UNIVERSITY OF THE ARCTIC

Module 11
Living Resources in the Arctic Marine Environment

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Key Terms and Concepts

- biomass
- spawning stock
- landings
- longline fishery
- fishing mortality
- recruitment
- demersal
- incidental take (bycatch)
- total allowable catch (TAC)
- exclusive economic zone (EEZ)
- International Whaling Commission (IWC)

Learning Objectives

Upon completion of this module, you should be able to

1. identify the main fishing grounds of the Arctic region.
2. develop an overview of Arctic fisheries and state their economic importance for the Arctic countries.
3. identify key fisheries species; describe their biology and relative economic importance.

4. outline trends in catch (landings) from key stocks, such as cod, walleye pollock, herring, and capelin, over time and regions, and discuss the impacts of fisheries on these stocks.

5. identify the main species of harvested marine mammals and seabirds in the waters of the circumpolar North.

6. provide an overview of (1) the commercial whaling of Arctic and non-Arctic nations, and (2) the effects of commercial whaling on Arctic whale stocks.

Reading Assignment

Freese (2000), *The Consumptive Use of Wild Species in the Arctic*; selected marine-related chapters as assigned by the instructor.

Overview

During the last century, global fisheries, including those in the Arctic, have increased rapidly because of technological innovations. Open rowboats were replaced by steamboats, then trawlers, and finally modern otter trawlers. Fishing gear changed from hook and line to trawl and purse seine. The skipper's eye and "sixth sense" has been largely replaced by radar and sonar equipment, able to locate the fish with great accuracy. All this technical improvement has enabled enormous amounts of fish to be caught from the Arctic and Subarctic oceans. Arctic fisheries probably reached a peak, in terms of amounts caught, in the late 1950s through the 1960s, but the fishing technologies are still evolving.

In general, the harvest of marine wild species is the single most important form of natural resource use across all the regions and peoples of the Arctic. Commercial fisheries, including whaling and sealing, are currently and historically a major economic activity. The fisheries are conducted in two major ocean systems—the North Atlantic Ocean and the Bering Sea. In this module we will explore these fisheries, their national importance, the type and amount of fish caught, and the status of these resources.[1] We will also discuss the

[1] The fisheries and economic statistics presented in this module can be accessed from marine research institutes and official statistics of the Arctic countries. However, the main source of statistical information and graphics in this module is the forthcoming "Chapter 12: Fisheries and Aquaculture" of the Arctic Council's Arctic Climate Impact Assessment (ACIA) Scientific Report, edited by Alf H. Hoel and Hjalmar Vilhjalmsson.

history of commercial whaling and sealing to some degree, as well as the subsistence use of marine living resources, especially whales and seals, by indigenous peoples and local residents.

Student Activity

As you work through this module, plot the main fishing grounds on a map of the North circumpolar region.

Lecture

The North Atlantic Ocean

Within the North Atlantic Ocean one can distingush between three major fisheries regions: the northeast Atlantic, fished mainly by Norway and Russia; the mid-Atlantic, fished by Iceland and Greenland; and the northwest Atlantic, fished by Canada.

The Northeast Atlantic

Geography

The northeast Atlantic area includes the northern and eastern parts of the Norwegian Sea to the South, and the North Norwegian coast and the Barents Sea to the east and north. The fisheries take place in the Barents Sea and the northern parts of the Norwegian Sea.

The fishing industry is found in numerous communities along the northern coast of Norway in the counties of Finmark, Troms and Nordland. These counties cover an area of 110,000 square kilometres with a total population of some 460,000. Russia's northern fisheries, in contrast, are concentrated in large cities in the Murmansk Oblast, Arkhangelsk Oblast, the Republic of Karelia, and the Nenets Autonomous Okrug. There is no significant commercial fishing activity east of these until one reaches the far eastern fishery basin in the North Pacific Ocean and Bering Sea.

Key Species

The seven most commercially and ecologically important fish stocks are capelin (*Mallotus villosus*); herring (*Clupea harengus*); Atlantic cod (*Gadus morhua*); polar cod (*Boreogadus saida*); haddock (*Melanogrammus aeglefinus*); saithe (*Pollachius virens*); redfish (*Sebastes marinus*); and Greenland halibut

(*Reinhardtius hippoglossoides*). Most species spawn along the coast of Norway and Russia in winter and spring (February to May) and egg and larval drift routes are towards the north and east. All species exhibit seasonal migrations coinciding with the formation and melting of ice—that is, towards the north and east during spring and summer, and towards the south and west during autumn and winter.

Cod, capelin, and herring are key species in the ecosystem, and interactions between them generate changes, which also affect other fish stocks as well as mammals and birds. Recruitment of cod and herring is enhanced by inflows of Atlantic waters carrying large amounts of suitable food, especially planktonic crustaceans, such as *Calanus finmarchicus*, and survival of the fish larvae increases so that juvenile cod and herring become abundant in the area. Biomass estimates of the main groups of fauna and the estimated consumption of these by top predators are given in table 11.1.

Table 11.1 Biomass of some fauna groups in the northeast Atlantic and estimated total annual consumption of these by top predators (million tonnes) in the Barents Sea and adjacent waters (from Hoel and Vilhjalmsson, forthcoming 2004)

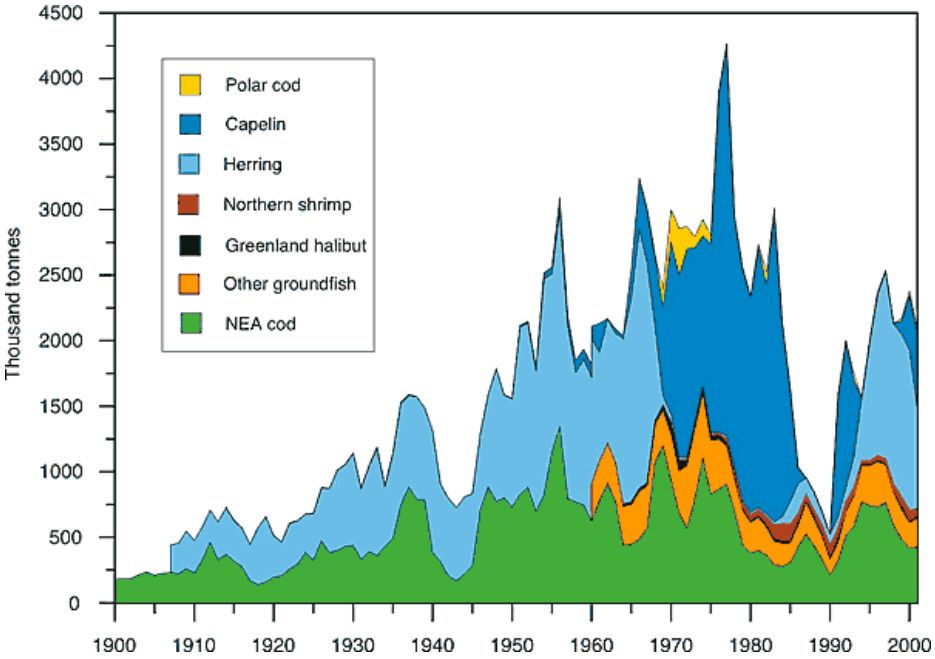
	Zooplankton (including krill)	**Capelin**	**Herring**	**Cod**	**Whales**	**Seals**	**Birds**
Biomass	~ 30	0.2–10	0–4	1–4	0.5	0.5	0.01
Consumption				3–10	1.8	3.4	1.4

The table shows the relative importance of capelin and herring as food for cod and higher predators. Thus, when capelin or herring stocks are small, the top predators will have to shift to prey in the zooplankton group, or starve.

Fisheries and Stock Abundance

For millennia, fishing for cod and herring has been an essential part of life for coastal communities in Norway and northern Russia. Throughout the centuries, fishing was purely coastal and seasonal and based on the large amounts of adult cod and herring migrating into nearshore waters for spawning. Small-scale offshore fishing for cod on the Svalbard banks, and herring off northern Iceland, began in the late nineteenth century. However, the quantities were small compared to the nearshore catches. By the turn of the twentieth century, modern nearshore and offshore fisheries had seen the light of day, with major technical improvements of fishing vessels and gears taking place during the twentieth century and up to the present time, dramatically enhancing the effectiveness of the fishing fleet.

Landing statistics for herring, capelin, polar cod, Greenland halibut, shrimp, cod, and other groundfish in the twentieth century are shown in figure 11.1. Total fish landings from the area increased from about 0.5 million tonnes at the beginning of the century to about 3 million tonnes in the 1970s. In 2001, the total fisheries in the area amount to some 2.1 million tonnes. The two most important fisheries are those for Atlantic cod and herring.



Source: Hoel and Vilhjalmsson (forthcoming 2004)

Fig. 11.1 Landings from the most important commercial stocks in the northeast Atlantic

In the beginning of the 1950s, the spawning stock of Norwegian spring-spawning herring (also called Atlanto-Scandian herring) was as large as 14 million tonnes, one of the world's largest stocks. Most of the adult herring migrated between Norwegian and Icelandic coastal waters. The herring fishery was important for several countries: Norway, Iceland, Russia, and the Faroe Islands. Herring fisheries remained largely seasonal and nearshore until the 1950s. This changed dramatically when horizontally ranging sonar, synthetic net fibres and hydraulic power blocks for hauling the large seine nets were introduced to the herring fishery during the late 1950s and early 1960s. These technical innovations, together with better knowledge of the migration routes of the great Norwegian spring-spawning herring complex, led to an international herring boom in which Icelandic, Norwegian, and Russian (Soviet) fishers were the main participants. This extraordinary herring fishery ended with the total collapse of the herring complex in 1966 owing to overexploitation of both adults and juveniles (see fig. 11.1). It took the Norwegian spring-spawning stock about two-and-a-half decades to recover in spite of severe catch restrictions. During the 1990s the stock recovered and started to make feeding migrations into the

Norwegian Sea; and catch quotas and landings increased. In 2002 the total landings of herring in the northeast Atlantic were some 830,000 tonnes.

The stock of Atlantic cod in the Barents Sea and the Norwegian Sea is variously referred to as Northeast Arctic (NEA) cod (*Gadus morhua*) or Atlantic cod. Prior to 1920, the bulk of the cod catch was from two large seasonal and coastal fisheries: the fishery for immature cod, feeding on spawning capelin along the northern coast of Norway and Russia; and the fishery for spawning cod further south, off northern Norway. In the 1920s and 1930s an international bottom trawl fishery, targeting cod as well as other demersal (bottom-feeding) species, such as haddock and redfish, developed in offshore areas in the Barents Sea and around Svalbard. Annual catches increased from about 400,000 tonnes in 1930 to some 800,000 tonnes at the end of the decade. Landings remained high also after the Second World War until the end of the 1970s, when they declined sharply because of reduced stock size and the introduction of exclusive economic zones (EEZ). The estimated average fishing mortality for the five-year period 1997–2001 is a record high (0.90) and about twice the fishing mortality corresponding to the precautionary approach (0.42). Also, since 1998, the spawning stock biomass has been well below the recommended level of 500,000 tonnes. Recruitment to the stock has been low in most of the recent years. Landings have varied considerably over time; in 2002 they stood at 430,000 tonnes.

