sea, including Northeast Arctic cod, Northeast Arctic haddock, capelin, Greenland halibut and beaked redfish. The joint fisheries commission and its bodies set TACs and share them between Norway, Russia and third countries. The parties also agree on reciprocal fishing rights in each other's zones, exchange quotas for both joint stocks and national stocks, and harmonise regulatory measures. They have drawn up management plans for cod, haddock and capelin including target stock levels and trigger points as a basis for setting TACs. The TACs jointly determined by Norway and Russia are based on management strategies agreed by Norway and Russia and on recommendations on catch levels from the International Council for the Exploration of the Sea (ICES), which includes both Norwegian and Russian scientists. Efforts to eliminate overfishing, together with joint management strategies and Norwegian-Russian cooperation on resource control, have been very important in improving the state of the Barents Sea cod stock, which is now highly satisfactory.

The TAC for Northeast Arctic cod in 2015 has been set at 894 000 tonnes. Norway and Russia have been allocated equal shares of this, and a quota is set aside for third countries (the EU, Iceland, Greenland and the Faeroe Islands). The TACs for Northeast Arctic haddock and capelin have been set at 178 500 tonnes and 120 000 tonnes respectively.

In recent years the distribution of some of the most important fish species in the Barents Sea has expanded considerably, and they are now found as far north as the waters around Svalbard and further northeast in the Barents Sea in summer and autumn (see Figure 3.2). This change is particularly marked for Northeast Arctic cod and haddock and for capelin. In addition, the distribution of mackerel has shifted northwards, and mackerel are now to be found far north in the Barents Sea in summer.

As a result of climate change, even larger sea areas are expected to be ice-free in summer and autumn, which may result in changes in harvesting patterns in the fisheries.

The greatest biological pressure on the marine environment is the deliberate harvesting of commercial fish stocks. Harvesting is an intentional and managed pressure on the ecosystem, but can have environmental impacts if harvesting levels are not sustainable.

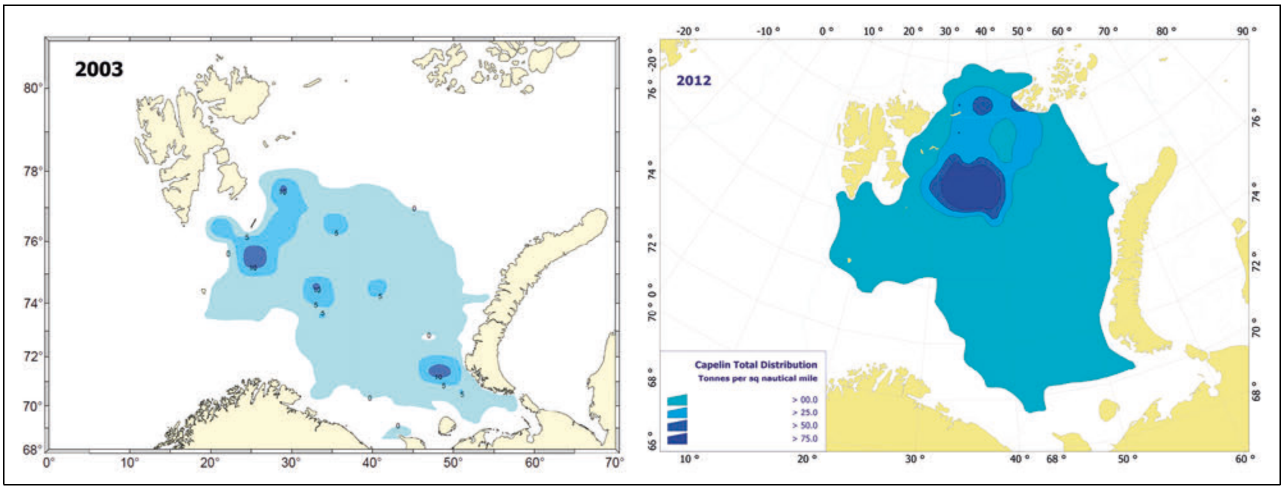

Figure 3.2 Changes in the distribution of capelin on feeding grounds in summer; the range has expanded and shifted from the central to the northeastern part of the Barents Sea. Distribution of capelin in 2003 (left) and 2012 (right).

Source: Institute of Marine Research.

The Coast Guard and the fisheries control system

The Coast Guard is responsible for resource control, in other words effective monitoring, maintaining an appropriate presence and carrying out regular inspections in all areas where there are commercial fishing activities. Priority is given to selected areas where the level of activity is highest and where breaches of the legislation are most likely. The Coast Guard therefore gives priority to preventing overfishing in the Barents Sea, discards of fish and unregistered landings, and to problems associated with bycatches. Through its operations, the Coast Guard exercises authority in the Economic Zone of Norway, the fisheries zone around Jan Mayen and the fisheries protection zone around Svalbard. Its operations are supported by satellite, aircraft and helicopter monitoring.

Information system for the fishing fleet

The fishing fleet has for a long time felt the need for an integrated, practical information system for distributing and reporting key information to vessels' own instrument systems. A joint project between the Norwegian Seafood Research Fund (which represents the seafood industry) and BarentsWatch (cooperation between government agencies and research institutes) has now resulted in a first version of an information system called FiskInfo. This has been available to the fishing fleet since February 2015. This version makes it possible for vessels to have updated information on their own chart plotters at all times, including data on deployed fishing gear, subsea installations, and planned and ongoing seismic surveys. BarentsWatch is to develop FiskInfo further so that it can provide services that are also useful for other vessel types and for other types of operations at sea and along the coast. Relevant user groups from maritime industries and the oil and gas industry will therefore be involved in the project in the course of 2015.

3.3 Maritime transport

The current traffic situation

Information on shipping in the waters around Svalbard has been considerably improved with data from the Norwegian AIS satellites, which pick up and transmit data on vessel position and movements. However, the historical data on trends in traffic patterns and volumes over time are still not good enough.

In 2014, just over 550 vessels (unique ships, both Norwegian and foreign) were registered in the part of the management plan area that will be within Arctic waters as defined by the Polar Code. About half of these were fishing vessels. The second largest vessel category was passenger/cruise ships (45 vessels). Chemical and oil tankers made up only a small proportion of the total, 17 vessels in all.

Data for total distance sailed show a similar pattern. Fishing vessels are the dominant category at present, accounting for about 69 % of the total distance sailed.

