1 THE BARENTS SEA AND THE NORWEGIAN SEA

1.1 The Barents Sea

1.1.1 Ecosystem Overview

1.1.1.1. Ecosystem components

Physical environment and plankton

The Barents Sea is a shelf area separated from the Norwegian Sea by the continental slope. It has an average depth of 230 m, although deeper channels and basins exist which strongly influence currents (Figure 1.1.1.1.1) (von Quillfeldt and Dommasnes, in prep.). North-flowing currents transport warm Atlantic water into the Barents Sea and north along the western coast of Svalbard (Figure 1.1.1.1.1). The branch flowing into the Barents Sea separates into a southern part and a northern part. Cold Arctic water flows into the Barents Sea from the northeast to the southwest. In the west there is a sharp, relatively stationary transition zone between Atlantic and Arctic water called the Polar Front following the bottom contours along approximately the 2°C isotherm. In the east, the transition zone is less distinct and much wider.

The Polar Front constitutes a natural, dynamic bio-geographical border for many ecosystem properties. The Barents Sea area is highly productive. However, many factors contribute to great differences between years in the ability of the primary and secondary production to support the larger organisms. Inflowing and outflowing water facilitates mixing of the water and nutrient supply and, therefore, primary production. Moreover, there is a substantial transport of organisms into the area (e.g. *Calanus finmarchicus* from the Norwegian Sea, and ice fauna from the Arctic Ocean). Advection results in the accumulation of many organisms (e.g. shrimp) in areas like the trenches on the Spitsbergen shelf. The areas around Bjørnøya and northeastward toward Hopen (Spitsbergenbanken) have depths of 20-100 m and mixing of the water reaches the bottom. The steady supply of new nutrients in these shallow areas makes them the most productive in the Barents Sea and, therefore, attractive to young fish feeding on zooplankton.

There are also variations in the spatial structure of the flux. This may partly explain the variation in advections in nutrients, phytoplankton, and zooplankton from the Norwegian Sea to the Barents Sea, since the timing of strong inflow events have to co-occur with peaks in the phyto- and zooplankton biomass in the Norwegian Sea in order to have maximum effect on the Barents Sea ecosystem. The properties of inflowing Atlantic water fluctuate considerably interannually, particularly in heat content, which again influence winter ice conditions. The northern, central, and eastern parts of the Barents Sea as well as most of the areas around Svalbard are covered with ice during winter, and the northern parts have ice also during summer in most years. This sea ice is mostly seasonal (i.e. one-yearly), with drift ice dominating. There is a relationship between sea temperature during winter and ice coverage, while meteorological conditions, especially increased radiation, are controlling factors during summer. During “cold” years ice also covers part of the Atlantic waters for some time.

As the ice melts a stable surface layer develops, uncovering winter concentrations of nutrient salts. The spring algae bloom starts 6–8 weeks earlier at the ice edge than in open sea further south. These favourable production conditions support large concentrations of crustaceans and other species of zooplankton and abundant fish, seabirds, and marine mammals which feed on them. The blooms in Arctic water are, however, often short-lasting compared to those in Atlantic water, which are therefore more productive overall. Warm years with less ice result in higher production, generally shorter generation times for zooplankton and greater import of zooplankton from the south than in cold years. A critical phase for the ecosystem is the transition from a warm to a cold period, with reduced production of phytoplankton and zooplankton to support the populations of larger animals dependent on them.

In cold years, when the ice stretches into Atlantic water, the warm Atlantic water under the ice prompts melting to start 4–6 weeks earlier than if the ice only covers Arctic waters. This may create an early spring phytoplankton bloom, but at the same time the probability of a mismatch between the bloom and zooplankton grazers increases and a greater part of the primary production is likely to sink down to the sea floor.

Some microalgae, zooplankton, and ice amphipods, have life histories dependent on the sea ice. Ice algae are a particularly important food source early in spring before primary production starts, and it is evident that regional and seasonal variations in sea ice development influence the overwintering strategy of grazing organisms. The production of ice algae has been estimated to be about one-fifth of the total primary production, depending on the extent of the ice-free areas.
The water temperatures in the Barents Sea have been relatively high during most of the 1990s, with a continuous warm period from 1989–1995. During 1996–1997, the temperature was just below the long-term average before it turned warm again at the end of the decade, and has remained warm until present. 2004 has been one of the warmest years recorded and with a record salinity (Fig. 1.1.1.1.2) (Føyn, in prep.).

The calanus species are the most abundant zooplankton in the Barents Sea and also the most important for pelagic fish like herring, capelin and polar cod. Its biomass fluctuates between years. Investigations on species compositions of plankton, however, are scarce. The warm and salient water are good conditions for several of the plankton species, but as the 0-group abundance of several fish stocks was recorded to be high in 2004 in the Barents Sea, grazing is expected to be a constraint on the abundance of zooplankton in 2005.

**Bottom habitat and bottom fauna**

Most of the area in the Barents Sea is covered by fine-grained sediment with coarser sediment prevailing on the relatively shallow shelf banks (<100 m) or in the sub littoral zone around islands (Jørgensen and Hop, in prep.). Stones and boulders are only locally abundant. The most southwesterly parts of the Barents Sea are influenced by Atlantic fauna with the diverse warm-water fauna decreasing and cold-water species increasing to the east and north. In general, the fauna biomass, including the benthic, increases near the polar front and in the shallow regions and edges of the banks. A generally reduced biomass towards the west is likely due to reduced mixing of water and consequently a shortage of food. The richest fauna is found on the sandy silts and silty-sand floors. Low biomass occur at areas with impeded upwelling, in areas of low primary production (and reduced vertical flux), and areas of less suitable substrata with heavy sedimentation (e.g. inner parts of glacial fjords).

In the open parts of the Barents Sea, polychaetes (bristle worms) are predominant at great depths and on soft sediment. Bivalves dominate lesser depths and harder bottoms. The main mass of echinoderms is found in western and central parts of the Sea, whereas the mass developments of bivalves are found in the southeastern parts of the Sea. The deeper western part of the Sea is rich in echinoderms and particularly poor in polychaetes. The bivalves are considerably reduced with depth, whereas the echinoderms increase in numbers and the polychaetes remain essentially unchanged.

Red king crab (*Paralithodes camtschatica*) was introduced to the Barents Sea, the Murmansk fiord, in the 1960s (Jørgensen and Hop, in prep.). The stock is growing and expanding eastwards, but more dominantly along the Norwegian coast westwards. Adult red king crabs are opportunistic omnivores. Epibenthic species such as the commercial Iceland scallop *Chlamys islandica* beds might be particularly exposed to risk of local extinction. Decapods are known predators of benthic bivalves, including scallops. Both the red king crab and the scallop have a sub-Arctic distribution. The Iceland scallop has a life span of 30 years, and matures after 3–6 years.