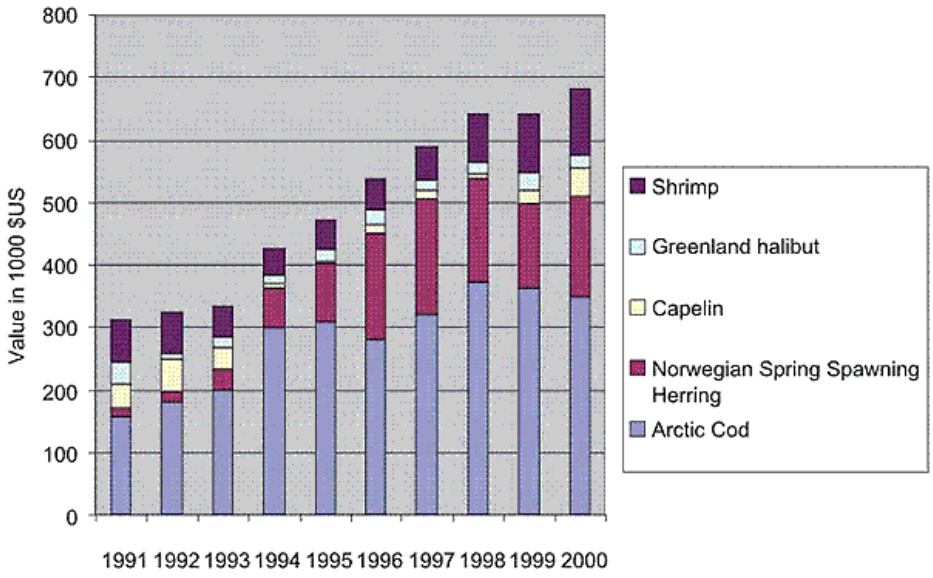
When the herring stock crashed in the late 1960s, the purse seine fleet began targeting the less valuable capelin, and catches increased rapidly in the 1970s. Management measures were introduced in the early 1970s, first by Norway and later jointly by Norway and Russia. Total allowable catches (TAC) have been enforced since 1978. Landings of capelin have fluctuated widely but were some 630,000 tonnes in 2002.

National Importance

As early as the year 1000, an extensive trade in dried cod developed in northern Norway. Dried cod from the north was transported to southern Europe and this trade provided an economic foundation for the communities along the northern coast.

The total-capture (in contrast to aquaculture) fishery in the northeast Atlantic currently yields about 2.1 million tonnes, with an annual value in the order of $US2 billion. In Norway, the export of fish products today accounts for some 14% of total national exports. Atlantic cod is by far the most important species in the Norwegian capture fisheries, with a landed value of approximately $US350 million in 2000. The landed value of herring has been increasing during the last decade to some $US160 million in 2000. The third most valuable species is shrimp, with a landed value of some $US100 million in 2000. (See fig. 11.2.) Most northern coastal communities in Norway are economically and

culturally highly dependent on fisheries. During the last two decades, aquaculture has become increasingly important, accounting for about half of the economic value produced by the fisheries sector.



Source: Hoel and Vilhjalmsson (forthcoming 2004)

Fig. 11.2 Nominal values of Arctic cod, Norwegian spring-spawning herring, capelin, Greenland halibut, and northern shrimp from Norwegian fisheries, 1991–2000

In northwest Russia, the fisheries are of less economic importance. A substantial share of the catches taken by Russian fisheries is landed abroad, especially in Norway. Atlantic cod is the most important fish stock. The total catches (all species) by Russia in the northeast Atlantic have increased from some 234,000 tonnes in 1990 to more than 500,000 tonnes in all the years since then.

Use of Marine Mammals

Fifteen to twenty species of whales and seals forage regularly in the northeast Atlantic, the two most important predators in the pelagic ecosystem being the harp seal (*Phoca groenlandica*) and the minke whale (*Balaenoptera acutorostrata*). Currently, however, Norwegian and Russian fishers commercially exploit only three species of marine mammals: the minke whale, hooded seal (*Cystophora cristata*), and harp seal (*Pagophilus groenlandicus*). In addition, coastal seals (grey and harbour seals) are exploited by local hunters along the Norwegian coast. (An overview of the history of commercial whaling in the North Atlantic is provided at the end of this module.)

Minke whales have been hunted in landlocked bays along the coast of Norway for centuries. Offshore hunting using small, motorized vessels developed prior to the Second World War. Catches increased until the 1950s with a mean annual

catch at 2,300 animals. Between 1987 and 1992 no commercial hunting was allowed. In recent years, the annual catches have been 400–600 individuals out of a stock estimated to harbour some 110,000 animals.

Two stocks of harp seal, in the West Ice (Greenland Sea) and in the East Ice (White Sea/Barents Sea), and one stock of hooded seal in the West Ice have been subject to offshore sealing since the late nineteenth century, mainly by Norwegian and Russian hunters. The total annual catch from these stocks increased from about 120,000 animals around 1900 to an average of about 350,000 per year in the 1920s. Since then, catches have declined because of catch regulations and loss of markets. In the 1990s annual catches of harp seal in the West Ice were 8,000–10,000 animals and 8,000–9,000 for hooded seal, while catches of harp seal in the East Ice have ranged from 14,000 to 42,000 per year.

Student Activity

1. What are the species of marine life near your community or region?

2. What kind of national importance do living marine resources have in your country?

The Mid-Atlantic

Geography

This section deals with the waters surrounding Iceland and Greenland, including Davis Strait, Irminger Sea, Denmark Strait, Iceland Sea, and Greenland Sea, as well as the fisheries conducted in these waters. The waters of Iceland and Greenland are different in many ways. Icelandic waters are warmer and generally ice-free under normal circumstances. Greenlandic waters are colder and ice conditions are much more severe; ports on the coastline are commonly closed for long periods because of winter ice and/or icebergs breaking off from glaciers. However, these seas are linked in biological terms, especially via the all-important stock of Atlantic cod, which has been known to drift between the two systems, borne on the western branch of the North Atlantic Current that flows west across the northern Irminger Sea towards Greenland. The other and smaller branch goes eastward onto the north Icelandic shelf, where it mixes with colder waters of an offshoot from the cold East Greenland Current. The influence of Atlantic water is, therefore, lowest on the east Icelandic shelf.

The warm Irminger Current is highly important for both the Icelandic and Greenland ecosystems as a transport mechanism for juvenile stages of various

species of fish. The eastern branch transports fish fry and larvae to the nursing areas on the shelf of northwest, north, and east Iceland, while the western branch may carry large numbers of larval cod, capelin, and other commercial species across the northern Irminger Sea to east Greenland and from there to nursery areas in west Greenland waters.

In Iceland, the fishing industry is spread among many communities all around the island; in Greenland, Nuuk is the hub of the fisheries industry.

Key Species

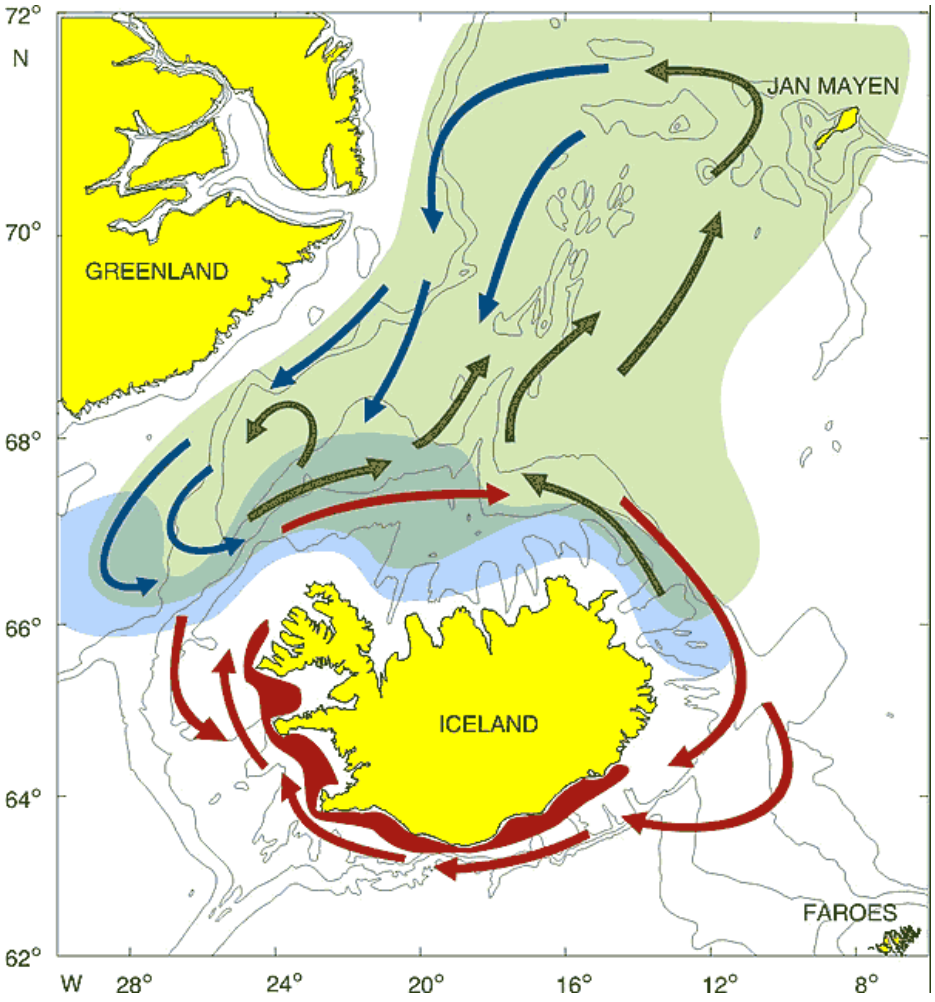
Because of the influence of warm Atlantic waters, the fish fauna of Icelandic waters is comparatively rich in species and comprises more than 25 commercially exploited stocks of fish and marine invertebrates. The most important species are the same as in the northeast Atlantic—that is, demersal roundfish species, such as Atlantic cod, haddock, saithe, and redfish; Greenland halibut among the flatfishes; and herring and capelin among the pelagic species. In addition, there are other species, such as wolffish (*Anarchias lupus*), plaice (*Pleuronectes platessa*) and blue whiting (*Micromesitius poutassou*). The most important invertebrates are northern shrimp (*Pandalus borealis*), Norway lobster (*Nephrops norwegicus*), and Iceland scallop (*Chlamys islandica*). Out of a total of 25 commercial species of fish and invertebrates in the Icelandic ecosystem, only capelin, Greenland halibut, and northern shrimp can be classified as truly Arctic.