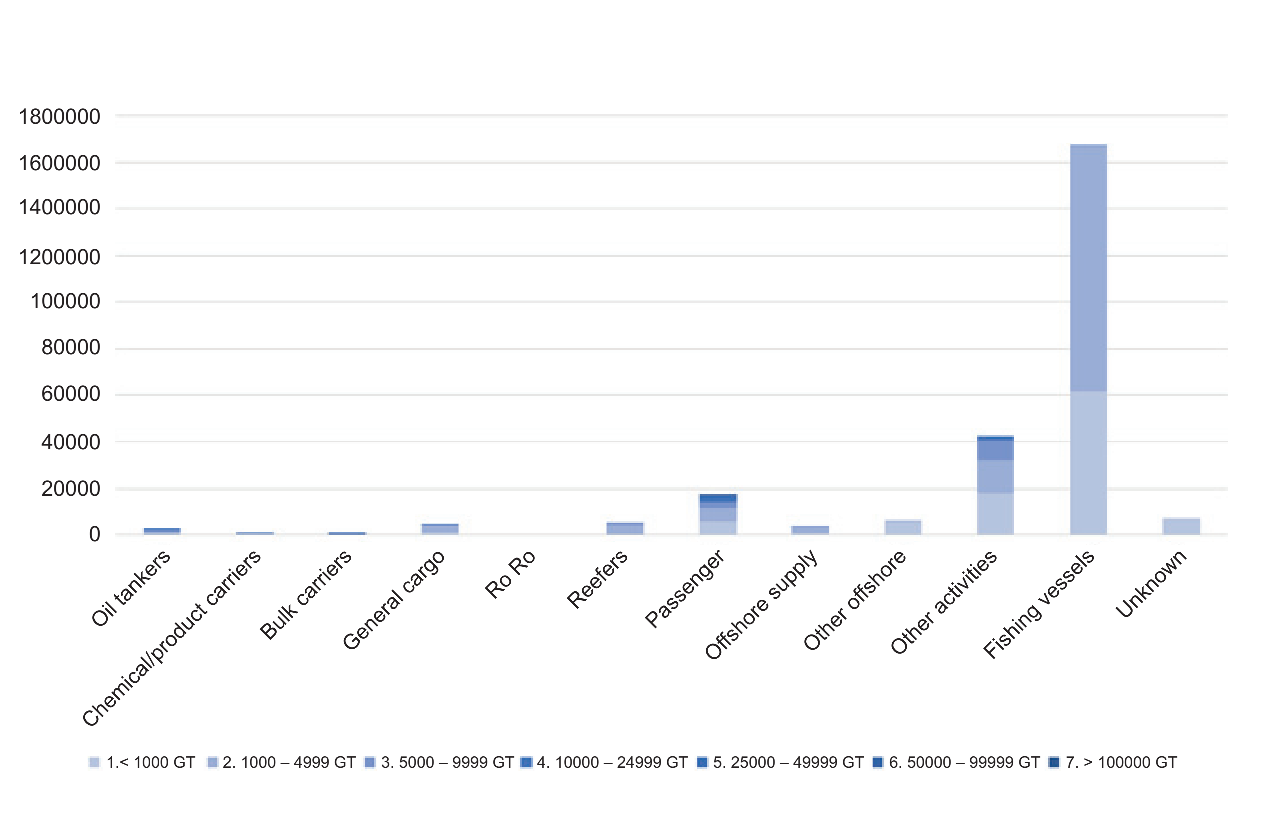

Figure 3.3 Distance sailed (nm) in 2014 in the part of the management plan area within Arctic waters as defined by the Polar Code.

Source: DNV GL. The figure is based on AIS data from the Norwegian Coastal Administration.

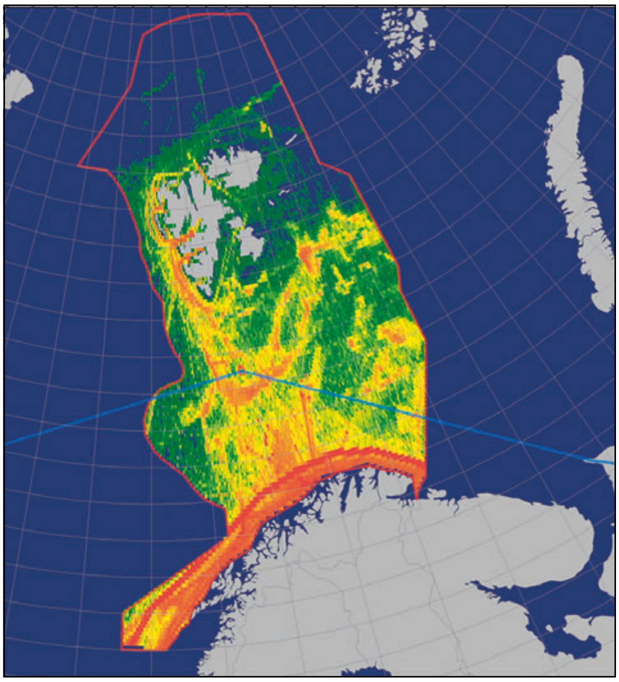

Figure 3.4 Traffic density map for all types of vessels in the management plan area in 2014.

Source: DNV GL. The figure is based on AIS data from the Norwegian Coastal Administration.

Expected trends

Few projections have been made for the Arctic, and those that are available are very uncertain. However, most of them indicate that a gradual increase in the volume of shipping in the Arctic is to be expected. The extend and speed of the increase are more uncertain, and are closely related to other uncertain factors, trends in and the profitability of industries that drive developments in shipping. The largest increase in the region is expected for traffic associated with oil and gas activities and for ships in transit, a result of reductions in multi-year ice and sea ice extent.

To prevent accidents and harmful releases of pollutants, the shipping industry needs to maintain high maritime safety and environmental standards.

Environmental pressures from maritime transport and work in progress by IMO

Shipping can have adverse impacts on the environment through releases both to the sea and to air. Releases to the marine environment include

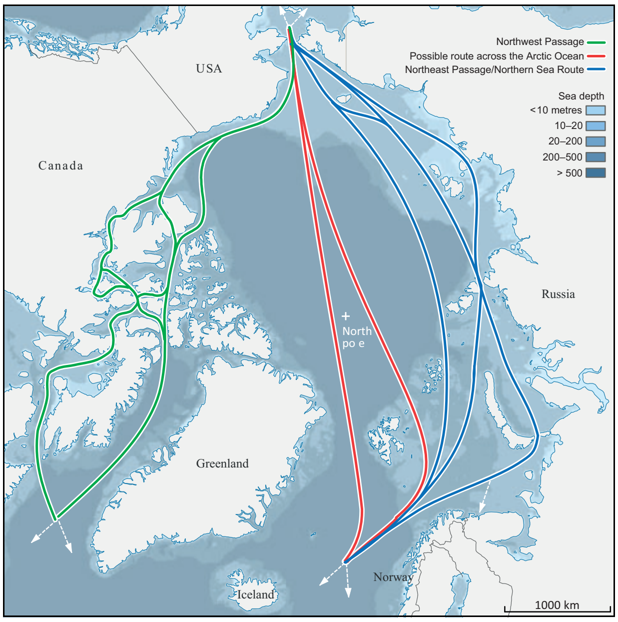

Figure 3.5 Main routes expected to be used by shipping across the Arctic Ocean. The most direct route (red lines) should be considered as a corridor with many options.

Source: Norwegian Polar Institute.

various types of operational discharges. In addition, accidental spills of oil and chemicals may occur. A spill of heavy oil in the Arctic could have very serious environmental impacts.

Operational discharges to the sea from shipping are very strictly regulated under international agreements.

In addition, shipping is responsible for air pollution, for example releases of nitrogen and sulphur oxides. Emissions of soot, or black carbon, are also a problem in the Arctic because soot is a short-lived climate pollutant that is having a considerable impact in parts of the Arctic, and because soot emissions are not regulated. The International Maritime Organization (IMO) is addressing the problems of soot emissions. The spread of alien species attached to ships' hulls or in ballast water can disturb the ecological balance in the Arctic. When the IMO Ballast Water Convention enters into force, it will go a long way towards eliminating the spread of alien species in this way. More knowledge is needed to understand the possible impacts of underwater noise from shipping. IMO has adopted voluntary guidelines for the reduction of underwater noise from shipping.