Northern shrimp (*Pandalus borealis*) is an important prey for several fish species, especially cod, but also other fish stocks like blue whiting (ICES 2005A). Consumption by cod significantly influences shrimp population dynamics. The estimated amount of shrimp consumed by cod is on average much higher than shrimp landings. Shrimp is most abundant in central parts of the Barents Sea and close to Svalbard, mostly at depths of 200–350 meter (Aschan, 2000). It is common close to the sea floor, preferably silt or fine-grained sand. Shrimp in the southern parts of the Barents Sea grow and mature faster than shrimp in the central or northern parts.

**Fish community**

The Barents Sea is a relatively simple ecosystem with few fish species of potentially high abundance. These are Northeast Arctic cod, saithe and haddock, Barents Sea capelin, polar cod, and immature Norwegian spring-spawning herring. The last few years there has in addition been an increase of blue whiting migrating into the Barents Sea. The abundance in 2004 was estimated to be 1.4 million tonnes (IMR, 2004). The composition and distribution of species in the Barents Sea depend considerably on the position of the polar front. Variation in the recruitment of some species, including cod and herring, has been associated with changes in the influx of Atlantic waters into the Barents Sea.

Capelin is a key species because it feeds on the zooplankton production near the ice edge and is usually the most important prey species in the Barents Sea, serving as a major transporter of biomass from the northern Barents Sea to the south (von Quillfeldt and Dommasnes, in prep.). During summer they migrate northwards as the ice retreats, and thus have continuous access to new zooplankton production in the productive zone recently uncovered by the ice. They often end up at 78–80˚N by September–October, and then they start a southward migration to spawn on the northern coasts of Norway and Russia. Cod prefer capelin as a prey, and feed on them heavily as the capelin spawning migration brings them into the southern and central Barents Sea. Capelin also is important prey for several species of marine mammals and birds.

Fluctuations of the capelin stock have a strong effect on growth, maturation, and fecundity of cod, as well as on cod recruitment because of cannibalism. The juveniles of the Norwegian spring-spawning herring stock are distributed in
the southern parts of the Barents Sea. They stay in this area for about three years before they migrate west and
southwards along the Norwegian coast and mix with the adult part of the stock. The presence of young herring in the
area has a profound effect on the recruitment of capelin, and it has been shown that when rich year classes of herring
enter the Barents Sea, the recruitment to the capelin stock is poor and in the following years the capelin stock collapses.
This happened after the rich 1983 and 1992 year classes of herring entered the Barents Sea. Also, when medium-sized
year classes of herring are spread into the area there is a clear sign of reduction in recruitment to the capelin stock, as is
currently the case. In this way, the herring impact both the capelin stock (directly) and the cod stock (indirectly).

Cod is the most important predator fish species in the Barents Sea, and feeds on a large range of prey, including the
larger zooplankton species, most of the available fish species, amphipods and shrimp (ICES 2004). The cod migrates
out of the Barents Sea and spawns in the Lofoten area in March. The average age at first maturation has been declining
over the last decades (ICES, 2004). Haddock is also a common species, and migrates partly out of the Barents Sea. It is
a predator on smaller organisms including bottom fauna. The stock has large natural variations in stock size. Saithe is
common in coastal water. The smaller individuals feed on zooplankton, but larger saithe are known to be predators on
fish.

In warm years there may be considerable quantities of blue whiting coming in with the Atlantic water in the southern
Barents Sea. The blue whiting is a plankton feeder. Polar cod is a cold-water species found particularly in the eastern
Barents Sea and in the north. It seems to be an important forage fish for several marine mammals, but to some extent
also for cod. There is little fishing on this stock.

Deep-sea redfish and golden redfish used to be important elements in the fish fauna in the Barents Sea, but presently the
stocks are severely reduced. Young redfish are plankton eaters, but larger individuals take larger prey, including fish.
Fishing on these two species is severely restricted in order to rebuild the stock.

Greenland halibut is a large and voracious fish predator with the continental slope between the Barents Sea and the
Norwegian Sea as its most important area, but it is also found in much of the Barents Sea.

Marine mammals and seabirds

Some mammal species have temperate mating and calving areas and/or feeding areas in the Barents Sea (e.g. minke
whale (Balaenoptera acutorostrata) and harp seals (Pagophilus groenlandicus)), others reside in the Barents Sea all
year round (e.g. white-beaked dolphin (Lagenorhynchus albirostris) and harbour porpoise (Phocoena phocoena)) (Bjørge and
Kovacs, in prep.). Some species are rare, either because this is natural (like white whale (Delphinapterus leucas)) or because of historic exploitation (like bowhead whale (Balaena mysticetus)). Other species are abundant (like harp seals and white-beaked dolphin). The diet of the marine mammals ranges from zooplankton to fish like capelin and
cod. The total consumption of marine mammals in the Barents Sea is estimated to be some million tonnes of biomass,
whereof the consumption of minke whales and harp seals on fish of commercial fish stocks, like capelin, cod, and
haddock, may amount to the same order as the total commercial catches of these stocks (Nilssen et al., 2000 and
Folkow et al., 2000). There are annual quotas on minke whales and harp seals.

The Barents Sea, including the Lofoten area, is an important Arctic area for seabirds, and a significant number of
them reside in the Barents Sea also during the winter (Anker-Nilssen et al., 2000). More than 30 species of seabirds
have been registered in the region. The numbers of seabirds in the Barents Sea have been estimated to 20 million
individuals (Barrett et al., 2001). The most abundant species are Brünnich’s guillemot (Uria lomvia), black-legged
kittiwake (Rissa tridactyla), Atlantic puffin (Fratercula arctica), little auk (Alle alle), and northern fulmar (Fulmarus
glacialis) of which the three first prefer fish as prey. Barrett et al. (2001) estimated the total consumption of seabirds in the
Barents Sea area to be half a million tonnes of 0-group and 1-group fatty fish: capelin, herring and sandeel. Some
species, like Brünnich’s guillemot and Atlantic puffin, seem to be sensitive to weak year classes of fish stocks (Anker-
Nilssen et al., 2000). Brünnich’s guillemot experienced a serious decline as a result of the collapse of the Norwegian
Spring-spawning herring in the late 1960s and declines also when the capelin stock collapses. Atlantic puffin is affected
when year classes of herring are poor, although the relationship is not as clear as with the Rost colonies in the Lofoten
area. While harvest of marine birds has a long tradition in the Barents Sea region, it is now reduced and strongly
regulated.