In contrast, the Greenlandic commercial fish and invertebrate fauna are characterized by cold-water species, such as Greenland halibut, northern shrimp, capelin, and snow crab (*Chionoecetes opilio*). Redfish are found mainly in Atlantic waters outside the cold waters of the Greenland continental shelf. Polar cod is common, and there is a local fjordic population of Greenland cod (*Gadus ogac*), but neither of these Arctic species is commercially used.

In Icelandic waters, most fish species spawn in the warm and relatively stable Atlantic water off the south and southwest coast. Fish larvae drift west and then north from the spawning grounds to the nursery areas on the shelf off northwest, north, and east Iceland, where they grow in a mixture of Atlantic and Arctic waters. When marine conditions are right, and in strong years, larvae of cod, capelin, and some other species are carried by the Irminger Current across to east Greenland and onward to west Greenland. The drift of larval cod to Greenland was extensive during the 1920s and 1940s. At maturity, many of these cod returned from the distant nursery areas at Greenland to spawn off of south and southwest Iceland.

At present, capelin is the largest fish stock in the Icelandic marine ecosystem and the key forage fish. During summer, it undertakes extensive feeding migrations north into the cold waters of the Denmark Strait and the Iceland Sea,

and it may even reach north to the southern Greenland Sea (north of lat 72° N). When the adult capelin return to the north Icelandic shelf in autumn after foraging in northern Arctic waters, they are preyed upon intensely by a number of predator species, such as cod, Greenland halibut, saithe, and haddock. Thus, capelin act as a huge source of energy transfer from Arctic northern regions to important commercial fish stocks in Icelandic waters (see fig. 11.3).



Source: Hoel and Vilhjalmsson (forthcoming 2004)

Fig. 11.3 Distribution and migrations of capelin in the Iceland–Greenland–Jan Mayen (Norway) area. Green shade: feeding area of adults; blue shade: distribution of juveniles; red shade: spawning areas; green arrows: feeding migrations of adults; blue arrows: return migrations; red arrows: spawning migrations.

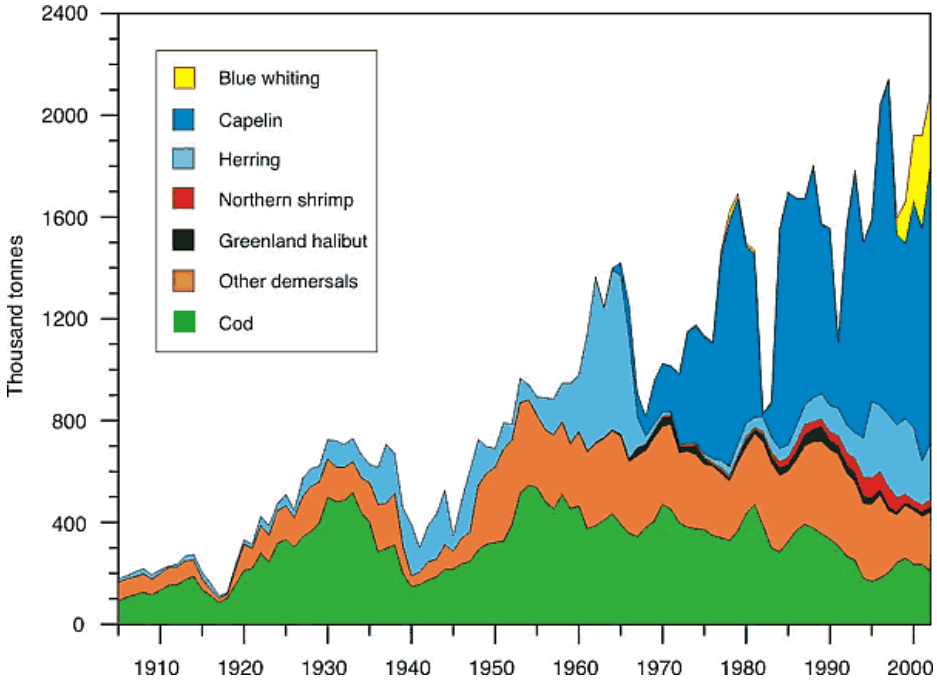
During the last decade, predators (fish, whales, and seabirds) may have consumed between 2 and 3.8 million tonnes of capelin annually. When considering the annual catch of roughly 1 million tonnes during the same

period, the average total annual removal of capelin from the ecosystem could have been between about 3.0 and 4.8 million tonnes per year.

At west Greenland, northern shrimp and Greenland halibut spawn at the shelf edge off the west coast. The northern shrimp stock is found in the general area of the Dohrn Bank, between east Greenland and northwest Iceland. From the early 1930s until the 1960s there was also an extensive spawning of cod off southeast, southwest, and west Greenland. In the marine ecosystem off Greenland, calanoid copepods, polar cod, capelin, and squids are probably the most important pelagic macrofauna as forage for fish, mammals, and seabirds. Benthic animals are also important. In particular, northern shrimp is a food item for many species of fish and marine mammals.

Fisheries and Stock Abundance

Historically, Icelandic demersal fisheries fell into two categories: the local nearshore fisheries conducted by Icelanders in open rowboats; and offshore fisheries conducted by foreign water fleets. Until the last decade of the nineteenth century, almost all fishing was carried out by hand lines. At the end of the seventeenth century, the combined landings by Icelandic, Dutch, and French fishing vessels are estimated to have been in the order of 35,000 tonnes annually. One hundred years later, the combined landings averaged about 55,000 tonnes. The introduction of steam and combustion engines and active fishing gear at the turn of the nineteenth century changed this drastically. The demersal catch in the waters near Iceland increased to about 160,000 tonnes in 1905, reaching 240,000 tonnes just before First World War. Although cod was still the most important species, the proportion of other species rose to about 30%. By the turn of the twentieth century, total catches had reached roughly 2 million tonnes (see fig. 11.4).



Source: Hoel and Vilhjalmsson (forthcoming 2004)

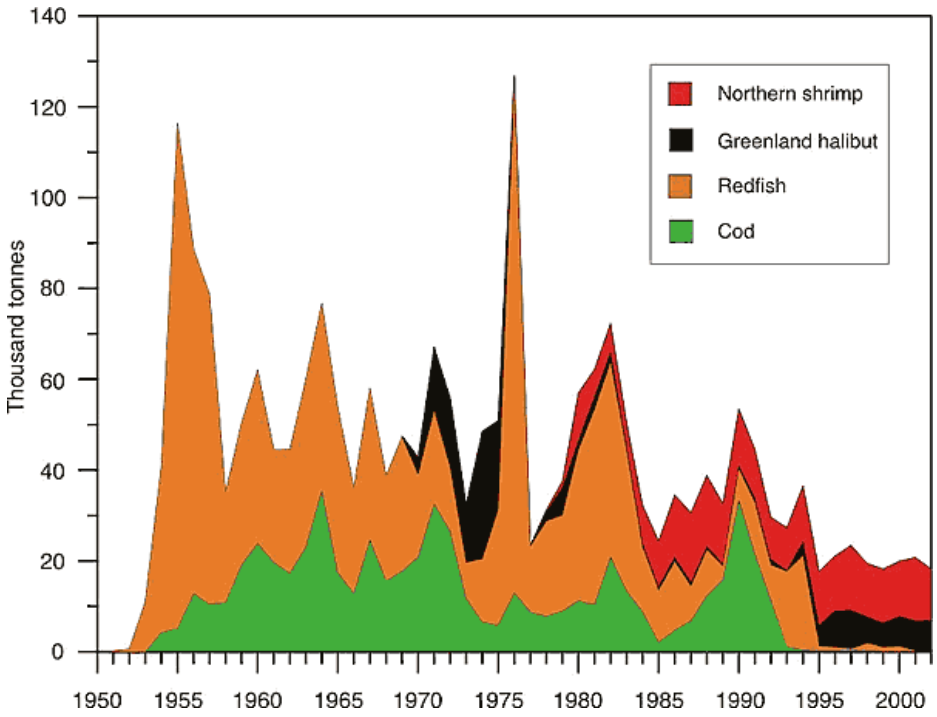
Fig. 11.4 The total catch from Icelandic fishing grounds, 1905–2002

Catches of Atlantic cod peaked at 520,000 tonnes in 1933, declined during the 1930s, and fell drastically during the Second World War. After the war, the demersal fishery increased rapidly to peak at about 860,000 tonnes in 1954, with cod accounting for about 550,000 tonnes. Still, because of strong cod years and good recruitment to other demersal stocks, the exploitation rate (as measured by fishing mortality) remained at a low level, although it was almost 50% higher than it was during the late 1920s. From 1955, the rate of exploitation of all demersal stocks, but especially that of cod, increased rapidly and with few exceptions remained high during the last 45 years of the twentieth century. Since the extension of the Icelandic EEZ to 200 miles in 1977, the high rate of fishing has been due solely to the enhanced efficiency of Iceland's fishing fleet.

Pelagic fisheries have a much shorter history at Iceland than do demersal fisheries. Norwegian fishers started a herring fishery in the 1860s on the north and east coast. This fishery increased gradually during the early twentieth century (see fig. 11.4). During the late 1950s and early 1960s, new technologies led to the great boom in the herring fisheries (see above) and later to their collapse. The herring collapse did not only include the Norwegian spring-spawning herring, but also local herring stocks—that is, the Icelandic summer- and spring-spawning herring stocks. The Icelandic summer-spawning stock has since recovered with annual yield about 100,000 tonnes. However, there are no signs of recovery of the Icelandic spring-spawning herring as of yet.