Environmental risk in the northern part of the Barents Sea

The environmental risk (the probability of acute pollution multiplied by the potential consequences of spills) associated with oil or chemical spills from ships in the Barents Sea varies from one geographical area to another and between seasons. The potential consequences will be most serious if a spill could affect areas where there are high densities of vulnerable species or areas of vulnerable habitat, such as the marginal ice zone and

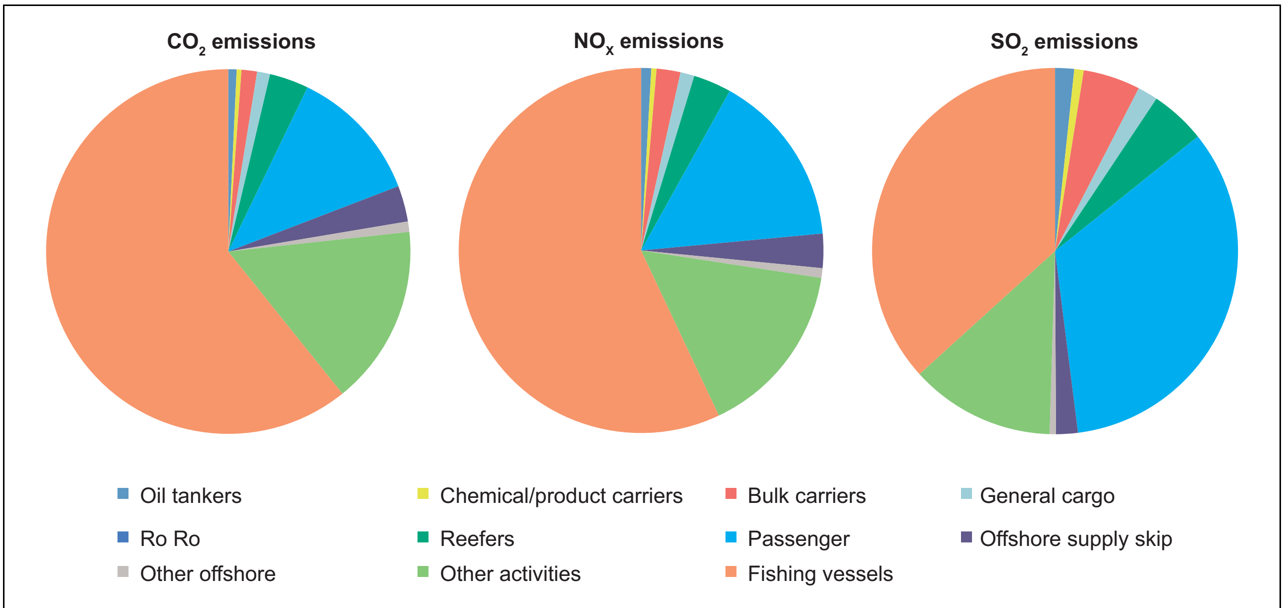

Figure 3.6 Releases of CO_2, NO_x and SO_x from shipping in the part of the management plan area within Arctic waters as defined by the Polar Code.

Source: DNV GL. The figure is based on AIS data from the Norwegian Coastal Administration.

coastal waters. In the Barents Sea, spills in the open sea may also have serious impacts, since there are high densities of vulnerable seabirds in different parts of the sea area at certain times.

The environmental risk associated with shipping is currently highest near the west coast of Svalbard and around Bjørnøya. The probability of incidents involving spills from shipping is also highest in these areas. However, the probability of spills is lower in the waters around Svalbard and Bjørnøya than along the mainland coast of Norway. Because the use of heavy bunker oil is prohibited around much of Svalbard, lighter fuel types are more widely used than along the mainland coast. This has implications for the organisation of the preparedness and response system for acute pollution. On the other hand, there are various areas where the environment is very vulnerable to oil pollution, and the environmental consequences of a spill could be severe. In 2012, as part of efforts to improve preparedness and response to acute pollution, a new mapping tool was established, called PRIMOS (priority areas of environment in Svalbard). Using the tool, the geographical positions of vulnerable species and habitats in and around Svalbard can be mapped and priorities defined, making it possible to concentrate clean-up operations where they are most needed in the event of a spill.

Prohibition against carrying heavy bunker oil in the protected areas around Svalbard

The prohibition against carrying heavy bunker oil in the protected areas around Svalbard was introduced in 2007, and its scope was expanded from 1 January 2015. It is now prohibited to carry heavy bunker oil when sailing to Ny-Ålesund and Magdalenefjorden, two routes that were formerly excepted from the prohibition. Ships are not permitted to use or carry heavy bunker oil when sailing into Nordaust- and Søraust-Svalbard nature reserves on the east coast of Svalbard or the three large national parks Sør-Spitsbergen, Forlandet and Nordvest-Spitsbergen in the western part of the archipelago. Instead, they must use light marine diesel, which causes less serious pollution in the event of a spill.