There is a close link between marine and terrestrial ecosystems, particularly in terms of energy transport from sea to
land (Bjørge and Kovacs, in prep.). Bird colonies often support nutrient-demanding plant communities, upon which
goose and reindeer can subsist. Terrestrial vegetation also serves as a habitat for many rare invertebrates. Arctic foxes
can subsist on seabirds and their eggs; fox denning areas are often in the vicinity of bird cliffs. Nutrient supply from
seabirds can also influence the production in some lakes (observed on Bjornoya and elsewhere). Furthermore, land
serves as haul-out places (for birthing, moulting) for some marine mammals, denning areas for polar bears and as
nesting sites for many seabirds.
1.1.1.2 Impact of fishing activity on the ecosystem

The most widespread gear used in the Barents Sea for demersal fish species is otter trawl. In order to conclude on the total impact of trawling, an extensive mapping of fishing effort and bottom habitat would be necessary. However, its qualitative effects have been studied to some degree. The most serious effects of otter trawling have been demonstrated for hard-bottom habitats dominated by large sessile fauna, where erected organisms such as sponges, anthozoans, and corals have been shown to decrease considerably in abundance with the passing of the ground gear. In sandy bottoms of high seas fishing grounds trawling disturbances have not produced large changes in the benthic assemblages, as these habitats may be resistant to trawling due to natural disturbances and large natural variability. Studies on impacts of shrimp trawling on clayey-silt bottoms have not demonstrated clear and consistent effects, but potential changes may be masked by the more pronounced temporal variability in these habitats (Løkkeborg, in press). The impacts of experimental trawling have been studied on a high seas fishing ground in the Barents Sea (Kutti et al., in press).

Trawling seems to affect the benthic assemblage mainly through resuspension of surface sediment and through relocation of shallow burrowing infaunal species to the surface of the seafloor.

Lost gears such as gillnets may continue to fish for a long time (ghostfishing). The catching efficiency of lost gillnets has been examined for some species and areas, but at present no estimate of the total effect is available. Other types of fishery-induced mortality include burst net, and mortality caused by contact with active fishing gear such as escape mortality. Some small-scale effects are demonstrated, but the population effect is not known.

The harbour porpoise is common in the Barents Sea region south of the polar front. The species is most abundant in coastal waters. The harbour porpoise is subject to severe bycatches in gill net fisheries (Bjorge and Kovacs, in prep). In 2004 Norway initiated a monitoring program on bycatches of marine mammals in fisheries.

Several bird scaring devices have been tested for long-lining, and a simple one, the bird-scaring line (Løkkeborg 2003), not only reduces significantly bird bycatch, but also increases fish catch, as bait loss is reduced. This way there is an economic incentive for the fishermen, and where bird bycatch is a problem, the bird scaring line is used without any forced regulation.

Estimates on unreported catches for cod in 2002, 2003, and 2004 indicate that this is a considerable problem. Unreported catches for North-East Arctic cod are estimated at 90 000–115 000 tonnes each of these years, i.e. 20% of the total catches (ICES, 2005b). For coastal cod, estimates of catches from some fisheries (e.g. tourist and recreational) are not available, but could be of the order of 30% (ICES, 2005b).

Discarding of cod, haddock, and saithe is thought to be significant in some periods although discarding is illegal in Norway and Russia. Data on discarding is scarce, but attempts to obtain better quantification continue.

References


Figure 1.1.1.1 Main currents and depths in the Barents Sea. The red arrows show Atlantic water, the blue: arctic water, and the green: coastal water.

Figure 1.1.1.2 Average temperature and salinity of the Fugloya-Bjørnøya section.
1.2 Norwegian Sea
1.2.1 Ecosystem Overview
1.2.1.1 Ecosystem Components

General geography

The Norwegian Sea is traditionally defined as the ocean bounded by a line drawn from the Norwegian Coast at about 61°N to Shetland, further to the Faroes-East Iceland-Jan Mayen-the southern tip of Spitsbergen-the Vesterålen at the Norwegian coast and the along the coast. In addition a wedge-shaped strip along the western coast of Spitsbergen is included in the area. The offshore boundaries follow in large part the mid-Atlantic subsurface ridges.

The Norwegian Sea covers an area of 1.1 million km² and has a volume of more than 2 million km³, i.e. an average depth of about 2000 m. The Norwegian Sea is divided into two separate basins of 3000-m to 4000-m depth, with maximum depth 4020 m. Along the Norwegian coast there is a relatively narrow continental shelf, between 40 and 200 km wide, which has a varied topography and geology. It has a relatively level sea-bottom with depths between 100 and 400 m. The shelf is crossed by several troughs deeper than 300 m. Moraine deposits dominate the bottom substratum on the shelf, but soft layered clay is commonly found in the deeper parts. Gravely and sandy bottoms are found near the shelf-break and on ridges where the currents are expected to be strong and the sedimentation rates low.

General oceanography

The circulation in the Norwegian Sea is strongly affected by the topography. On the continental shelf at the eastern margin of the area flows the low salinity Norwegian Coastal Current. It enters the area from the North Sea in the south and exits to the Barents Sea in the north east. The inflow of water from the north Atlantic to the Norwegian Sea takes place through the Faroe-Shetland Channel and flows over the Iceland-Faroe Ridge. At the northern slope of the ridge the warm Atlantic water meets the cold Arctic water and the boundary between these waters is called the Iceland Faroe Front. The major part of the warm and high salinity Atlantic Water continues northward as the Norwegian Atlantic Current along the Norwegian shelf, but parts of it branches into the North Sea and also into the more central parts of the Norwegian Sea. At the western boundary of the Barents Sea, the NAC further bifurcates into the North Cape Current flowing eastwards into the Barents Sea and the West Spitsbergen Current flowing northwards into the Polar Ocean through the Fram Strait.

The border zones between the domains of the Norwegian Atlantic Current and the Arctic waters to the west are known as the Arctic and Jan Mayen Fronts, located north and south of Jan Mayen, respectively. Cold Arctic water flows into the southern Norwegian Sea in the East Icelandic current.

With respect to the underlying waters, there is evidence that the Arctic Intermediate Water has been expanding in volume in recent decades (Blindheim, 1990; Blindheim et al., 2000). The Arctic Intermediate water manifests itself as a salinity minimum in the water column and it blankets the entire Norwegian Sea, thus precluding direct contact between the warm surface waters and the dense deep waters (T< -0.5°C) whose properties are defined by inflows from the Greenland Sea. The circulation in the deep waters is topographically influenced and clockwise in the two basins. The cold deep water flows out of the Norwegian Sea through the Faroe Bank channel, the deepest connection to the North Atlantic (Blindheim 2004).
Figure 1.2.1.1  Norwegian Sea main circulation pattern.

Climate variability

Between Iceland and Jan Mayen variation in the volume of Arctic waters carried by the East Icelandic Current (EIC) may result in relatively large shifts of the front between the cold Arctic waters and the warm Atlantic water. Fluctuations in fluxes and water-mass properties in the two major current systems are therefore of decisive importance for the structure and distribution of the water masses in the Nordic Seas. A high NAO index with strong westerly winds results in increased transport in the EIC. E.g. in the early 1990s the NAO index was high and the Arctic water occupied a larger portion of the Norwegian Sea. The volume of and properties of the Arctic water carried directly into the Norwegian Sea by the EIC play a larger role than previously believed in the creation of variability in the distribution of water masses and their properties in the Nordic Seas (Blindheim et al. 2000 and Blindheim 2004).