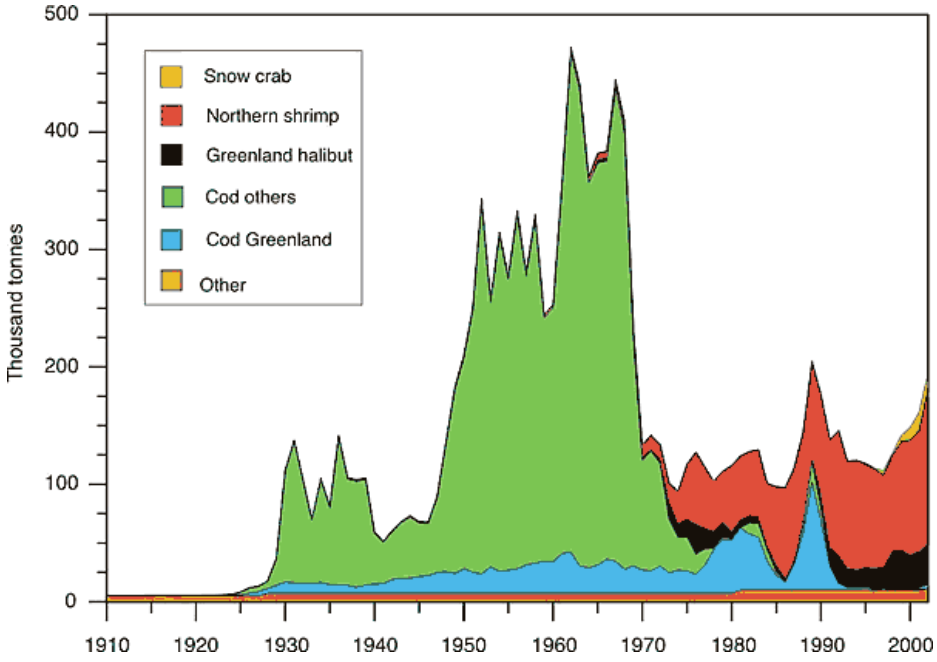
A capelin fishery began in the mid-1960s and within a few years this fishery replaced the rapidly dwindling herring fishery. During the last decade, the annual capelin catch has been fluctuating around one million tonnes, annually (see fig. 11.4).

Atlantic cod is currently rare in Greenlandic waters and limited to a small inshore population. Although cod has been fished there intermittently for centuries, the success of the cod fishery at Greenland has been variable. During the twentieth century, cod appeared in fishable amounts in offshore regions off west Greenland in the 1920s. Fisheries by foreign vessels expanded quickly and catches increased from about 5,000 tonnes in 1926 to 130,000 tonnes in 1930 (see fig. 11.5b). The increase of the cod catch continued over the following decades, with landings varying between about 380,000 and 480,000 tonnes during the 1960s. By 1970, the catch had fallen to about 140,000 tonnes and then fluctuated greatly until the early 1990s, when it collapsed. After 1993, practically no Atlantic cod has been caught in Greenlandic waters.



Source: Hoel and Vilhjalmsson (forthcoming 2004)

Fig. 11.5a The total catch from east Greenlandic fishing grounds, 1900–2002



Source: Hoel and Vilhjalmsson (forthcoming 2004)

Fig. 11.5b The total catch from west Greenlandic fishing grounds, 1900–2002

The Greenland halibut fishery began in earnest in the 1970s and peaked in 1976 at about 126,000 tonnes; since then it has declined. The catch of northern shrimp off west Greenland has increased steadily since 1970 and is currently at about 175,000 (see fig. 11.5b).

East Greenland waters have been fished commercially only since the end of the Second World War. The main reason is the speed and irregularity of ocean currents, especially at and near the edge of the continental shelf, which preclude all except large powerful vessels and robust fishing gear. The main species off east Greenland are Greenland halibut, northern shrimp, cod, and redfish. Since 1978, large quantities of capelin have been fished during summer in the ocean waters between Iceland, east Greenland, and the island of Jan Mayen (Norway). This fishery is conducted by fleets from Iceland, Norway, Greenland, and other countries under Greenlandic licence.

National Importance

For centuries, pasture farming and fishing were Iceland's most important economic activities. By the end of the nineteenth century, fishing overtook farming in terms of economic importance. By 1910, almost 25% of the working population was engaged in the fishing industry—fishing and fish processing—generating three-quarters of Iceland's merchandise exports. Although the fraction of labour working in the fishing industry declined in the following

decades, the importance of fish exports increased to 90% towards the middle of the twentieth century. Since then, both the share of fish products in exports and the fraction of the total labour force engaged in fishing have declined significantly. In the year 2000, the fishing industry employed 9% of the labour force in Iceland (12,800 employees), accounted for 63% of exports, and generated 42% of export earnings. Total export value of fish products in the year 2000 was about US$1,220 million. The economic importance of the fishing industry varies greatly from one region of the country to another. In the year 2000, more than 35% of the working population in the western fjords and almost 30% of the working population in the eastern fjords were employed in the fishing industry, compared to only 3% in the capital region of Iceland.

The fishing industry in Greenland developed much later than in Iceland and does not offer the same overwhelming historical evidence of national economic importance. For example, out of the approximately 8 million tonnes of cod taken in Greenland waters during the twentieth century, Greenland's share was only a few per cent. With the extension of the fisheries jurisdiction in the late 1970s, the status of Greenland changed completely and it became by far the largest player in the fisheries in Greenlandic waters. Unfortunately, the Greenland cod stock had by then been depleted.

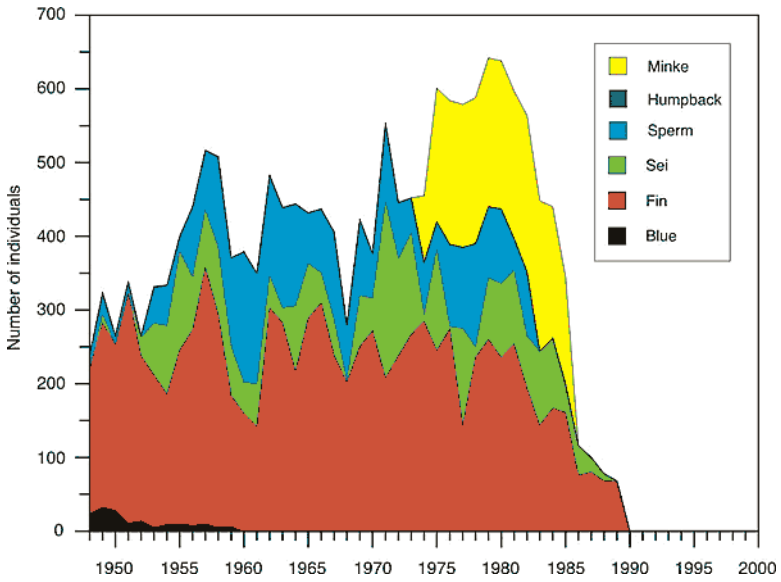
Northern shrimp and Greenland halibut are currently the most valuable stocks, and their contribution to the Greenlandic economy is highly important. In the 1960s and early 1970s, the export of fish and fish products represented 80–90% of the total export from Greenland. Between 1975 and 1990, export of lead and zinc became highly significant in the national economy but ceased in 1990. Since then, the export of fish and fish products has been about 90% of the total Greenland export. In the year 2000, the value of the export of fish and fish products was around US$300 million.

Use of Marine Mammals and Seabirds

Sealing has never reached industrial proportions in Iceland, the total number of skins varying between 1,000 and 7,000 during the last four decades of the twentieth century. The populations of the two main species, harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*), are currently estimated at 15,000 and 6,000 animals, respectively. Both species have decreased greatly in recent decades, mostly because of government-subsidized culling of the stocks. Historically, the seabird hunt has been important for domestic use. At the present time, however, this hunt can be regarded more as a recreational sport activity than a means of subsistence.

Commercial whaling has been conducted intermittently in Iceland for more than a century. Between 1948 and 1986, a small Icelandic whaling company operated from the west coast, targeting manly fin, sei, and sperm whales. The average yearly catches were 234, 68, and 76 animals, respectively. In addition,

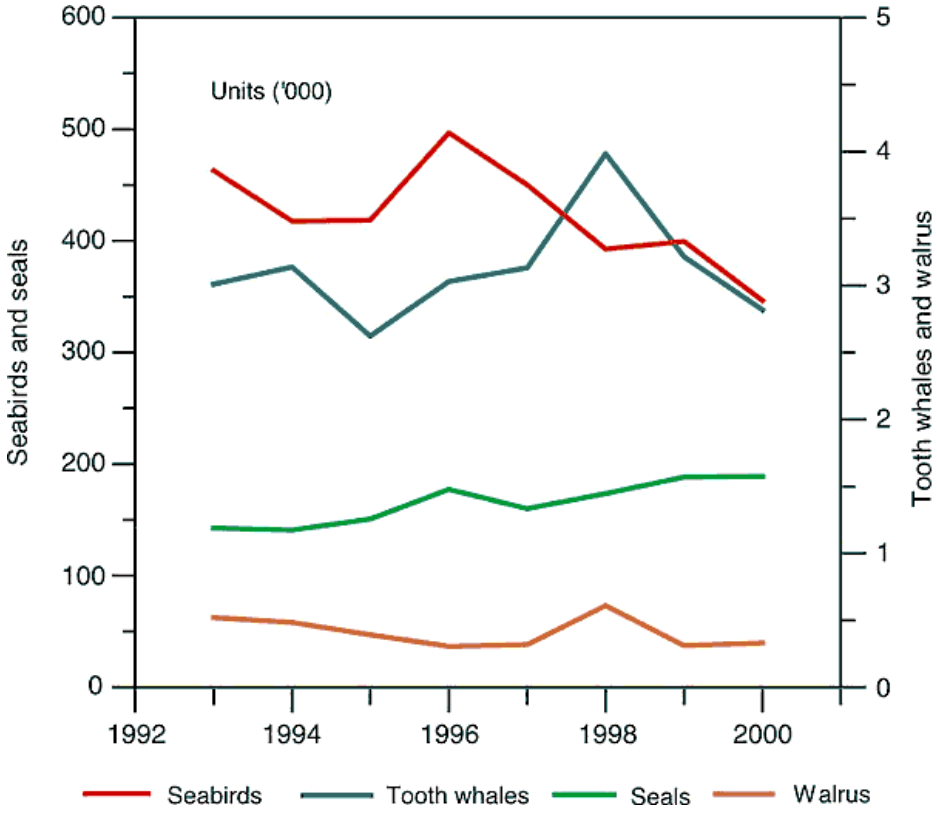
100–200 minke whales where taken annually by small-time operators in the years 1974–1985. (See fig. 11.6.) Although never economically important on a national scale, whaling was highly profitable for those engaged in the industry.



Source: Hoel and Vilhjalmsson (forthcoming 2004)

Fig. 11.6 The catch of large whales near Iceland, 1948–2000

In Greenland, about 170,000 seals are taken annually, mainly harp and ringed seals (see fig. 11.7). They are an important source of traditional food, and about 100,000 skins are sold each year to the tannery in Nuuk, Greenland. There is concern that harbour seals may be threatened in Greenland, but otherwise Greenland's seal stocks are plentiful. Some 400 walruses are taken every ear in Greenland, the main hunt including some 375 animals from a population of a few thousand that winters along the west coast of Greenland. In addition, 30–50 walruses are taken from a small population of about 500 animals that winter off west-central coast of Greenland. There are concerns that the current level of walrus take in Greenland exceeds sustainable yields.