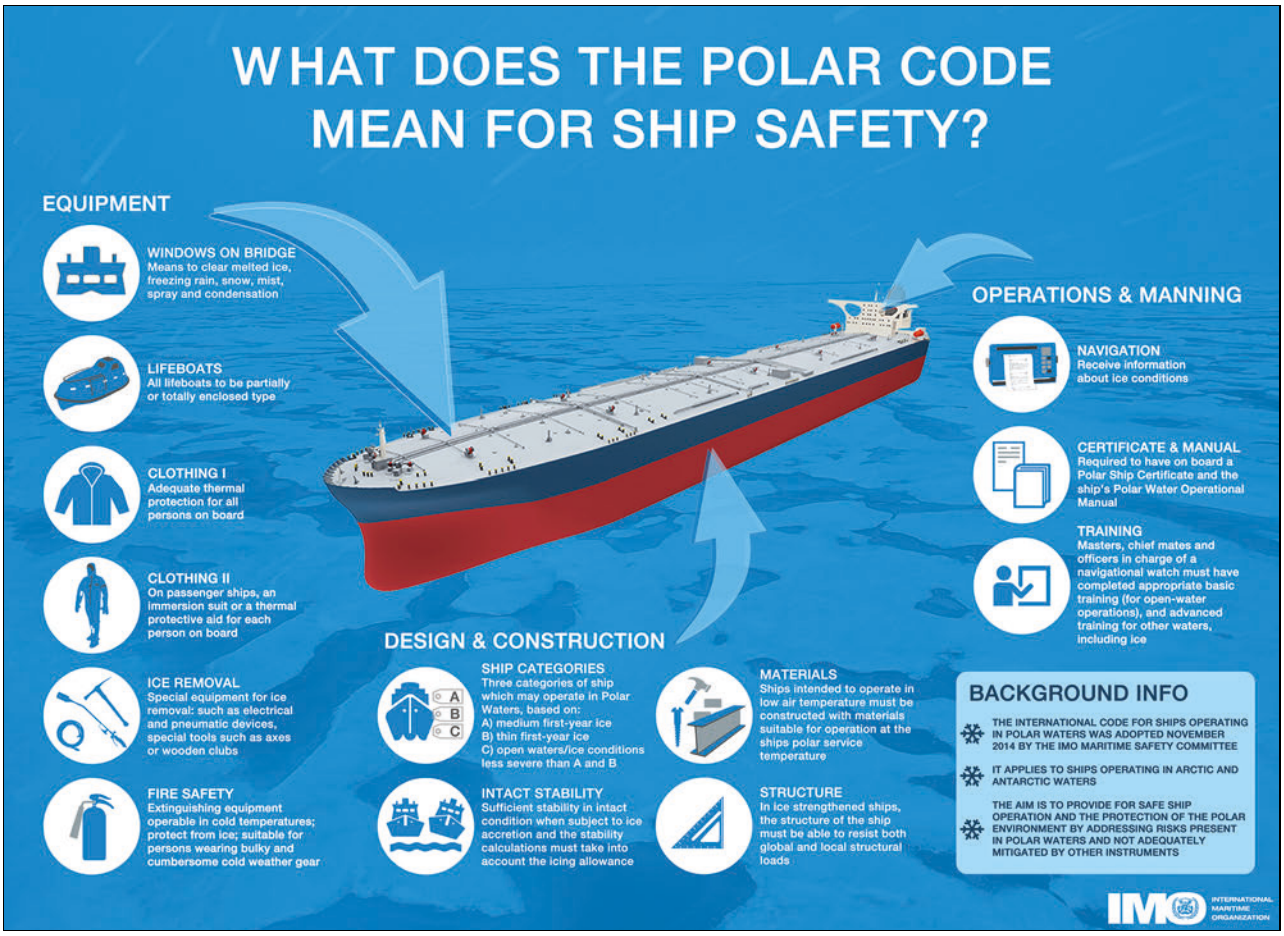

Figure 3.7 Safety requirements for ships under the IMO Polar Code.

Source: International Maritime Organization.

The IMO Polar Code

Like shipping in other parts of the world, shipping in polar waters is subject to the rules of international conventions adopted by IMO. Until now, this regulatory framework has not been adapted to the particular conditions found in polar waters. The development of global binding rules for ships operating in Arctic and Antarctic waters was put on the IMO agenda in 2009 after a proposal by Denmark, Norway and the US. IMO adopted the Polar Code in 2014. Norway has played a key role in the development of the Polar Code and coordinated the work under IMO. The Polar Code lays down globally binding rules for ships operating in polar waters, i.e. Arctic and Antarctic waters. Its rules apply in addition to those of already existing conventions and codes on maritime safety and pollution from shipping (SOLAS, MARPOL, the STCW Convention, etc).

The Polar Code consists of two parts, one on safety and one on environment-related matters. It sets specific requirements for ships operating in polar waters, for example on ship design, equipment, operations, environmental protection, navigation and crew qualifications. The Polar Code enters into force on 1 January 2017.

The most important environment-related provisions deal with pollution by oil, chemicals, sewage and garbage released from ships. The Polar Code is considered to be one of the most important developments for improving maritime safety in polar waters. The Norwegian Government will take steps to ensure its effective implementation.

Particularly Sensitive Sea Areas (PSSAs)

Member states can apply to IMO to have certain areas designated as Particular Sensitive Sea Areas (PSSAs). The approval process involves assessing the sensitivity of the area against its vulnerability to environmental pressures and the risk of damage by shipping activities. If an area is designated as a PSSA, control measures must be identified to prevent damage. These are dealt with by IMO on a case-by-case basis since they may involve new requirements that necessitate amendments to conventions or the publication of recommendations.

So far, 14 PSSAs have been designated in different parts of the world (see Figure 3.8).

In 2013, the Protection of the Arctic Marine Environment Working Group (PAME) under the Arctic Council published a report reviewing and making recommendations on specially designated Arctic marine areas in the Arctic high seas (the AMSA II(D) report. The review was intended to provide a basis for assessing possible joint proposals for the risks posed by international shipping activities.

Maritime safety (coastal state measures)

Maritime safety measures are an essential basis for safe, effective maritime transport. In recent years, a number of preventive measures have been introduced, and together, they have considerably reduced the risks associated with shipping in the Arctic.

Figure 3.8 Map of existing PSSAs.

Source: International Maritime Organization.

Systems for monitoring shipping in Norwegian waters have been considerably strengthened. The Vardø VTS Centre monitors shipping throughout Norway's exclusive economic zone and in the fisheries zone around Svalbard, focusing particularly on tankers and other high-risk traffic. It also issues navigational warnings for shipping in Arctic waters. The Norwegian AIS satellites make it possible to pick up position data even from vessels that are far out at sea, and put the Norwegian authorities in a better position to take action if incidents occur at sea. Traffic separation schemes and recommended routes have been established from Vardø to Røst and off the coast of Western and Southern Norway. These divert high-risk traffic away from the coast, and analyses show that they considerable reduce the probability of and consequences of accidents.

In summer 2013, a mandatory ship reporting system, Barents SRS, was established. Under this system, which has been approved by IMO, higher-risk categories of ships are required to submit reports of their positions when sailing in the Barents SRS area. The system gives both Norwegian and Russian authorities a better picture of maritime traffic in the Barents Sea.

In 2012, the Norwegian state pilotage service was extended to the waters around Svalbard. The pilots use their local knowledge of the waters and navigation expertise to ensure safe navigation in coastal waters.

The Norwegian Coast Guard has important functions related to search and rescue, maritime safety, oil spill preparedness and response, tugboat capacity and other civilian tasks. The Coast Guard plays a part in national emergency preparedness through its participation in coastal emergency response and on-scene command. As the NH 90 maritime helicopters are phased in, monitoring and search and rescue capacity in coastal and marine areas will improve.

Nautical charting and accurate charts are of crucial importance for maritime safety. There are many areas around Svalbard that have not been charted and where no satisfactory depth measurements are available. Surveys have been made more efficient in recent years with new equipment and new survey vessels. On the west coast of Svalbard, priority is being given to those of the remaining non-surveyed areas that are most important for tourist traffic. To the north and east of Svalbard, the priority is to survey areas that are of special importance for safe navigation around the archipelago. Progress in surveying the waters around Svalbard depends on suitable weather conditions during the short survey season, and on being able to use the available resources effectively. Plans and priorities for surveying around Svalbard are drawn up in consultation with the Coast Guard, research institutions and the Governor of Svalbard.

The monitoring and information system BarentsWatch has been developed through the High North cooperation and will also help to improve maritime safety.

In spring 2015, the Government will publish a new maritime strategy, in which one of the topics covered will be the High North. The Government also plans to submit a white paper providing an overall review of maritime safety and the preparedness and response system for acute pollution. The High North will be an important element of this white paper as well.

3.4 Petroleum activities

Petroleum activities in the Barents Sea South

The Storting opened the Barents Sea for oil and gas activities in 1979. At that time, 20 blocks in the Tromsøflaket area were opened. Exploration drilling started, and the Askeladd field, which is part of the Snøhvit development, was discovered in 1981. Later in the 1980s, further areas of the Barents Sea South were opened, and nearly all of the remaining area was opened in 1989. In all, 137 wells have been drilled in the Barents Sea.

Several oil and gas discoveries of varying sizes have been made. The Snøhvit field (gas and condensate) has been developed and is producing, and Goliat is under development and should start producing oil in the course of 2015. The planning process for development of the Johan Castberg field is well under way.

A few exploration wells were drilled in the northern part of the Barents Sea towards the end of the 1980s. In 2013 and 2014 new exploration wells (Wisting (three wells), Apollo, Mercury, Saturn, Pingvin and Isfjell) were drilled.