Phytoplankton

The annual rate of primary production in the Atlantic Water has been estimated to be about 80 g C m⁻² year⁻¹ (Rey 2004). Of this production about 60% is new production, i.e. the remainder 40% of the production is assumed to be based on regenerated nutrients. The new production represents the potential for harvest in the ocean. The spring bloom, defined as the time of the maximum chlorophyll concentration, occurs in the mean around 20th of May, but may occur a month earlier or later. The most important group of phytoplankton is the diatoms, with most of the species belonging to the Order Centralis, and the most important representatives are species of the genus Thalassiosira and Chaetoceros. After the diatom spring bloom the phytoplankton community is often dominated by the flagellate Phaeocystis pouchetii. In the Norwegian Coastal Current the primary production varies from 90–120 g C m⁻² year⁻¹.

Zooplankton

The zooplankton community of the Norwegian Sea is dominated by copepods and euphausids. The main copepod is Calanus finmarchicus in the Atlantic water while Calanus hyperboreus is the dominant species in the Arctic watermasses. The main euphausids are Meganyctiphanes norvegica, Thysanoessa inermis, and Thysanoessa longicaudata. Other important zooplankton are the hyperids Themisto libellula and Themisto abyssorum. The plankton community show varying productivity with concentrations of the most important species Calanus finmarchicus varying for instance between about 8 g/m² dryweight in 1997 to 28 g/m² dryweight in 1995. The highly variable availability of zooplankton is an important factor for fish stock productivity.
Benthic habitats in the Norwegian Sea

Coral reefs formed by the cold-water coral *Lophelia pertusa* are quite common in the easter shelf area of the Norwegian Sea. Nowhere else in the world similar densities and sizes of such reefs have been found. The largest reef, or reef-complex (comprising several closely situated individual reefs) known as the Røst Reef, is situated south-west off Lofoten. *Lophelia* reefs offers habitats (microhabitats) for a great diversity of other species. Redfish (*Sebastes* spp.) are common on the reefs. The great abundances of this fish have been known by local fishers for a long time. More recent fishery practice employing rock hopper trawl gear close to or directly on these reefs has led to severe damages. Other corals such as gorgonians also form habitats utilised by fish and other organisms. These habitats are often called “gorgonian forests”, and are common in some fjords and along the shelf break.

Fish community of the Norwegian Sea

The Norwegian Sea fish community is characterised by a number of large stocks of medium sized highly migratory pelagic species exploiting the pelagic zone of the waste areas with large bottom depths, smaller mesopelagic species exploiting the same areas and several demersal and pelagic stocks exploiting and/or spawning in the marginal eastern continental shelf areas. The large stocks exploiting the area for feeding must be regarded key species in the ecosystem while those visiting the more marginal north eastern shelf area for spawning are expected to be of less significance.

The main pelagic stocks feeding in the area are the blue whiting, *Micromesistius poutassou*, NE Atlantic mackerel, *Scomber scombrus*, and *Norwegian spring-spawning herring*, *Clupea harengus*. Herring also spawns in the eastern shelf areas. With regard to horizontal distribution in the feeding areas herring is the most northern one, mackerel more southern while blue whiting seems distributed over most of the area. With regard to vertical distribution during the feeding season mackerel is closest to the surface, herring somewhat deeper, while blue whiting as a mesopelagic species with the deepest mean depth distribution. Other important mesopelagic species in the area are redfish *Sebastes* sp., pearlside, *Maurolicus muelleri*, and lanternfishes, *Benthosema glaciale*. The open Norwegian Sea all the way into the polar front is an important nursery area for the lumpersuckers, *Cyclopterus lumpus*, and the northeastern shelf areas are important spawning grounds. Local stocks of herring exist in many fjords along the Norwegian coastline. The stocks make limited migration out in to the open waters for feeding.

None of the main pelagic species has their entire lifecycle within the Norwegian Sea ecosystem. Blue whiting spawns west of the British Isles and perform a northerly and westerly feeding migration into the Faroese ecosystem and the Norwegian Sea ecosystem. Mackerel spawn west of the British Isles and in the North Sea and perform northerly feeding migrations into the Norwegian Sea. Norwegian spring-spawning herring has its main spawning and feeding areas in the Norwegian Sea while the main nursery and young fish areas is in the neighbouring Barents Sea ecosystem.

As pelagic feeders all the three stocks must be expected to have major influences on the ecosystem. Studies on this subject have only been carried out to a limited degree and what exists are mainly of descriptive character. For instance was the highest catches of salmon ever (1970s) taken during a period when the herring stock was at a record low level. This has been suggested to be a potential effect of reduced competition beneficial for salmon stock productivity (Hansen et al., 2000).

The North East Artic cod, *Gadus morhua*, and haddock, *Melanogrammus aeglefinus*, have their main adult feeding and nursery areas in the Barents Sea while the main spawning areas are along the eastern shelf areas of the Norwegian Sea and into the SE parts of the Barents Sea ecosystem. There are local cod stocks connected to the coast and only doing limited migrations from the coast for feeding. The Northeast Artic saithe also spawn along the eastern shelf areas of the Norwegian Sea and has important nursery areas on this coastline and into the Barents Sea. The migration of older and mature saithe are to a large degree linked with those of the Norwegian spring-spawning herring out into the high seas areas of the Norwegian Sea. There are also stocks of ling, *Molva molva*, and tusk, *Brosme brosme*, along the eastern shelf region. Greenland halibut, *Reinhardtius hippoglossoides*, is found along the eastern shelf and also in the western areas in the shelf areas of Jan Mayen. Other important species inhabiting the hydrographic transition zone include roughhead grenadier, *Macrourus berglax*, several species of eelpouts, *zoarids*, and the rajiids, *Raja hyperborear, R radiate* and *Bathyraja spinicauda* (Bergstad et al., 1999).

The demersal species are in general connected to the eastern shelf area and the presence of the largest stocks is connected to spawning. The fish then migrates back to the Barents Sea for feeding. The fry also in general drift out of the Norwegian Sea and into the Barents Sea. As compared to the pelagic stocks, the demersal stocks must accordingly be regarded as less significant for the Norwegian Sea ecosystem as a whole.

Seabirds

The Norwegian Sea is currently estimated to hold approximately 20 million seabirds. This number includes a breeding population of 4.5 million pairs and their young as well as non-breeding immatures, deferred breeders and visitors from
other waters (Barrett et al. 2002, Anker-Nilssen & Lorentsen 2004). The two dominating species of this important seabird community, the Atlantic puffin Fratercula arctica and the northern fulmar Fulmarus glacialis, are both pelagic and account for 31% and 28% of seabird numbers, respectively. Whereas few of the 7.7 million seabirds breeding on Iceland are considered part of the Norwegian Sea ecosystem, a coarse estimate of 2.0 million visiting fulmars and equally many wintering little auks Alle alle were added to these calculations.