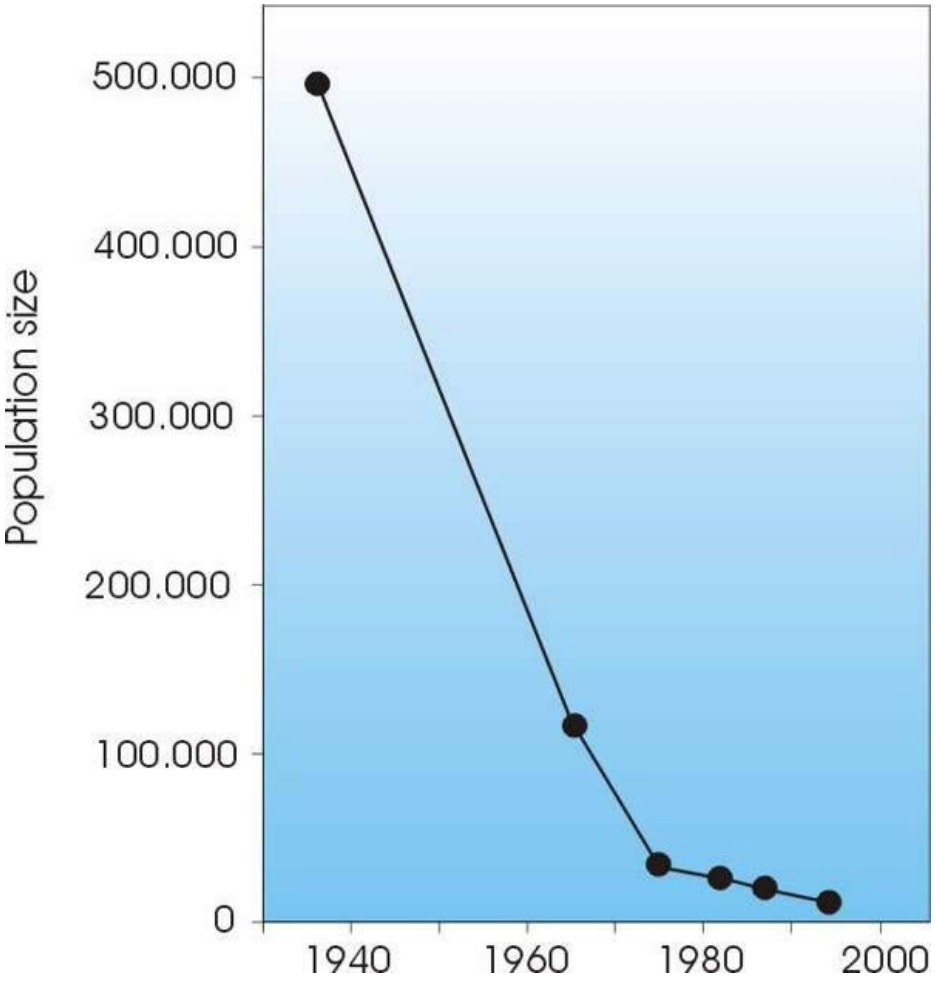
Source: Hoel and Vilhjalmsson (forthcoming 2004)

Fig. 11.7 Greenlandic annual catches (thousands) of seabirds, tooth whales, seals, and walruses in the years 1993–2000

Although foreign fleets have pursued large-scale whaling in Greenlandic waters in past centuries, native Greenlanders have hunted whales only for domestic use. The harvest currently focuses mainly on beluga (white whale, *Delphinapterus leucas*) and narwhal (*Monodon monoceros*) along the coast. Fin and minke whales are also taken—as well as pilot whales, and killer and humpback whales on occasion. The fin and minke whale catches are sanctioned by the International Whaling Commission (IWC) within the agreements for Aboriginal subsistence whaling. West Greenland is permitted an annual catch of 19 fin whales and 175 minke whales. East Greenland can take up to 12 minke whales annually. The Greenland Institute of Natural Resources has documented that beluga have declined because of overexploitation in Greenland and suggests that the beluga needs increased protection, along with the narwhal and the harbour porpoise.

An average of 150 polar bears are harvested annually in Greenland. This is mostly in accordance with recommendations from the International Agreement for the Conservation of Polar Bears and Their Habitat (1973). Still, scientists are concerned that polar bears may require increased protection in Greenland.

Seabird harvesting in Greenland has a long history, and it continues to have a key role in Greenland's subsistence hunting. Murres and eiders are the most heavily harvested species, but others, such as Arctic terns, dovekies (little auk), and kittiwakes, are also harvested frequently in some regions of the country. Murres, eiders, and Arctic terns have all recently declined because of overexploitation. For example, the number of thick-billed murre breeding colonies has been reduced from 48 to 23 during the last 30 years on the west coast of Greenland. The colonies closest to human settlements have been the most effected (see fig. 11.8).



Source: CAFF 2001

Fig. 11.8 Decline of Brünnich's guillemot (*Uria lomvia*) in west-central Greenland

Student Activity

1. Historically speaking, has there been fishing off the coast near your community or region?

2. Try to speak with someone who remembers the condition of the local fishery 50 years ago, or otherwise gather this information. What is the condition of the local fishery today? Has there been a change over the years? If yes, what has caused the change?

Northwest Atlantic

Geography

Fisheries in the northwest Atlantic can be subdivided as suggested by authors G. R. Lilly and J. E. Carscadden into "those near the coast of Greenland, those near the coast of Canada, and those in deep waters of Baffin Bay and Davis Strait between Greenland and Canada" (Lilly and Carscadden 2002, 1–2).

According to Lilly and Carscadden, the Arctic and Subarctic seas extend

> [a]long the northeast coast of Canada . . . southward to the central Grand Bank . . . . [This is explained] by the presence of the Labrador Current, which transports cold water southward from Davis Strait, the Canadian [Arctic] Archipelago and Hudson Bay. The . . . southerly extent of sea ice is on the northern Grand Bank at approximately 47° N (Anon. 2001a) and bottom water temperatures on the northern Grand Bank are below 0°C for considerable periods. The southerly extent of cold conditions is also indicated by the regular presence of Arctic [polar] cod . . . along the northeast coast of Newfoundland and their occasional occurrence on the northern Grand Bank (Lilly et al. 1994; Lilly and Simpson 2000). (As cited in Lilly and Carscadden 2002, 2)

Fish has dominated the history of Newfoundland since the time of British colonization. Britain's great interest in Newfoundland after the island's "discovery" in 1497 was generated by the presence of incredibly large numbers of codfish. The French also saw the value of Newfoundland's fishery. Therefore, possession of the island was one of the goals of both sides during the colonial wars of the eighteenth century.

Key Species

Lilly and Carscadden are informative regarding the key species of the area:

> The ecosystem off northeastern Canada . . . [is, like other Arctic and Subarctic marine ecosystems,] characterised by a relatively small number of species, a few of which have historically occurred in high abundance (Bundy et al. 2000; Livingston and Tjelmeland 2000; Carscadden et al. 2001). The dominant fodder fish has historically been capelin, with Arctic [polar] cod more prominent to the north and sand lance (*Ammodytes dubius*) more prominent to the south on the plateau of Grand Bank. Herring . . . is found only in the bays and adjacent waters. These four species of planktivorous fish feed mainly on calanoid copepods and larger crustaceans . . . . The dominant . . . [demersal species have] been Atlantic cod, but Greenland halibut . . . and American plaice . . . have also been important. Snow crab . . . and northern shrimp . . . [are the most important invertebrate species]. . . .
>
> The Labrador/Newfoundland ecosystem experienced major changes during the last two decades of the twentieth century. Atlantic cod and most other demersal fish, including species that were not targeted by commercial fishing, experienced declines

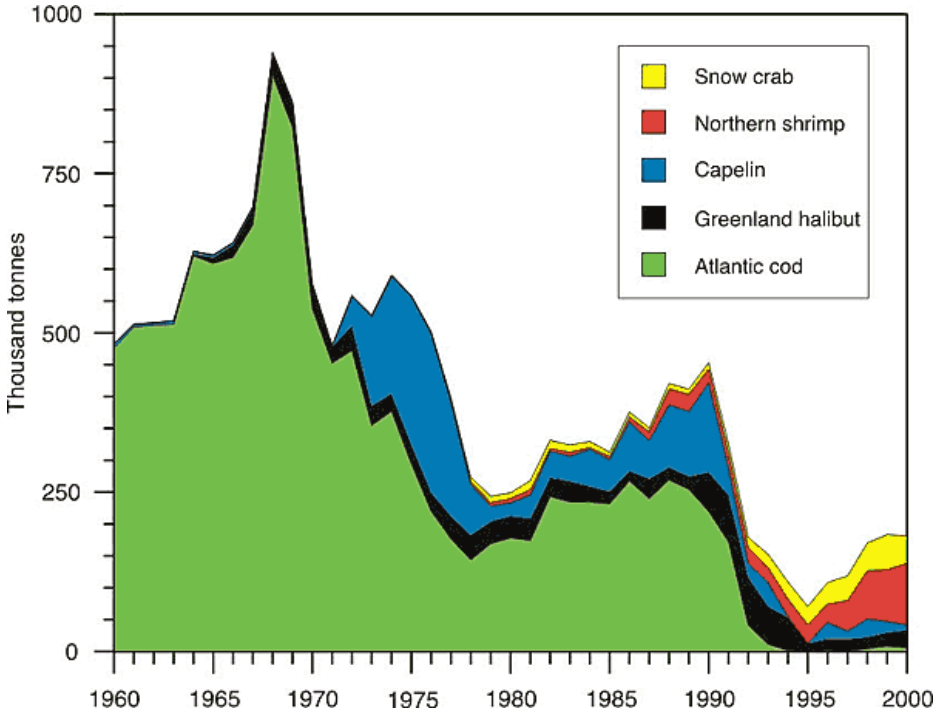
> to very low levels by the early 1990s (Atkinson 1994; Gomes et al. 1995). In contrast, snow crab . . . and especially northern shrimp . . . surged during the 1980s and 1990s and now support the most important fisheries in the area. Harp seals increased in abundance from fewer than 2 million individuals in the early 1970s to more than 5 million in the late 1990s (Healey and Stenson 2000; Stenson, et al. 2002). Capelin have been found in much reduced quantities in offshore acoustic surveys since the early 1990s . . . (DFO 2000, 2001). (As cited in Lilly and Carscadden 2002, 2–3)

Fisheries and Stock Abundance

Lilly and Carscadden also report on the stock abundance of the fisheries:

> The waters of eastern Newfoundland have been fished for centuries, primarily for Atlantic cod but with an increasing emphasis on other species during the latter half of the twentieth century. These fisheries have undoubtedly had an influence on both the absolute abundance of some species and the abundance of species relative to one another. . . . The area experienced cooling during the last three decades of the twentieth century, with particularly cold periods in the early 1970s, early to mid-1980s and early 1990s. This cooling is thought by some to have played an important role in the dramatic decline of Atlantic cod and other demersal fish and the increase in crustaceans, especially northern shrimp. . . .
>
> The distribution of Atlantic cod along the coast of Canada has historically been from the northern Labrador Shelf southward . . . .
>
> The European fishery for Atlantic cod off eastern Newfoundland began in the late fifteenth century. For the first few centuries fishing was by hook and line . . . . There is evidence that local inshore overexploitation was occurring even in the nineteenth century (Cadigan 1999) . . . . The deep waters, both inshore and offshore, remained refugia until the 1950s, when longliners . . . were introduced . . . and distant water fleets from Europe started to employ bottom-trawlers to fish the deeper water of the outer banks . . . . Landings increased dramatically in the 1960s . . . [and] peaked at 894,000 t in 1968 . . . . [Catches] then declined steadily to only 143,000 t in 1978. Following Canada's extension of . . . [the EEZ] to 200 nautical miles in 1977, the stock recovered somewhat and catches were in the range 230–270,000 t during most of the 1980s. However, catches fell rapidly during the early 1990s as the stock declined to very low levels, and a moratorium on fishing was declared in 1992. A small [cod] fishery, limited to the inshore [areas], was reintroduced in 1998. (Lilly and Carscadden 2002, 3–4)

See figure 11.9.



Source: Hoel and Vilhjalmsson (forthcoming 2004)

Fig. 11.9 The total catch in the waters east of Newfoundland and Labrador, 1960–2000

Lilly and Carscadden further report on the northern shrimp and the snow crab (see fig. 11.9):

> A [northern shrimp] fishery with large trawlers began off northeastern Canada in the late 1970s (Orr et al. 2001a). . . . Catches increased above 25,000 t by the mid-1990s. . . . [By] 1995, it became apparent that commercial catches of shrimp were very small relative to . . . biomass, and quotas were increased considerably during the late 1990s. Total landings from the area rose to more than 90,000 t by 2000. . . .
>
> The [snow crab] fishery off eastern Newfoundland began in the late 1960s as a bycatch from gillnets . . . but soon expanded into a directed fishery with crab traps (pots). . . . Catches . . . reach[ed] almost 55,000 t in 1999. (Lilly and Carscadden 2002, 11–12)

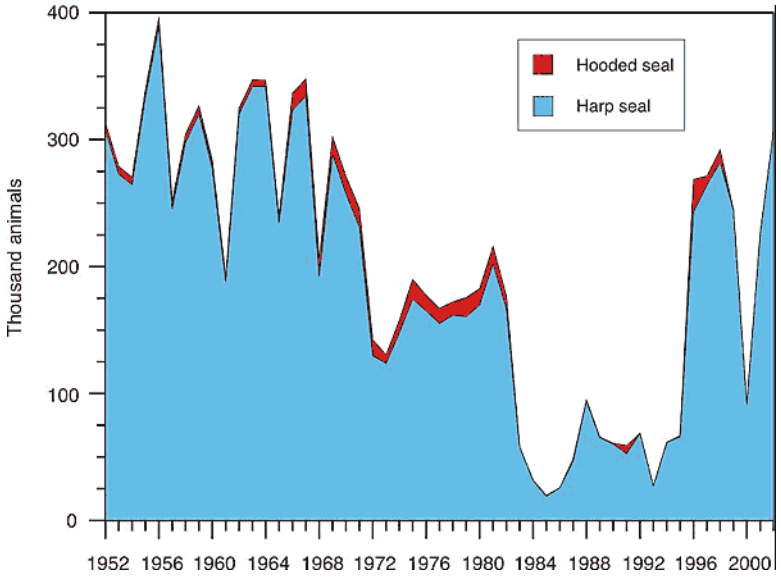
National Importance

By 2001, fishery harvesting and processing sectors accounted for only 3% of Newfoundland's GDP, while the service industries accounted for 68%, and oil production, a new industry in Newfoundland, already accounted for 8.4%. Yet, while the fishery may not be of great economic importance, it continues to dominate the economy in rural areas of the province, and, perhaps even more important, its culture.

The Newfoundland fishery did not end with the collapse of the groundfishery in 1992; shellfish have replaced groundfish as the main components of fishery landings in Newfoundland. The value of landings in all Newfoundland fisheries in 1991 was around Can$280 million. It fell during the first year of the moratorium to Can$195 million and then doubled to Can$389 million by the year 2000. Thus, during the cod moratorium there has been an increase of one-third in the real value of Newfoundland fish and shellfish landings. In 2000, crab accounted for 46% of the value, and shrimp for a further 30%.

Use of Marine Mammals

Harp and hooded seals are the two most common seal species in Canadian Arctic waters. The population of harp seals increased during the last decades of the twentieth century from fewer than 2 million animals to more than 5 million between the early 1970s and the mid-1990s. Hooded seals are much less abundant than harp seals. Both species are commercially hunted in Canadian waters (see fig. 11.10). For 2002, the total allowable catch (TAC) for harp seals was 275,000; for hooded seals it was 10,000. Although the actual harvest quotas have remained constant in recent years, the number of animals harvested varies, depending on ice conditions, market prices, and subsidy systems. Some subsistence hunting of harp and hooded seals takes place in northern regions, but this hunt only numbers a few thousand animals. Grey, ringed, and bearded seals are taken in subsistence harvests in Labrador and throughout the Canadian Arctic. Ringed seals (*Phoca hispida*) are by far the most important Arctic seal for human consumption and use in the Canadian Arctic, but figures are not available regarding harvest levels.



Source: Hoel and Vilhjalmsson (forthcoming 2004)

Fig. 11.10 The catch of harp and hooded seals, 1952–2002. The data also includes seals taken in the Gulf of St. Lawrence.

Commercial harvesting of walrus was banned in Canada in 1931. All hunting currently conducted is Aboriginal subsistence hunting. The quota is set at four animals per hunter per year in most areas and the harvest has averaged some 530 animals annually. Four Atlantic walrus stocks occur in the eastern Canadian Arctic. Their status is poorly known and there are concerns that some of them may be overexploited.

Canada discontinued commercial whaling in 1972. However, whaling has been important to Inuit in the Canadian Arctic since prehistoric times and Arctic Inuit currently hunt about 700 belugas and about 300 narwhal annually. There is concern for the conservation of several beluga stocks in eastern Canada, while those in the west are harvested well within sustainable yields. Narwhal are hunted in Hudson Bay and Baffin Bay under a quota system. The hunting of bowhead whales has recently resumed in both the eastern and western Canadian Arctic following the settlement of land claim agreements. Both of these bowhead populations are classified as endangered, and harvesting is in violation of the International Whaling Commission.

Polar bear harvesting in Canada is done according to quotas assigned through the International Agreement for the Conservation of Polar Bears and Their Habitat (1973). Between 500 and 600 polar bears are taken annually in Canada by Inuit and Amerindian hunters. Licensed sport hunting and the sale of skins are important sources of cash income for small settlements in northern Canada.

Historically, seabirds were an important component of the subsistence lifestyle for coastal peoples, but today seabird harvesting for birds and eggs is much less widespread. The most intense consumptive use of seabirds occurs in Newfoundland and Labrador, where thick-billed and common murres are harvested according to a set hunting season and bag limits. In the past, hunting levels were extreme and unsustainable, but they have improved with newly enacted legislation. Currently, 200,000–300,000 murres are shot in the Newfoundland/Labrador hunt and approximately 20,000 common eiders are taken in Atlantic Canada. In addition, some 25,000 common eiders, thick-billed murres, and black guillemot are harvested in Arctic Canada.

Student Activity

1. Is there any commercial fishing of the waters near your community or region? If yes, which country or countries fish near you?
2. What appear to be the trends in landings over time in your area?
3. What key stocks have been fished in your area?
4. What impact have commercial fisheries had on these stocks?

The Bering Sea

Geography

The Bering Sea is a Subarctic sea delineated by the Bering Strait to the north and the Aleutian Islands archipelago to the south. It lies between 52^{o} and 66^{o} north latitude, and between 162^{o} east and 157^{o} west longitude. The narrow and shallow 85-km passage of the Bering Strait connects the Bering Sea to the south with the Chukchi Sea and the Arctic Ocean to the north. Because of low stock abundance, operating difficulties, and distance from markets, only limited commercial fisheries are conducted in the Chukchi Sea or in the Arctic Ocean north of the Bering Strait. Marine mammal populations, however, are locally important for subsistence use. In contrast, the continental shelves of the eastern and western Bering Sea combine to produce one of the world's largest and most productive fishing areas. They contain some of the largest populations of marine mammals, birds, crabs, and groundfish in the world. Fully 25% of the total global yield of fish came from this region in the 1970s.

Commercial fisheries in the Bering Sea are generally large-scale trawl fisheries for demersal species of which about 30% of the total catch is processed at sea and the remainder delivered to processing plants in Russia and the United States. Home base for many of the Bering Sea vessels is outside the Arctic region. Small coastal, mostly indigenous, communities on both sides of the Bering Sea conduct subsistence fishing. These communities depend on coastal species, especially salmon, herring, and halibut. Anadromous species—that is, those that swim up a river from the sea to spawn—extend far inland via the complex river systems and are critical resources for indigenous peoples.