Opening of the southeastern part of the Barents Sea

In 2011, the Government decided, with the approval of the Storting, that once the maritime delimitation treaty between Norway and Russia for the Barents Sea and Arctic Ocean had entered into force, it would initiate an impact assessment in accordance with the Petroleum Act for the previously disputed area west of the delimitation line in the Barents Sea South, with a view to granting

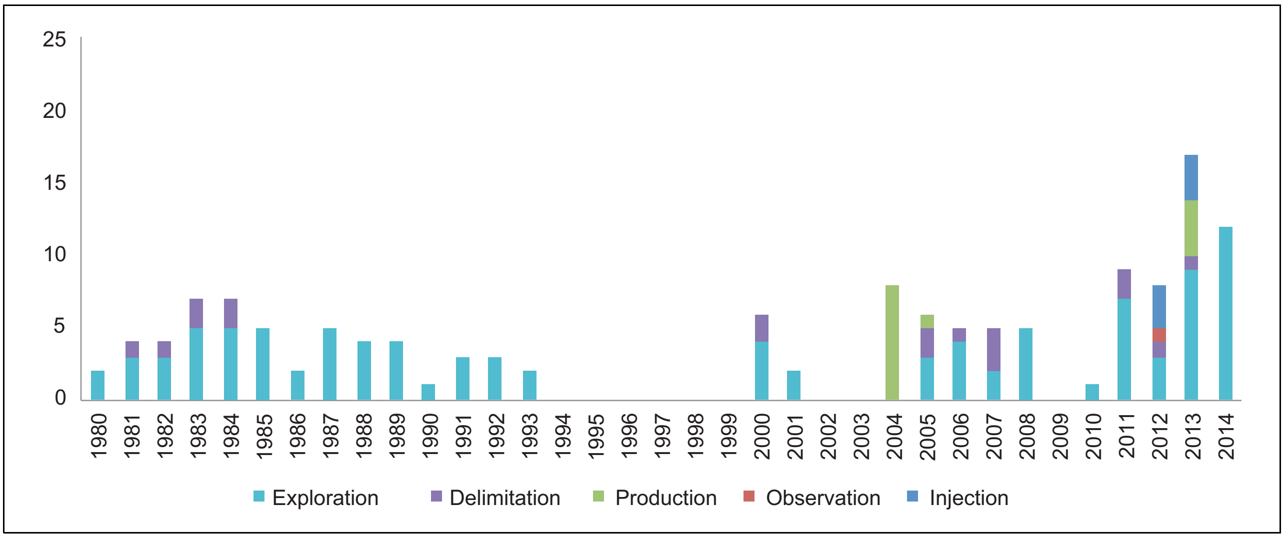

Figure 3.9 Wells drilled in the Barents Sea 1981–2015.

Source: Norwegian Petroleum Directorate.

production licences and collecting data from the area, see the white papers *An industry for the future – Norway's petroleum activities* (Meld. St. 28 (2010–2011)) and the first update of the Barents Sea–Lofoten management plan (Meld. St. 10 (2010–2011)).

The impact assessment for the Barents Sea southeast was carried out in 2012/2013. It was followed up by the publication of two white papers (Meld. St. 36 and 41 (2012–2013)); these were debated by the Storting, which decided to open the southeastern part of the Barents Sea for petroleum activities.

The white papers on the Barents Sea southeast state that no petroleum activities will be initiated in the areas along the edge of the marginal ice zone and the polar front at present, but also point out that this does not preclude oil and gas activities throughout the southeastern part of the Barents Sea.

Petroleum activities in the marginal ice zone and the 23rd licensing round

Petroleum activities in Norway are subject to strict requirements as regards the health, safety and working environment framework and environmental concerns. It is also considered important to facilitate coexistence with other industries. The same also applies to the Barents Sea and in the 23rd numbered licensing round.

In accordance with the framework the Storting has approved for the 23rd licensing round, there are restrictions on when exploration drilling is permitted along the outer edge of the marginal ice zone (wherever this is located at the time of operation). The Government has made these restrictions applicable to the whole of the Barents Sea for the 23rd licensing round. The framework that applies to new production licences for the Barents Sea safeguards species and ecosystems in the marginal ice zone.

In addition, recent sea ice data show that the marginal ice zone, as delimited using ice data for the period 1985–2014, is north of the areas that have now been opened for petroleum activities. The definition of the marginal ice zone is discussed in depth in Chapter 2 of the present white paper.

This means that there will be no petroleum activities in the marginal ice zone in the current parliamentary period.

Environmental risk associated with oil spills

Oil and gas drilling and production entail a certain risk of events that may result in acute pollution. The 2011 white paper on the Barents Sea–Lofoten management plan concludes that generally speaking, the probability of major spills from petroleum operations is low, and will remain low up to 2020 according to conservative estimates based on realistic predictions of the level of activity in the area. Releases of gas have only limited adverse impacts on the environment. To avoid any increase in risk levels, measures can be taken to reduce the probability of acute pollution and, in the event of an incident, to limit the impacts. The possible envi-