Twenty-two species breed in numbers exceeding 2000 pairs, including half the world population of European storm-petrels Hydrobates pelagicus (265 000 pairs). Northern fulmar (1.0 million pairs), great cormorant Phalacrocorax carbo carbo (20 000 pairs), European shag P. aristotelis (20,000 pairs), great skua Stercorarius skua (6,000 pairs) and Atlantic puffin (1.8 million pairs) also constitutes more than 25% of the biogeographical population they belong to, and common eider Somateria mollissima, common gull Larus canus, herring gull L. argentatus, great black-backed gull L. marinus, black-legged kittiwakes Rissa tridactyla and common guillemots Uria aalge and black guillemot Cepphus grylle arcticus also are relatively abundant species.

The annual consumption of seabirds in the Norwegian Sea amounts to about 1.2 million tonnes (Anker-Nilssen & Lorentsen 2004). An estimated 0.47 million tonnes are invertebrate prey, two thirds of which are eaten by the fulmars. Correspondingly, 45% of the 0.77 million tonnes of fish prey are taken by the puffins. In terms of quantity the single-most important fish prey is 0-group herring produced by the Norwegian spring-spawning stock, but lesser sandeels Ammodytes marinus and young (0–2 group) gadoids such as NE Arctic saithe Pollachius virens and haddock Melanogrammus aeglefinus are also expected to be important.

Only a small selection of colonies are monitored at a regular basis and in most cases the existing knowledge is insufficient to explain the documented population trends in any detail (see Anker-Nilssen & Lorentsen for a summary). One exception is the importance of 0-group herring for the reproduction of puffins at Røst in the Lofoten Islands, the largest seabird colony in mainland Europe, breeding parameters of which have proven to be early and accurate indicators of herring year class strength (e.g. Anker-Nilssen 1992, Sætre et al. 2002, Durant et al. 2003).

Seals in the Norwegian Sea

There are two seal stocks of particular importance in the Norwegian Sea: Harp and hooded seals. Both species are mainly connected to the Norwegian Sea through feeding. They show opportunistic feeding patterns in that different species are consumed in different areas and at different times of the year.

Whales in the Norwegian Sea

Due to topographical and hydrographic characteristics beneficial for production the Norwegian Sea has abundant stocks of whales feeding on plankton, pelagic fishes and Cephalopods. Besides minke whale, fin whale, blue whale, sperm whale, humpback and killer whales are important species in the area. Except from killer whales all species are seasonal migrants visiting the Norwegian Sea for feeding during the summer.

The minke whale Balaenoptera acutorostrata is the smallest in size and most numerous in stock size of the baleen whales in the Norwegian Sea. It is found throughout the area, in particular along the eastern shelf area and in the Jan Mayen area. The species is an opportunistic feeding with special preference for herring in the Norwegian Sea ecosystem.

The killer whales Orcinus orca in the area are closely linked to the yearly migrations of the Norwegian spring-spawning herring. In the present wintering area of the herring, the Vestfjord, Tysford, and Ofotfjord an estimated 500 killer whales have been feeding on herring during the winter months. A total estimate of killer whales for the Norwegian Sea and the Barents Sea it is at some few thousands individuals.

1.2.1.2 Impact of fishing on activity on ecosystem

Destruction of deepwater coral reefs has been documented in the eastern shelf areas. These descriptions have resulted in management measures like area closures for bottom trawling. Effects on bottom fauna could be expected from bottom trawling activities in the eastern shelf areas.

Work is carried out within the frames of ICES in order to sort out the scale of unintentional bycatch of salmon in the pelagic fisheries in the Norwegian Sea (SGBYSAL), but no such major effects have been documented so far.

Mortality of seabirds occurs in longline fisheries. Magnitude and species composition is unknown.
Bycatch of harbour porpoise is routinely observed in net fisheries. In episodes of coastal invasion of artic seals large mortality of seals has been observed in net fisheries. This mortality has not been regarded problematic for seal stocks due to healthy state of these stocks and a general low harvesting level.

Mortality of large marine mammals due to bycatch has not been described and is probably low.

Ghost fisheries have been documented through dredging of lost gear along the eastern shelf area. A programme for retrieval of such gears is in action along the Norwegian coast towards the Norwegian Sea. A high number of ghost fishing nets are retrieved yearly. The need for such activity is probably larger than what is currently carried out given the fish mortality observed in retrieved nets.

A major collapse in the herring stock was observed during the late 1960s. Various analyses have shown that the fisheries were a major factor driving the collapse.

1.3 The human use of the ecosystem

1.3.1 Overall impacts

1.3.2 The fisheries

The major demersal stocks in the Northeast Arctic include cod, haddock, saithe, and shrimp. In addition, redfish, Greenland halibut, and flatfishes (e.g., long rough dab, plaice) are common on the shelf and at the continental slope, with ling and tusk found also at the slope and in deeper waters. In 2004, landings of slightly less than 0.9 million t were taken from the stocks of cod, haddock, saithe, redfish, and Greenland halibut, which is an increase of about 10% compared to 2003. An additional catch of about 100 000 t was taken from other demersal stocks, including crustaceans, not assessed at present.

The major pelagic stocks are capelin, herring, and polar cod. The highly migratory species blue whiting and mackerel extend their feeding migrations into this region. There was no fishery for capelin in the area in 2004 due to the stock being in poor condition, and there was no directed fishery for herring in the area. The highly migratory species blue whiting and mackerel extend their feeding migrations into this region, but there is no directed fishery for the species in the area. Species with relatively small landings include salmon, halibut, hake, pollack, whiting, Norway pout, anglerfish, lump sucker, argentines, grenadiers, flatfishes, horse mackerel, dogfishes, skates, crustaceans, and molluscs. The most widespread gear used in the central Barents Sea is bottom trawl, but also long line and gillnets for the demersal fisheries, and purse seine and pelagic trawl for the pelagic fisheries. Other gears more common along the coast include handline and Danish seine. Gears used in a relatively minor degree are float line (used in a small but directed fishery for haddock along the coast of Finnmark in Norway) and various pots and traps for fish and crabs. The variety of the gears varies with time, space and countries, with Norway having the largest variety caused by the coastal fishery. For Russia, the most common gear is trawl, but a longline fishery is present (mainly directed for cod and wolffish). The other countries mainly use trawl.

For most of the exploited stocks an agreed quota is decided (TAC). In addition to an agreed quota, a number of additional regulations are applied. The regulation differs among gears and species and may be different from country to country, and a non-exhaustive list is summarised in Table 1.3.2.1.

The fishery on Norwegian coastal cod is conducted both with trawlers and with smaller coastal vessels using traditional fishing gears like gillnet, longline, handline, and Danish seine. The fishery is dominated by gillnet (50%), while longline/handline account for about 20%, Danish seine 20% and trawl 10% of the total catch. Norwegian vessels take all the reported catch. However, trawlers from other countries probably take a small amount when fishing near the Norwegian coast fishing for Northeast Arctic cod and Northeast Arctic haddock.