Key Species

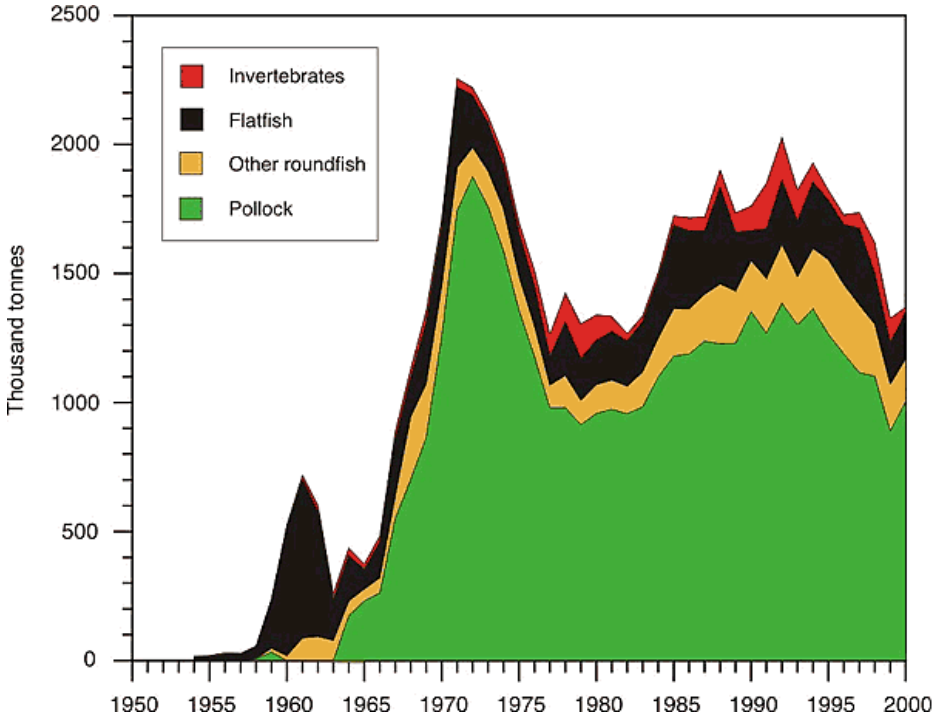
The fish and invertebrate fauna of the Bering Sea is diverse and naturally a bit different from the North Atlantic fauna. Still, there are many similarities and, as in the Atlantic, there are relatively few species with high enough biomass to be commercially exploited. Walleye pollock (*Theragra chalcogramma*) is the most abundant species within the Bering Sea and is also widely distributed throughout the North Pacific. Walley pollock is a semidemersal schooling fish that becomes increasingly demersal with age. It is relatively short-lived and fast-growing. In the eastern Bering Sea, capelin occur in the vicinity of the Pribilof Islands and the continental shelf break; in the western part it occurs in the northern Anadyr Gulf and near the Kamchatka coast. Pacific cod (*Gadus macrocephalus*) has a widespread distribution, from southern California to the Bering Sea, although the Bering Sea is the centre of greatest abundance for this species. Greenland halibut is widely distributed in the Bering Sea but are more abundant on the eastern side. Yellowfin sole (*Limanda aspera*), the most abundant flatfish, is distributed from British Columbia to the Chukchi Sea and

from the western Bering Sea along the Asian coast. Polar cod, which is the main fish species in the Chucki and Arctic seas, extends in summer to lat 59–62° N in the Bering Sea. The Bering Sea is an important habitat for the five species of Pacific salmon (genus *Oncorhynchus*)—chinook, chum, coho, pink, and sockeye—during the ocean phase of their life history. Stocks from origins in Siberia, Alaska, the Aleutian Islands, Japan, Canada, and the west coast of the United States intermingle in the Bering Sea.

Pandalid shrimp (primarily *Pandalus jordani*) are well distributed along the outer third of the eastern continental shelf. Humpy shrimp (*P. goniurus*) are widely distributed throughout the northern Bering Sea shelf and the Anadyr Gulf, in contrast to northern shrimp (*P. borealis*), which are less abundant. Snow crab (*Chionoecetes opilio*) and Tanner crab (*C. bairdi*) are distributed throughout the eastern Bering Sea shelf, with the exception of the shallow waters of Bristol Bay.

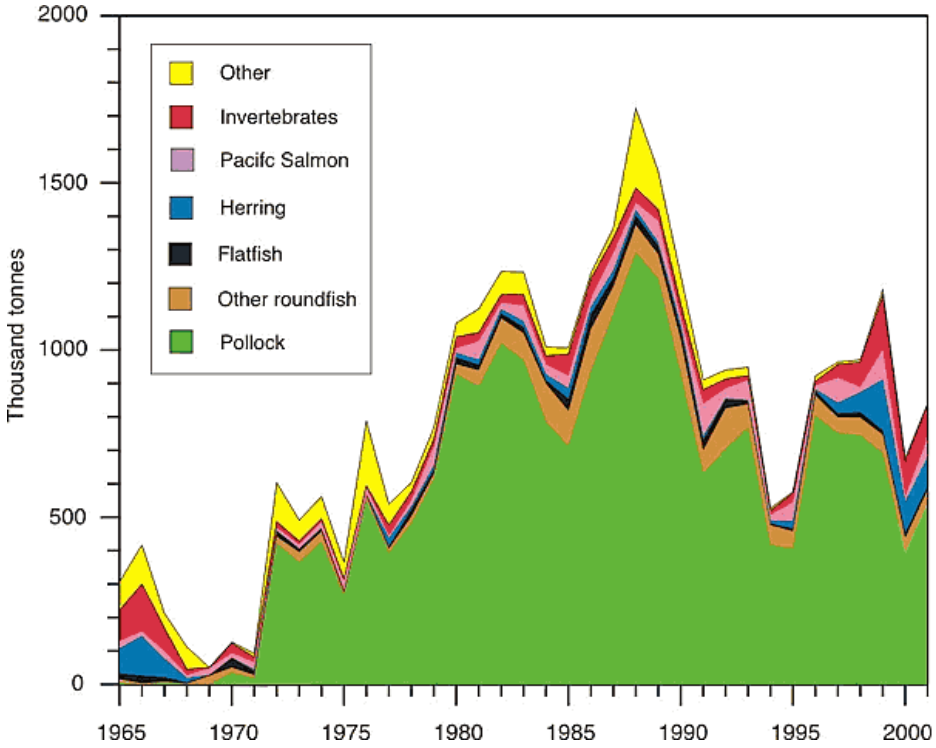
Fisheries and Stock Abundance

Figures 11.11 and 11.12 show landings of main commercial species from eastern and western parts of the Bering Sea, respectively, during the latter half of the twentieth century. The eastern Bering Sea fisheries are managed and conducted mainly by US fishing fleets, while Russian fleets conduct the western Bering Sea fisheries.



Source: Hoel and Vilhjalmsson (forthcoming 2004)

Fig. 11.11 Catch by species from the eastern Bering Sea, 1955–2000



Source: Hoel and Vilhjalmsson (forthcoming 2004)

Fig. 11.12 Catch by species from the western Bering Sea, 1965–2000

Walleye pollock currently supports the largest fishery in the United States and the largest fishery in Russian waters and comprises around 80% of the annual catch. These fisheries began in the late 1960s and reached a peak on the US side in 1970–75, when they ranged from 1.3 to 1.9 million tonnes annually (see fig. 11.11). Since the extension of the US EEZ in 1977, the annual average eastern Bering Sea pollock catch has been 1.2 million tonnes. On the Russian side, the pollock catch began slowly in the 1970s and peaked in the 1980s with an average of some 800,000–900,000 tonnes. Since 1990, the catch has declined and is currently at approximately 400,000 tonnes (see fig. 11.12). Vessels of "third countries" began fishing in the mid-1980s in the international zone of the Bering Sea (referred to as the "donut hole"). The catch grew rapidly and peaked in 1989 at 1.45 million tonnes and has since declined sharply.

Fisheries for Pacific cod are the second largest in the Bering Sea. During the early 1960s, a Japanese longline fishery—that is, a fishery that uses a deep-sea fishing line with a large number of baited hooks attached to it—harvested Bering Sea Pacific cod. For the next decade, foreign catches were in the 30,000–70,000 tonnes range. In 1981, a US domestic trawl fishery for cod began and has since displaced foreign operations. Catches of Pacific cod since 1978 have

ranged from 33,000 tonnes in 1979 to 232,600 tonnes in 1997, with an average of 141,900 tonnes. In the western Bering Sea, the Russian cod fishery slowly developed and was mostly unsuccessful until the late 1960s. The Pacific cod harvest peaked at 117,650 tonnes in 1986. In the 1990s, this fishery began to decline. Pacific cod biomass was estimated at 766,000 tonnes in 1989 and has declined to 172,000 tonnes in 2000 (see fig. 11.11 and fig. 11.12 for data on other roundfish).

Yellowfin sole has been harvested on the Bering Sea shelf since 1954. The species was overexploited in 1959–62, when catches averaged 404,000 tonnes annually and the stock declined. In the early 1980s, after the stock condition had improved, catches again increased, reaching a recent peak of more than 227,000 tonnes in 1985. Prior to 1980, yellowfin sole was fished exclusively by non-US fisheries. However, since 1990, only domestic harvesting and processing has occurred, and yellowfin sole is currently the target of the largest flatfish fishery in the United States (see fig. 11.11 and fig. 11.12 for data on flatfish).

Northern shrimp was the first commercially exploited shrimp in the Bering Sea, beginning in 1960. This shrimp fishery was conducted by Japanese vessels and reached a maximum in 1963 at 31,600 tonnes. After that, the northern shrimp stock sharply declined, and commercial fishing ceased after 1967. At present, no commercial fishery exists for pandalid shrimp in the eastern Bering Sea. In 1978, the annual harvest of the Russian humpy shrimp fishery exceeded 11,200 tonnes. However, this fishery declined because a market for small-sized shrimp did not exist.

The combined Japanese–Russian catch of snow crab and Tanner crab increased until 1970 to 22,844 tonnes, after which quotas were established and the catch was sharply reduced. The American crab fishery began shortly thereafter and realized an increasing harvest during the 1980s, peaking in 1991 at 172,588 tonnes. The Tanner crab fishery has been closed since 1997 in the eastern Bering Sea.

The earliest fisheries for salmon were likely Aboriginal subsistence fisheries in which salmon were captured as they returned to their native streams to spawn. Statistics from the Pacific salmon fishery in eastern Kamchatka region show that pink salmon contributes three-quarters of the catch. The average pink salmon catch for 1989–2001 was roughly 38,000 tonnes per year.

Use of Marine Mammals and Seabirds

The Bering Sea contains a rich and diverse assemblage of marine mammals, including north temperate, Arctic, and Subarctic species. Twenty-six species from the orders Pinnipedia (sea lions, walrus, and seals), Cetacea (whales, dolphins, and porpoises), and Carnivora (sea otter), as well as polar bears, are present in 39 distinct stocks. Arctic species, including polar bears, walruses,

ringed and bearded seals, and bowhead whales are found mostly during fall and winter and are associated with the presence of seasonal sea ice. The majority of the marine mammal species is found over the continental shelf and in coastal areas. Nine of the 39 marine mammal stocks are estimated to be increasing; five are stable; three are declining; and the status of the others is unknown.

Marine mammals have been harvested on a commercial scale at least since 1790, when the harvest of the northern fur seal (*Callorhinus ursinus*) began. This harvest peaked in the 1870s at more than 100,000 animals and was at levels exceeding 40,000 males annually until 1985, when the harvest was stopped and only subsistence hunting by Aleuts was allowed in the Pribilof Islands. In the Russian EEZ, fur seal hunting has had many ups and downs and had declined to some 2,200 animals in 2000. Steller sea lions were very abundant in the Pribilof Islands when they were discovered in 1786, but were overexploited soon thereafter. More recently, Steller sea lion populations have undergone significant declines in the northern part of their range. Most notable has been the 80% decline in numbers in the Aleutian Islands between the late 1970s and 1992. Causes of the decline are not known but may include deliberate killing by fishers, incidental take (bycatch) by fisheries, subsistence harvests, disease, and reduced food supply owing to the offtake by the fishing industry. The Steller sea lion was listed as a threatened species under the US Endangered Species Act in 1990; Russia has also adopted protective measures.