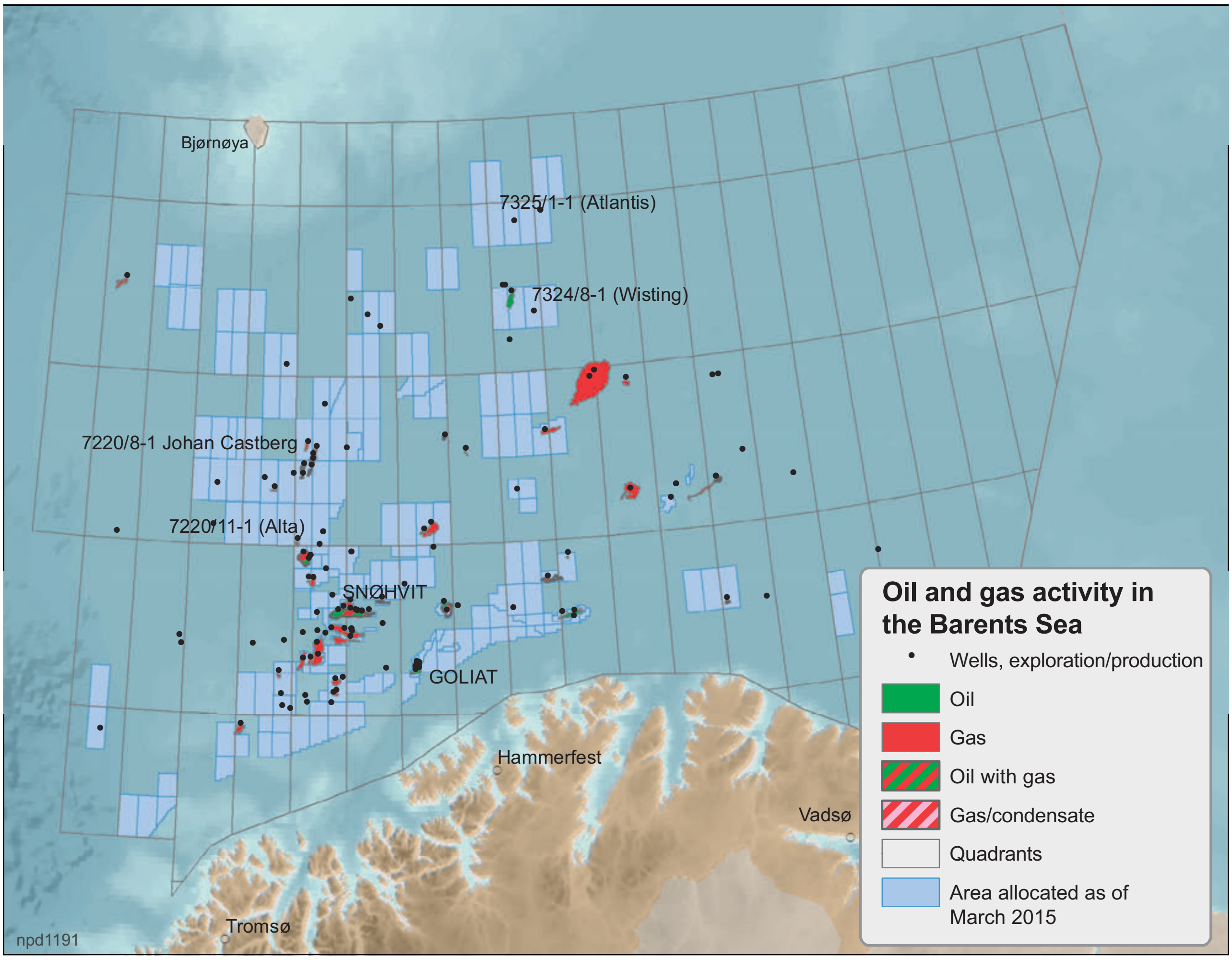

Figure 3.10 Oil and gas activities in the Barents Sea.

Source: Norwegian Petroleum Directorate.

ronmental impacts of spills differ considerably from one geographical area of the Barents Sea to another and between seasons, just as they do in other areas of the Norwegian continental shelf. The consequences will depend mainly on the size of the spill, the type of hydrocarbons released, and when and where the spill occurs in relation to valuable and vulnerable areas and living marine resources.

The potential consequences will be greatest if a spill could affect areas where there are high concentrations of valuable species and habitats, such as the marginal ice zone and coastal waters. In the Barents Sea, spills in the open sea may also have serious impacts, since there are high densities of vulnerable seabirds in different parts of the sea area at certain times.

Analyses carried out as part of the planning process for exploration drilling in the Barents Sea show that environmental risk is strongly associated with the when and where large numbers of seabirds congregate in the open sea. For activities nearer the coast, the highest environmental risk is associated with the large seabird colonies on land (including Bjørnøya). At the most northerly sites where exploration drilling has been carried out so far (the Wisting wells, Apollo and Mercury), the analyses show a certain probability of consequences in the marginal ice zone in the event of a major oil spill during drilling at certain times of year.

The established methodology for assessing environmental risk needs to be adapted to deal with special challenges such as how to calculate oil drift in ice.

Safety considerations for petroleum activities in icy waters

In winter, ice, prolonged darkness, low temperatures and polar lows are all typical of the northernmost areas on the Norwegian continental shelf. In

Figure 3.11 Winterised drilling rig. Transocean Barents.

Source: Transocean.

summer, fog can be a problem. People working in the Barents Sea have to contend with changeable weather at all times of year. However, wind and wave conditions become gradually better further north and east in the area.

Oil and gas installations that are to be used in the Barents Sea must be adapted to meet these weather conditions. Installations and equipment must be protected against the low temperatures so that it is safe for people to work on board, a process known as winterisation. This ensures that equipment and workplaces can operate as normal even in the harsh winter weather. The most important step is to enclose parts of the installation, but this means that the risk of gas accumulation and explosions must be considered. Examples of winterised equipment include insulation of pipes, work clothes that are specially designed for low temperatures and better lighting for the winter darkness.

In the northernmost areas that have been opened for petroleum activities, uncertainty about the presence of sea ice poses special challenges. The distribution of the sea ice is not static – it varies seasonally and from year to year. In addition, ice is not just ice; there are many different types. Because of their size, icebergs are a threat and have the potential to cause serious damage. Smaller pieces of ice may be remains of icebergs or smaller ice floes that have separated from the pack ice and are drifting southwards. Icebergs are rather easier to detect than smaller pieces of ice, which can be difficult to distinguish from the water surface even though they are still large enough to cause damage to installations and equipment near the surface. Icebergs, smaller pieces of ice and ice floes all constitute a real risk to installations and to well control. In areas where icebergs and sea ice may be encountered, good strategies and tools for dealing with risk must therefore be in place, for example:

– ensuring that reliable ice projections and forecasts are available so that safe time windows for operations can be identified;
– using robust methods for monitoring ice, so that steps to make operations safe or to halt them can be taken as soon as possible;
– towing away icebergs, smaller piece of ice or ice floes that are on a collision course with an installation;
– designing installations so that they can withstand collisions;
– disconnecting and moving installations until an iceberg has passed;
– using subsea installations for production, with wellheads, Christmas trees and pipelines buried in the seabed.

3.5 Preparedness and response system for acute pollution and special challenges relating to operations in icy waters

Oil spill preparedness and response in Arctic conditions

We now have a good basis for assessing the special challenges relating to oil spill preparedness and response system under Arctic conditions, existing methods for dealing with oil in ice, and the need for further development of oil spill response technology. The Norwegian Coastal Administration has drawn up an environmental risk and emergency preparedness analysis for Svalbard, Jan Mayen and Bjørnøya, which uses environmental risk as a starting point for evaluating the need for governmental preparedness and response capability to deal with acute pollution and major spills in icy waters.

The northernmost sea areas have little infrastructure and limited telecommunications coverage and capacity: the availability of oil spill response equipment and personnel is also limited, there is a lack of sites where recovered oil and waste can be deposited, and distances are long, meaning that response times are also long if there is an incident.

Natural conditions will also affect oil spill recovery operations – for instance the very limited daylight for part of the year, low temperatures and the risk of icing on equipment, and the often rapid shifts in weather conditions. The presence of ice makes it considerably more difficult to deal effectively with acute pollution. These conditions mean that the methods and strategies, material and vessels for dealing with oil spills need to meet other requirements than those that apply in the waters off mainland Norway. Finding efficient logistics solutions will be a major challenge for all types of operations in Arctic waters. Personnel and material will need to be transported to and from the area affected during an oil spill operation, and recovered oil will have to be transported out of the area unless it is burned off in situ. Operational platforms including ships, aircraft and drones must be robust and meet adequate safety standards. It is essential to comply with health, safety and working environment requirements for response personnel during all types of activities.

It would be very demanding to carry out a large-scale shoreline-cleaning operation in Svalbard because of the long distances involved and the lack of resources and infrastructure on land. Dealing with waste would be particularly difficult, and it will be necessary to focus on techniques for reducing waste quantities.

Existing methods for dealing with oil spills in ice

Practical experience of oil spill response operations, including the recovery of oil released when *MS Godafoss* grounded off the Hvaler archipelago in the outer Oslofjord in winter 2011, indicates that there are currently no adequate and effective methods for dealing with oil in waters where ice is present. There is considerable uncertainty about the efficiency of the equipment that is available, possible operational problems and the environmental impacts of response techniques. Whenever oil or chemical spill operations are organised, possible response techniques must always be evaluated to determine the methods that will result in least environmental damage. The following methods may be appropriate for operations in Arctic waters:

Mechanical recovery using conventional booms and skimmers

Mechanical recovery involves collecting and concentrating oil using booms and then removing it from the surface using various types of skimmers. Mechanical recovery as close as possible to the source of pollution is the primary strategy for the governmental preparedness and response system for acute pollution. Practical experience of response operations shows that it is possible to use conventional mechanical equipment even if ice is present, but a drop in efficiency is to be expected.