The fishery for Northeast Arctic cod is conducted both by an international trawler fleet operating in offshore waters and by vessels using gillnets, longlines, handlines and Danish seine operating both offshore and in the coastal areas. 60–80% of the annual landings are from trawlers.

Northeast Arctic haddock are harvested throughout the year. In years when the commercial stock is low they are mostly caught as bycatch in the cod trawl fishery, and when the commercial stock abundance and biomass are high haddock are harvested in a targeted fishery. On average approximately 25% of the catch is with conventional gears, mostly longline, which are used almost exclusively by Norway. Part of the longline catches are from a directed fishery.

Northeast Arctic saithe are mainly harvested by purse seine and trawl fisheries, which accounted for 60% of the landings in 2000. A traditional gillnet fishery for spawning saithe accounts for about 22%. The remaining catches are
taken by Danish seine and handline in addition to minor bycatches in the longline fishery for other species. Some changes in recent regulations have led to fewer amounts being taken by purse seine.

Greenland halibut fisheries are dominated by longline and gillnets and operate in relatively deep waters with minimum bycatch implication. Target trawl fishery has been prohibited and trawl catches are limited to bycatch only.

The only directed fisheries for *Sebastes mentella* (deep-sea redfish) are trawl fisheries. Bycatches are taken in the cod fishery and as juveniles in the shrimp trawl fisheries. Traditionally, the fishery for *S. mentella* was conducted by Russia and other East European countries on grounds located south of Bear Island towards Spitsbergen.

The fishery for *Sebastes marinus* (golden redfish) is mainly conducted by Norway which accounts for 80–90% of the total catch. Germany also has a long tradition of a trawl fishery for this species. The fish are caught mainly by trawl and gillnet, and to a lesser extent by longline and handline. The trawl and gillnet fishery have benefited from the females concentrating on the “spawning” grounds during spring. Some of the catches by Norway, and most of the catches taken by other countries, are taken in mixed fisheries together with saithe and cod. Important fishing grounds are the Møre area (Svinøy), Halten Bank, the banks outside Lofoten and Vesterålen, and Sleppen outside Finnmark. Traditionally, *S. marinus* has been the most popular and highest priced redfish species.

The recent developments in the stocks of cod, haddock, saithe, Greenland halibut, redfish, herring, and capelin are summarized in the following:

Coastal cod is experiencing reduced reproductive capacity and is harvested unsustainably.

For Northeast Arctic cod, the spawning biomass is considered to have full reproductive capacity but, based on the most recent estimates of fishing mortality, is at risk of being harvested unsustainably.

Northeast Arctic haddock has full reproduction capacity and is harvested sustainably.

Northeast Arctic saithe has full reproduction capacity and is harvested sustainably.

The stock status of Greenland halibut in Subareas I and II is not precisely known. SSB has been low since the late 1980s, but shows a slight increase in recent years.

The stock of *Sebastes mentella* is experiencing reduced reproductive capacity and is at present near a historical low.

The available information on *Sebastes marinus* indicate that this stock is in very poor condition with reduced reproductive capacity.

The capelin stock is experiencing a risk of reduced reproduction capacity, but is currently not harvested.

The Norwegian spring-spawning herring is classified as having full reproduction capacity and is harvested sustainably.

Most stocks are overexploited, i.e. the current fishing mortality exceeds the level that would give a high yield in the longer term.

The state of the individual stocks is presented in more detail in the stock Sections 1.5.1 to 1.5.8.
Table 1.3.2.1  
Description of fisheries by gears. The gears are abbreviated as: trawl roundfish (TR), trawl shrimp (TS), longline (LL), gillnet (GN), handline (HL), purse seine (PS), Danish seine (DS) and trawl pelagic (TP). The regulations are abbreviated as: Quota (Q), mesh size (MS), sorting grid (SG), minimum catching size (MCS), minimum landing size (MLS), maximum bycatch of undersized fish (MBU), maximum bycatch of non-target species (MBN), maximum as bycatch (MB), closure of areas (C), restrictions in season (RS), restrictions in area (RA), restriction in gear (RG), maximum bycatch per haul (MBH), as bycatch by maximum per boat at landing (MBL), number of effective fishing days (ED), number of vessels (EF), restriction in effort combined with quota and tonnage of the vessel (ER).

<table>
<thead>
<tr>
<th>Species</th>
<th>Directed fishery by gear</th>
<th>Type of fishery</th>
<th>Landings in 2004 (tonnes)</th>
<th>As bycatch in fleet(s)</th>
<th>Location</th>
<th>Agreements and regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capelin</td>
<td>PS, TP</td>
<td>seasonal</td>
<td>0</td>
<td>TR, TS</td>
<td>Northern coastal areas to south of 74°N</td>
<td>Bilateral agreement, Norway and Russia</td>
</tr>
<tr>
<td>Coastal cod</td>
<td>GN, LL, HL, DS</td>
<td>all year</td>
<td>32599</td>
<td>TS, PS, DS, TP</td>
<td>Norwegian coast line</td>
<td>Q, MS, MCS, MBU, MBN, C, RS, RA</td>
</tr>
<tr>
<td>Cod</td>
<td>TR, GN, LL, HL</td>
<td>all year</td>
<td>580000</td>
<td>TS, PS, TP, DS</td>
<td>North of 62°N, Barents Sea, Svalbard</td>
<td>Q, MS, SG, MCS, MBU, MBN, C, RS, RA</td>
</tr>
<tr>
<td>Wolffish¹</td>
<td>LL</td>
<td>all year</td>
<td>21081</td>
<td>TR, (GN), (HL)</td>
<td>North of 62°N, Barents Sea, Svalbard</td>
<td>Q, MB</td>
</tr>
<tr>
<td>Haddock</td>
<td>TR, GN, LL, HL</td>
<td>all year</td>
<td>116293</td>
<td>TS, PS, TP, DS</td>
<td>North of 62°N, Barents Sea, Svalbard</td>
<td>Q, MS, SG, MCS, MBU, MBN, C, RS, RA</td>
</tr>
<tr>
<td>Saithe</td>
<td>PS, TR, GN</td>
<td>seasonal</td>
<td>161916</td>
<td>TS, LL, HL, DS, TP</td>
<td>Coastal areas north of 62°N, southern Barents Sea</td>
<td>Q, MS, SG, MCS, MBU, MBN, C, RS, RA</td>
</tr>
<tr>
<td>Greenland halibut²</td>
<td>LL, GN</td>
<td>Seasonal</td>
<td>18762</td>
<td>TR</td>
<td>deep shelf and at the continental slope</td>
<td>Q, MS, RS, RG, MBH, MBL</td>
</tr>
<tr>
<td>Sebastes mentella</td>
<td>No directed fishery</td>
<td>all year</td>
<td>4914</td>
<td>TR</td>
<td>deep shelf and at the continental slope</td>
<td>C, SG, MB</td>
</tr>
<tr>
<td>Sebastes marinus</td>
<td>GN, LL, HL</td>
<td>all year</td>
<td>7293</td>
<td>TR</td>
<td>Norwegian coast</td>
<td>SG, MB MCS, MBU, C</td>
</tr>
<tr>
<td>Shrimp</td>
<td>TS</td>
<td>all year</td>
<td>43600</td>
<td></td>
<td>Spitsbergen, Barents Sea, Coastal</td>
<td>ED, EF, SG, C, MCS</td>
</tr>
</tbody>
</table>

¹The directed fishery for wolffish is mainly Russian EEZ and in ICES area IIB, and the regulations are mainly restricted to this fishery

²The only directed fishery for Greenland halibut is by a limited Norwegian fleet, comprising vessels less than 28 m.