Whaling spread to the Bering Sea in the mid-nineteenth century. Large numbers of bowhead whales were taken at that time (2,500 in 1853). This harvest continued for 50 years until the bowhead whale population became depleted. At present, there is no commercial hunt of marine mammals on the US side, but a small-scale subsistence harvest is allowed for three species: northern fur seals, beluga whales, and bowhead whales. In Russia, marine mammal populations are classified as commercial, non-commercial, and protected. Protected species include all whales and dolphins (with the exception of grey whales taken by indigenous peoples for subsistence), sea otter, and polar bears. A commercial quota has been established for the beluga whale, but whaling does not exist. Walrus, as well as spotted, ringed, and ribbon seal, are hunted in the northwestern Bering Sea. However, harvest levels have been relatively low and in 1998–2000 they represented less than 60% of the established total allowable catch for different seal species, averaging 32.8%.

Human Effects on Marine Resources

Impact on Fisheries

Marine fisheries dominate commercial uses of wild species in the Arctic and are of major significance to several regional and national economies. Enormous amounts of fish are landed from Arctic and Subarctic seas each year (see table

11.2). The total yearly catch fluctuates widely but is currently somewhere between 6 and 7 million tonnes.

Table 11.2 Average annual landings (thousand tonnes), 1950–1998 (adapted from FAO)

Species	NE Atlantic	NW Atlantic	NE Pacific	NW Pacific	Totals
Greenland halibut	43	32	3	3	81
Arctic cod	30	0	0	2	32
Capelin	1150	62	0	4	1216
American plaice	2	61	0	0	63
Atlantic redfishes	222	172	0	0	394
Atlantic cod	1528	789	0	0	2317
Atlantic herring	1815	320	0	0	2135
Pacific cod	0	0	105	108	213
Walleye pollock	0	0	1200	~700	~1900
Total	**4790**	**1436**	**1308**	**~817**	**~8351**

As detailed in previous sections of this lecture, most fish stocks have been overexploited at one time or another. Often, the Arctic nations have been able to intervene with protection measures before the stocks have collapsed completely, but this has not always been the case (e.g., Norwegian spring-spawning herring), and in some cases the stocks have not been able to recover in spite of strong protection measures (e.g., Atlantic cod off Labrador; Icelandic spring-spawning herring). Natural variability in stock abundance, which depends largely on ocean conditions, complicates the picture. Thus, the collapse of the Norwegian spring-spawning herring coincided with a sharp cooling in the North Atlantic in the 1960s. Also, the demise of the Greenland cod fishery can be attributed to this cooling period, during which the drift of cod larvae from Iceland to Greenland ceased.

Figures 11.1, 11.4, 11.5a–b, and 11.9 illustrate how the long-term effects of commercial fisheries occur on top of natural fluctuations. The figures show, among other things, combined landings of Atlantic cod in all regions of the North Atlantic during the latter half of the twentieth century. Clearly there are natural fluctuations in abundance, but overall the trend is downward, which is not surprising considering the high fishing mortality in modern fisheries.

Bycatch (Incidental Take)

Modern fishing does not affect only the targeted stocks. Almost all fishing techniques also exploit other species that are not the primary fishing target. Non-target catch is called "bycatch" or "incidental take." Bycatch is generally thrown overboard and not recorded, so the actual volume is hard to estimate. Worldwide, bycatch of marine mammals, sharks and rays, sea turtles, salmon, and large albatrosses is of highest concern, especially connected to longline fisheries. In the Bering region, there is a concern over bycatch of the endangered short-tailed albatross (*Phoebastria albatrus*) in longline fisheries. Seabird bycatch in gillnets in the Arctic region has been studied by Conservation of Arctic Flora and Fauna (CAFF), who has written a technical report entitled *Incidental Take of Seabirds in Commercial Fisheries in the Arctic Countries* (CAFF 1998, http://www.caff.is/sidur/uploads/incidentalpart3.htm.pdf). The species most at risk are diving species, such as auks, razorbills, puffins, and eiders. When they are feeding, these species get entangled and drown in gillnets that are laid close to the shore. The average annual number of accidentally caught seabirds off Newfoundland during 1981–84 was around 27,500 birds. For razorbills, 12.4% of the population was lost in this way. In the same area, the annual marine mammal bycatch number exceeded 1,000. In other Arctic countries, there are records of tens of thousands of murres or guillemots being drowned in one season. Abandoned, freely drifting gillnets are also responsible for a large number of deaths. Fish and other marine organisms often escape hurt from the fishing gear and later die of injuries. In addition, benthic habitats are destroyed and bottom-living species are killed by bottom trawls.

Overall, modern fishing practices are far from sustainable. Declining fish stocks—especially those of large fish species—all over the world are becoming a major concern. The Arctic countries try their best to protect this vital resource through various fisheries management practices, such as total allowable catch (TAC) limits, boat owner quotas, protection of spawning grounds, and so on. We must hope that these measures will suffice.

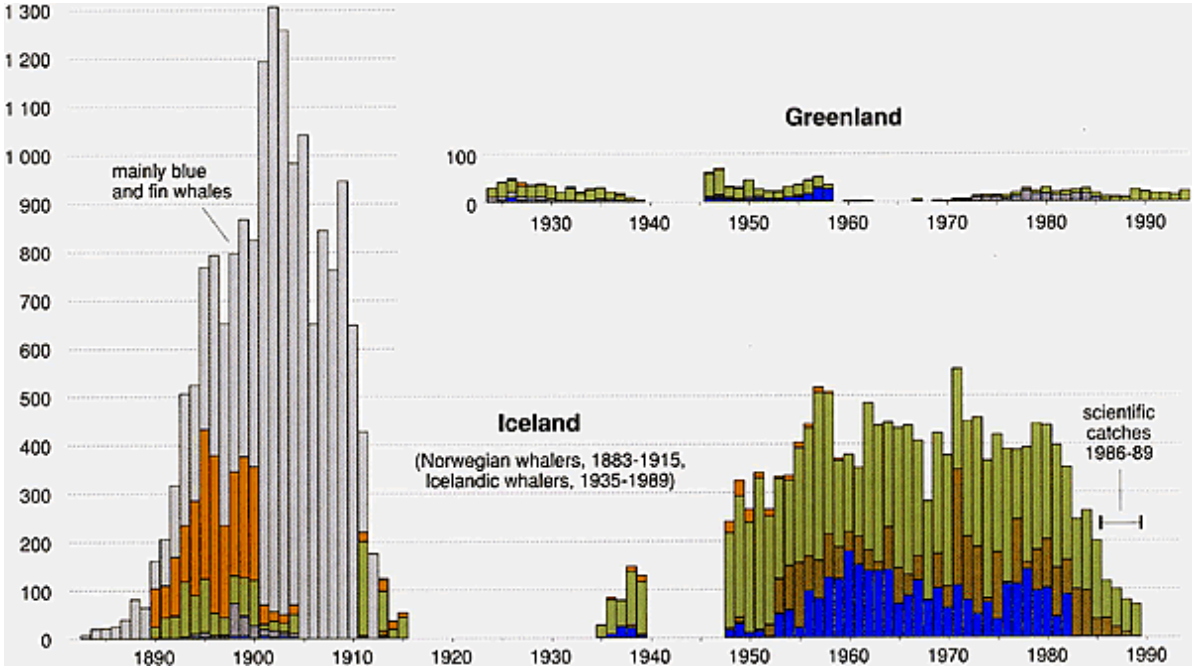
Whaling Impacts

The history of commercial whaling in Arctic waters is a sad tale of greed. In the North Atlantic, the history goes at least 400 years back. One after another of the great whale populations were hunted to near extinction, or total extinction in some cases.

The first whale populations began disappearing from Nordic waters as early as the seventeenth century because of whaling operations by mostly Dutch, English, and French whalers. The target species were the so-called "right" whales: the bowhead (*Balaena mysticetus*) and black northern right whale (*Eubalaena glacialis*). These species were called right whales because they were slow swimmers and easy to capture in open boats and therefore the "right"

species to catch. It is estimated that some 35.000 bowheads occupied Nordic waters in the seventeenth to eighteenth centuries. Currently, some 250 bowheads live west of Greenland, and an occasional bowhead is seen off Svalbard.

The hunt for the fast swimming baleen whales such as blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), sei whale (*B. borealis*), and humpback whale (*Megaptera novaeanglia*), began in earnest in the late eighteenth century, using steam ships equipped with harpoon guns. By this time, Norwegians had taken over as the main whaling nation in the North Atlantic, establishing whaling stations in northern Norway, Svalbard, and Iceland. During a thirty-year period from 1980 to 1910, several thousand large whales were caught each year near Iceland (see fig. 11.13). The same type of mass kill had occurred off Norway a few years earlier. By the turn of the century, the North Atlantic blue whale stock had been greatly depleted the same fate came to the fin-, sei-, and humpback a few decades later. Declining stocks resulted in a temporary whaling ban off Norway in 1905 (until 1918) and off Svalbard in 1912 (until around 1930). In 1912, whaling was banned in Iceland to protect the stocks. Whaling remained insignificant in Icelandic waters until after the Second World War, when it resumed under the aegis of the International Whaling Commission. As populations of the large whales began to shrink, interest in smaller species increased. Norwegians began hunting minke whales in the 1920s; Icelanders followed suit in the 1950s. By the mid-twentieth century, some 4,000 minke whales where caught annually in Nordic waters.



Source: Bernes (1996)

Fig. 11.13 Commercial whaling around Iceland and Greenland during the late nineteenth and the twentieth centuries

Commercial whaling after the Second World War, although much more tightly controlled than previously, was conducted on already depleted stocks. The pressure of world opinion resulted in a total ban on commercial whaling in 1986. Norway, which never agreed to the whaling moratorium, has kept on harvesting a few hundred minke whales each year. In 2003, Iceland resumed whaling of minke whales for scientific purposes and is trying to win support for small-scale commercial whaling of recovered stocks of minke, fin-, and sei whales.

Student Activity

1. Are the waters near you rich or poor in species diversity compared to other areas of the Arctic discussed in this module?

2. What do you think will be the future for the living marine resources in your region over the next 50 years?

Supplementary Materials

FishBase is a searchable database of living marine species: [Online] http://www.fishbase.org/search.cfm.

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