Chemical dispersion

Chemical dispersion involves applying a dispersant, a chemical solution, to an oil slick to break up the oil into small droplets. The oil droplets spread and are diluted in the water column, and are gradually broken down. The Government (the Norwegian Coastal Administration) does not currently maintain any chemical dispersion capacity. The petroleum industry (the Norwegian Clean Seas Association for Operating Companies, NOFO) has dispersants and application technology available to deal with spills on the Norwegian continental shelf, but this has not been specifically adapted for use where ice is present.

Simulations and development programmes indicate that chemical dispersion can be an effective way of dealing with spills of diesel in cold conditions and partial ice cover. Further research and development is needed concerning the efficiency of dispersion and its possible environmental impacts.

In-situ burning

For in-situ burning, an ignition device is used to start the burn. It may be necessary to concentrate the oil using fire-resistant booms to ensure that the slick is thick enough to burn. In-situ burning has not so far been used during clean-up operations in Norway.

The long distances, limited oil spill response resources (equipment and personnel), the logistical challenges involved in handling recovered oil and with oil in ice are all arguments for dealing with an oil spill on-site as far as possible. In-situ burning can deal with relatively large quantities of oil quickly and only generates moderate amounts of waste. This may therefore be an appropriate method. In recent years, R&D projects have shown that in-situ burning can be effective in ice. However, it also results in emissions of soot to the Arctic environment. More knowledge and further development of methods is needed, for example as regards the environmental impacts of in-situ burning.

Shoreline clean-up

Shoreline clean-up is generally the most time-consuming and resource-intensive part of an oil spill response operation, and often requires protracted efforts and a large workforce. If shoreline clean-up is required in Arctic areas, the limited availability of personnel and other resources over time and factors such as the lack of daylight in the winter months will make this an even more challenging process than in other parts of Norway. Many areas where oil might make landfall are inaccessible and it can be difficult to go ashore. Special safety assessments would therefore be necessary. Dealing with recovered oil is also particularly difficult in such areas.

Monitoring and remote sensing

Monitoring and remote sensing are used to obtain the best possible information on where an oil spill is at any time. This is essential for effective response operations. It is particularly important under Arctic conditions, where operations will often have to be carried out in darkness, foggy conditions and in icy waters. Data from remote sensors makes it possible to deploy response equipment and personnel to best effect. Using remote sensing normally makes it possible to treat or recover more oil. The Norwegian Coastal Administration has new oil recovery vessels equipped with infra-red cameras and oil spill detection radar. These provide good capacity for remote sensing, but have clear limitations in ice-covered waters. The Coastal Administration's surveillance aircraft is also equipped with radar and infra-red systems, and has sufficient range to fly directly from the mainland to an oil spill in Arctic waters. The aircraft has proved to be very valuable during response operations. Considerable advances are expected in surveillance and remote sensing systems adapted for Arctic conditions. All NOFO's vessels on permanent stand-by are equipped with oil spill detection radar and infra-red sensors.

Need for further development of oil spill response technology

The volume of shipping in areas north of the coast of Finnmark and northwards to Svalbard is expected to increase in the next few years, and petroleum activities are expanding northwards. New knowledge, products and technology will therefore be needed to find solutions to the problems involved in oil spill response operations in a cold climate and icy waters. Solutions are needed that will provide better capacity and be more effective, and that will expand the window of opportunity for operations, for example in terms of light, visibility and temperature. It will also be important to develop better methods of separating oil and water, transport methods and logistical solutions as support for response operations. The logistical challenges also mean that there is an even more pressing need for better technology and knowledge about in-situ treatment of oil, for example burning and chemical dispersion in ice.

The Norwegian Coastal Administration is cooperating with NOFO on the Oil Spill Response 2015 programme. Projects focusing on oil spill response in the Arctic, including topics such as collection technology, dispersion, remote sensing and in-situ burning, are of particular interest in this technology development programme.

International cooperation on emergency preparedness and response in the Arctic and the Barents Sea

As mentioned in Chapter 1, the Arctic Council has a permanent Emergency Prevention, Preparedness and Response Working Group (EPPR). Its goal is to contribute to the protection of the Arctic environment from the threat or impacts of accidental releases of pollutants or radionuclides and to deal with the consequences of natural disasters. The members exchange information on best practices and carry out projects on topics including the development of guidelines and risk assessment methodologies, response exercises and training. The EPPR is also responsible for maintaining the operational guidelines for the cooperation agreement discussed in the next paragraph. Current projects include developing a guide to oil spill response in snow and ice conditions and a searchable database of Arctic oil spill response assets.

The Arctic states (Norway, Canada, Denmark, Finland, Iceland, Russia, Sweden and the US) signed the Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic at the Arctic Council ministerial meeting on 15 May 2013. The agreement establishes binding cooperation on preparedness and response at operational level between the member states of the Arctic Council. It includes provisions on notification of oil pollution incidents and routines for receiving and providing assistance. Operational guidelines have been drawn up for the agreement. The agreement strengthens the overall prepared-

Box 3.3 Preparedness and response to acute pollution

Governmental preparedness and response

The Norwegian Coastal Administration has 16 oil spill response depots along the Norwegian coast. They hold booms, skimmers, shoreline clean-up equipment and emergency off-loading units. Each depot has a staff of 10 and a supervisor. The locations of the depots and the types of equipment stored there have been decided based on the Administration's emergency preparedness analysis, which includes calculations of the probability and consequences of acute pollution along different stretches of coastline. Most of the equipment is designed for use in coastal waters.

The Coast Guard has 11 vessels and the Coastal Administration owns six, and all of these carry specialised oil spill response equipment. The crews of the vessels have received training in the use of the equipment in oil response operations. The Coastal Administration also has contracts for the use of 35 smaller vessels. These are privately owned, but will be made available to the Coastal Administration in the event of an oil spill response operation. These vessels do not normally carry oil spill response equipment, but will use equipment from the depots if deployed to an operation. The *Polarsyssel*, the Governor of Svalbard's vessel, is an important resource for the preparedness and response system for acute pollution in the waters around the archipelago. The ship carries oil spill response equipment during the part of the year when it is in use around Svalbard.

The emergency tugboat service has four vessels stationed along the Norwegian coast. These are also privately-owned, and are contracted to the Coastal Administration. The Vardø VTS Centre can use the tugboats the traffic situation makes it necessary. The primary task of the tugboats is to prevent vessels from drifting ashore.

In addition to their own preparedness and response resources, both the operators and the Coastal Administration have access to additional resources through agreements with other countries and organisations.