1.4 Assessments and advice

Mixed fisheries and fisheries interactions

All fisheries should be considered in the management. The major fisheries in the area are:

1. Factory and freezer trawlers operating in the whole area all year round, targeting mainly cod, haddock, and saithe and taking other species as bycatch. The number of these vessels has been stable in recent years, at a lower level than previously.
2. Fresh fish trawlers operating in Subarea I and Division Ia all year round, targeting mainly cod and haddock, taking other species as bycatch. The number of these vessels has been reduced in recent years.
3. Freezer trawlers operating in Subarea I and Division Ib fishing shrimp. The number of these vessels has been stable.
4. Large purse seiners and pelagic trawlers targeting herring, mackerel, blue whiting, capelin, and polar cod in seasonal fisheries in this region. These vessels fish some of the same species in other areas as well.
5. Small fresh fish trawlers targeting shrimp and capelin in near-coast areas in Subarea I. The size of this fleet has decreased in recent years.
6. A fleet of vessels using conventional gears (gillnet, longline, handline, and Danish seine) mainly in near-shore fisheries, targeting various demersal species all around the year. This fleet, together with fleets 7 and 8, accounts
for approximately 30% of the landings of demersal stocks. This share is maintained by quota allocation. When vessels in this fleet are modernised or replaced, there is a trend towards medium-sized (app. 15–20 m) multi-gear vessels with crews of 3–5.

7. Small purse seiners targeting saithe in coastal waters in a seasonal fishery, to a large extent vessels belonging to the group using conventional gears.

8. Longliners operating offshore, targeting non TAC-restricted species, mainly ling, blue ling, and tusk. These vessels are generally larger than those in the coastal fisheries and use technologically advanced auto-line systems.

9. Small vessels using gillnets, longlines, handlines, and Danish seine operating in near shore waters along the Norwegian coast north of 62°N, exploiting coastal cod, and Northeast Arctic cod.

Some of these fisheries are mixed fisheries, with many stocks exploited together in various combinations. In cases where significant interactions occur, management advice must consider both the state of individual stocks and their simultaneous exploitation. Stocks in the poorest condition, particularly those having reduced reproductive capacity, necessarily become the overriding concern for the management of mixed fisheries where stocks are exploited either as a targeted species or as a bycatch.
### Single-stock exploitation boundaries and critical stocks

The state and the limits to exploitation of the individual stocks are presented in the stock sections (Sections 1.5.1 to 1.5.8). ICES considers limits to exploitation of single stocks as follows:

<table>
<thead>
<tr>
<th>Species</th>
<th>State of the stock</th>
<th>ICES considerations in relation to single-stock exploitation boundaries</th>
<th>Upper limit corresponding to single-stock exploitation boundary for agreed management plan or in relation to precautionary limits. Tonnes or effort in 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spawning biomass in relation to precautionary limits</td>
<td>Fishing mortality in relation to precautionary limits</td>
<td>Fishing mortality in relation to target reference points</td>
</tr>
<tr>
<td><strong>Northeast Arctic cod</strong></td>
<td>Full reproductive capacity</td>
<td>F in 2004 is higher than intended under the management plan</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Norwegian Coastal cod</strong></td>
<td>Reduced reproductive capacity</td>
<td>Harvested unsustainably</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Northeast Arctic haddock</strong></td>
<td>Full reproductive capacity</td>
<td>Harvested sustainably</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Northeast Arctic saithe</strong></td>
<td>Full reproductive capacity</td>
<td>Harvested sustainably</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Greenland halibut</strong></td>
<td>Unknown</td>
<td>Unknown</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Sebastes mentella</strong></td>
<td>Reduced reproductive capacity</td>
<td>Unknown</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Sebastes marinus</strong></td>
<td>Reduced reproductive Capacity</td>
<td>Unknown</td>
<td>NA</td>
</tr>
<tr>
<td>Species</td>
<td>State of the stock</td>
<td>ICES considerations in relation to single-stock exploitation boundaries</td>
<td>Upper limit corresponding to single-stock exploitation boundary for agreed management plan or in relation to precautionary limits. Tonnes or effort in 2006</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------</td>
<td>---------------------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>Shrimp</td>
<td>Unknown</td>
<td>ICES recommends that a TAC should be implemented for 2006 and set no higher than the current catch level of 40 000 t.</td>
<td>&lt; 40 000 t</td>
</tr>
</tbody>
</table>
Identification of critical stocks

The table above identifies the stocks that have reduced reproductive capacity, i.e. Norwegian coastal cod and the two redfish stocks in Subareas I and II (*Sebastes marinus* and *Sebastes mentella*). These stocks are an overriding concern in the management advice.

ICES advice for fisheries management

The fisheries in the Northeast Arctic should therefore be managed such that the following rules apply simultaneously:

1. For Norwegian coastal cod, there should be no catch.
2. For *Sebastes marinus* and *Sebastes mentella* in Subareas I and II, there should be no directed fishery and stronger regulations are advised to reduce bycatch.
3. The fishing of all other species should be restricted within the precautionary limits or according to the management plan as indicated in the table of individual stock limits above.

Furthermore, unless ways can be found to harvest species caught in a mixed fishery within precautionary limits for all those species individually, then fishing should not be permitted.

Management considerations

ICES notes that this advice presents a strong incentive to fisheries to avoid catching species when their reproductive capacity is reduced. If industry-initiated programmes aim at reducing catches of species with reduced reproductive capacity to levels close to zero in mixed fisheries, then these programmes could be considered in the management of these fisheries. Industry-initiated programmes to pursue incentives should be encouraged, but must include a high rate of independent observer coverage, or other fully transparent methods for ensuring that their catches of species with reduced reproductive capacity are fully and credibly reported.

The demersal fisheries are highly mixed, usually with a clear target species dominating, and with low linkage to the pelagic fisheries (see table below). Although the degree of mixing may be high, the effect of the fisheries will vary among the species. More specifically, the coastal cod stock and the two redfish stocks are presently at very low levels. Therefore, the effect of the mixed fishery will be largest for these stocks. In order to rebuild these stocks, further restrictions in the regulations should be considered (e.g. closures, moratorium, restrictions in gears). A quantification of the degree of mixing and impact among species requires detailed information about the target species and mix per catch/landing and gear. Such data exist for some fleets (e.g. the trawler fleet), but is incomplete for other fleets. The available data has not yet been gathered and compiled for a quantitative analysis.

**Flexibility in coupling between the fisheries.** Fleets and impact on the other species (H - high, M - medium, L - low and 0 - nothing). The lower diagonal indicates what gears couples the species, and the strength of the coupling is given in the upper diagonal. The gears are abbreviated as: trawl roundfish (TR), trawl shrimp (TS), longline (LL), gillnet (GN), handline (HL), purse seine (PS), Danish seine (DS) and trawl pelagic (TP).
<table>
<thead>
<tr>
<th>Species</th>
<th>Cod</th>
<th>Coastal cod</th>
<th>Haddock</th>
<th>Saithe</th>
<th>Wolffish</th>
<th>S. mentella</th>
<th>S. marinus</th>
<th>Greenland halibut</th>
<th>Capelin</th>
<th>Shrimp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cod</td>
<td></td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>L</td>
<td>M-H</td>
</tr>
<tr>
<td>Coastal cod</td>
<td>TR, PS, GN, LL, HL, DS</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>M-L</td>
<td>L</td>
<td>0-L</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Saithe</td>
<td>TR, PS, GN, LL, HL, DS</td>
<td>TR, PS, GN, LL, HL, DS</td>
<td>TR, PS, GN, LL, HL, DS</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Wolffish</td>
<td>TR, GN, LL, HL</td>
<td>TR, GN, LL, HL</td>
<td>TR, GN, LL, HL</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>0</td>
<td>M</td>
</tr>
<tr>
<td>S. mentella</td>
<td>TR</td>
<td>TR</td>
<td>TR</td>
<td>TR</td>
<td>TR</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>juvenile Sebastes</td>
</tr>
<tr>
<td>S. marinus</td>
<td>TR, GN, LL</td>
<td>TR, GN, LL</td>
<td>TR, GN, LL</td>
<td>TR, GN, LL</td>
<td>TR, LL</td>
<td>TR</td>
<td>L</td>
<td>0</td>
<td>L-M</td>
<td>juvenile Sebastes</td>
</tr>
<tr>
<td>Greenland halibut</td>
<td>TR, GN, LL</td>
<td>TR, GN, LL, DS</td>
<td>TR, GN, LL, DS</td>
<td>TR, GN, LL, DS</td>
<td>TR, LL</td>
<td>TR</td>
<td></td>
<td>0</td>
<td>M-H</td>
<td></td>
</tr>
<tr>
<td>Capelin</td>
<td>TR, PS, TS, TP</td>
<td>PS, TP</td>
<td>TR, PS, TS, TP</td>
<td>TS</td>
<td>TP</td>
<td>TP</td>
<td>TP</td>
<td>None</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Shrimp</td>
<td>TS</td>
<td>TS</td>
<td>TS</td>
<td>TS</td>
<td>TS</td>
<td>TS</td>
<td>TS</td>
<td>TS</td>
<td>TS</td>
<td></td>
</tr>
</tbody>
</table>

*TR, PS, GN, LL, HL, DS: Various locations and sampling methods.*
Accordingly, at least the following fisheries are suspected of having significant interactions that deserve attention in setting up TACs applying to single stocks:

- Norwegian coastal cod are caught together with Northeast Arctic cod in some fisheries.
- For *Sebastes marinus*, some of the catches by Norway, and most of the catches taken by other countries, are taken in mixed trawl fisheries.
- *Sebastes mentella* is caught as a bycatch in the cod fishery, the pelagic fishery for blue whiting and NSS herring and as juveniles in the shrimp trawl fisheries.
- Shrimp trawl fishery with bycatch of juvenile redfish and Greenland halibut.
- Directed pelagic trawl fisheries targeting herring and blue whiting in the Norwegian Sea where 15% catch of redfish is allowed.

The catch options that would apply if single stocks could be exploited independently of others are presented in the sections on individual stocks (Sections 1.5.1 to 1.5.8).

However, for the mixed demersal fisheries, catch options must be based on the expected catch in specific combinations of effort in the various fisheries, taking into consideration the advice given above. The distributions of effort across fisheries should be responsive to objectives set by managers, but must also result in catches that comply with the scientific advice presented above.

At the 31st meeting of the Joint Russian-Norwegian Fisheries Commission, the Parties agreed on a harvesting strategy for Northeast Arctic cod and haddock. In 2004 ICES evaluated HCR for cod and stated that the rule was incomplete in the last part. It was amended by ICES for performing the evaluation. The amended HCR was considered by ICES as consistent with the Precautionary Approach. At the 33rd Session of The Joint Norwegian-Russian Fishery Commission the HCR was amended for rebuilding situations and ICES was requested to evaluate the new rule and provide an advice in accordance to it. For Northeast Arctic cod, ICES evaluated the rules as amended and concluded that a management plan based on these rules is in agreement with the Precautionary Approach, provided that the spawning biomass is above $B_{lim}$ and that the assessment uncertainty and implementation error are not greater than those calculated from historical data. The harvest strategy has not been evaluated for haddock.

ICES has been asked to calculate management options for 2006 on the basis of the harvest control rule as amended. The calculated catches and SSBs are given in Sections 1.5.1 and 1.5.3.

**Regulations in force and their effects**

The fisheries in Subareas I and II are managed by TAC constraints for the main stocks and by allocation of TAC shares amongst states with established fishing interests. These Subareas consist mainly of waters within EEZs, but also contain some waters outside EEZs.

For the main species, the fisheries in the EEZs are regulated by quotas at a variety of scales (vessels, fleets, species, seasons). Management measures also regulate minimum landing size, mesh size, and use of sorting grids. Since January 1997, the use of sorting grids in the trawl fisheries has been mandatory for most of the Barents Sea and Svalbard area. Minimum landing size is also a minimum catching size, implying that vessels have to avoid fishing grounds with small-sized fish. Discarding is prohibited in some EEZs. Time and area closures may be implemented to protect small fish.

Compilation of effort data relevant to the different species is difficult when the fisheries are regulated by vessel quotas. In some cases the effort targeted at the main species, e.g., cod, may be calculated, but it is almost impossible to calculate effort for non-target species.

**Quality of assessments and uncertainties**

The unreported landings for Northeast Arctic cod have apparently increased sharply in 2002 and have remained at this level since. The main mechanism used for avoiding quota control seems to be trans-shipping of fish from the Barents Sea. The assessment includes estimates of non-reported landings. The catch forecast refers to total catch, which would only be equivalent to a TAC if no unreported landings occur in the future. This has to be taken into account when using the results of the catch forecasts.