Private preparedness and response

Through their own organisation NOFO, the operating companies have access to 31 oil recovery vessels that meet NOFO standards and 34 vessels suitable for towing in the open sea. In addition, there are 25 ocean-going mechanical recovery systems and 10 ocean-going oil dispersion systems. One vessel carrying equipment for both mechanical recovery and dispersion is permanently deployed to the Goliat field. In addition, three recovery and dispersion systems are available at the Hammerfest base. If further resources are required for operations in the Barents Sea, they must be obtained from bases further south on the continental shelf and along the Norwegian coast (Sandnessjøen, Kristiansund, Mongstad, Stavanger). The current NOFO standard for oil recovery vessels is from 2009 and does not include specific requirements for adaptation or strengthening for operations in ice. NOFO also has 63 oil recovery vessels for coastal operations, 30 in Finnmark and 30 from the Lofoten Islands (Vestfjorden) south to Stad at 62° N. In addition, NOFO has the use of three support vessels, four speed barges, and one large and two small work barges. Recovery equipment includes 25 coast and fjord systems and various boom types, including absorbent booms.

NOFO has also established an emergency task force for shoreline cleanup, consisting of 40 people who can quickly be deployed to critical areas with high-speed vessels and with the necessary equipment to limit damage along the shoreline.

ness and response system and the joint capacity of the Arctic states to respond to major oil spills in the region.

At the ministerial meeting in Kiruna in 2013, the Arctic Council decided to establish a Task Force on Arctic Marine Oil Pollution to draw up a plan for the Arctic Council's contribution to preventing marine oil pollution in the Arctic. The Task Force has drawn up a framework plan for cooperation on prevention of oil pollution from petroleum and maritime activities in the marine areas of the Arctic, which is to be discussed at the ministerial meeting in Iqualuit in April 2015.

In 1994, Norway and Russia entered into a bilateral agreement on combating oil spills in the Barents Sea. The agreement has been implemented in the form of a joint contingency plan and annual joint exercises, the most recent of which took place in the outer Varangerfjord, in the border area between Norway and Russia, in June 2014.

4 Measures for the conservation and sustainable use of ecosystems

The purpose of the management plans is to provide a framework for value creation through the sustainable use of natural resources and ecosystem services in each sea area and at the same time maintain the structure, functioning, productivity and diversity of the ecosystems.

In geographical terms, this update of the management plan for the Barents Sea–Lofoten area focuses mainly on the northern/Arctic part of the management plan area. The update includes a particular thorough account of the marginal ice zone as a particularly valuable and vulnerable area, the implications of climate change for environmental status, and developments in human activities in this part of the Barents Sea.

Climate change is currently the predominant cause of changes that are influencing species and ecosystems in this part of the management plan area. Environmental status in the northern part of the Barents Sea is generally good, but the shrinking extent of the sea ice and declining seabird populations are cause for concern. In future, ocean acidification is also expected to have far-reaching impacts on marine ecosystems.

At present, the most important human activities in the northern part of the management plan are fisheries and maritime transport. Changes in sea ice extent are opening up opportunities for shipping to sail along new routes. Petroleum fields in the Barents Sea South are already producing, and new fields are under development and in the planning phase. Exploration activity started 35 years ago and is continuing.

4.1 Continuation of the management plan system

The management plans are a tool both for facilitating value creation and food security within sustainable limits, and for maintaining good environmental status. They clarify the overall framework for different activities and encourage closer coordination and clear priorities for management of Norway's sea areas. Activities in each area are regulated on the basis of existing legislation governing different sectors. Through the system of management plans, Norway has been at the forefront in developing an integrated, ecosystem-based marine management regime. The plans are a clear expression of Norway's willingness and capacity as a coastal state to ensure sound management of its marine areas.

An overall revision of the management plan for each area will be based on a thorough scientific assessment of business development, new knowledge, monitoring results and other information on long-term changes in ecosystems. An update of a management plan has a more limited scope, dealing with a restricted number of issues or part of the geographical area of the management plan. The Storting has previously agreed that the management plan for the Norwegian Sea is to be revised by 2025 at the latest and the management plan for the North Sea and Skagerrak at the latest by 2030. The Government is basing its work on this timetable.

The way scientific work on the management plans is organised has recently been simplified and made more effective to reduce the resources used by the institutions represented in the Forum for Integrated Marine Management and Advisory Group on Monitoring, the two scientific groups involved in the management plan work. Further steps can be taken to simplify routines and make them more effective to ensure appropriate use of resources and organisation of the work.

The Government will:

– Continue to use the system of management plans for sea areas.
– Submit a white paper on revision of the management plan for the Barents Sea–Lofoten area in 2020.
– Initiate work by the Forum for Integrated Marine Management on a scientific basis for the revision during the current parliamentary period.
– Update the management plans as needed.

4.2 The marginal ice zone as a particularly valuable and vulnerable area

The combination of high biological production and high biodiversity in the marginal ice zone led to its identification as a particularly valuable and vulnerable area. It is delimited using the line where ice is present on 30 % of the days in April, based on ice data for the latest 30 years. No petroleum activities are to be started up in the marginal ice zone. Recent sea ice data show that the updated delimitation of the marginal ice zone does not overlap with areas that have been opened for petroleum activities.

The Government will:

- Continue to use the present definition of the marginal ice zone as a particularly valuable and vulnerable area, using the line where sea ice is present on 30 % of the days in April to delimit the boundary. This delimitation is to be based on ice data for the 30-year period 1985–2014.
- Carry out the next update of the delimitation of the marginal ice zone as a particularly valuable and vulnerable area in connection with the revision of the management plan for the Barents Sea–Lofoten area in 2020.

4.3 Knowledge building

A sound knowledge base is essential for the further development of Norway's marine management system. By strengthening basic knowledge about marine ecosystems, we intend to maintain and further develop Norway's role as a knowledge-based maritime nation and a responsible steward of the seas. Sustainable management is a necessary basis for value creation from marine resources.

Climate change, pollution and a general rise in the level of activity in marine areas means that more knowledge is needed about pressures on marine ecosystems and how we can ensure that ecosystems are resilient. We need more knowledge to understand the consequences of environmental and climate change for Arctic ecosystems, and in order to set an appropriate framework for expanding commercial activities. Marine research is in itself an important part of Norway's presence in the High North.

The Government will:

- Assess how it is most appropriate to coordinate and strengthen knowledge building about the ecosystems in the Arctic part of Norway's marine areas. Research on the implications of climate-related changes in Arctic marine ecosystems must be included.
- Continue the work of mapping of the seabed under the MAREANO programme.
- Continue environmental monitoring of Norway's sea areas.
- continue to develop the monitoring and information system BarentsWatch.

4.4 Strengthening international cooperation on conservation and sustainable use of the Arctic marine environment

Cooperation across national borders is essential for achieving good environmental status in sea areas that are shared between countries, such as the Barents Sea and the Arctic Ocean.

The Government will:

- Strengthen cooperation with the other Arctic states, including cooperation in the Arctic Council.
- Continue cooperation with Russia on the marine environment with the goal of developing an ecosystem-based management regime on both sides of the delimitation line in the Barents Sea.

5 Economic and administrative consequences

Work on the management plans will be carried out within the existing budget framework for the ministries involved. Simplified procedures for this work are expected to result in more effective use of resources. 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 Ministry of Climate and Environment

r e c o m m e n d s :

that the Recommendation from the Ministry on the update of the integrated management plan for the Barents Sea–Lofoten area including an update of the delimitation of the marginal ice zone as a particularly valuable and vulnerable area should be submitted to the Storting.

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Kåre Tveter (1922–2012)
Watercolour, 27 x 22 cm, *Arctic Light*, 1994
Kåre Tveter has been called Scandinavia's most prominent painter of light. This can be seen in the Arctic motifs inspired by his many visits to Svalbard.

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