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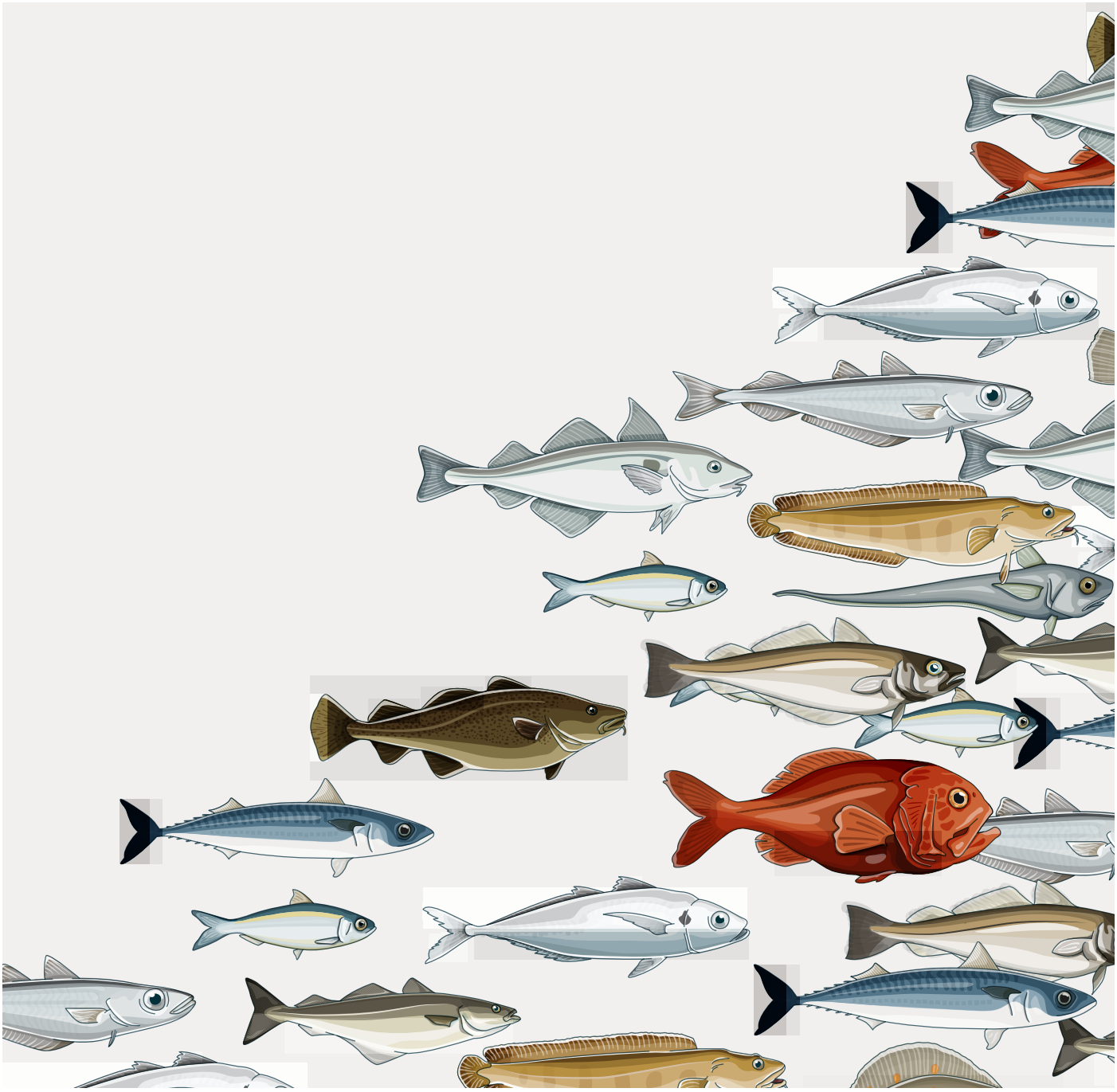

Turning the Tide

Ending overfishing in north-western Europe

The Pew Charitable Trusts

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The Pew Charitable Trusts is an independent non-profit, non-governmental organization, founded in 1948. Pew's mission is to serve the public interest by improving public policy, informing the public and invigorating civic life. It's work in the European Union focuses on enhancing fisheries management and ocean conservation.

This publication documents the role and development of fisheries in Europe's north-west waters and the opportunities created by the EU's reformed Common Fisheries Policy to restore fish stocks there.

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Map 1

North-West European Waters

Overview

The seas of north-western Europe—the North, Irish, and Celtic seas, and the waters west of Scotland and Ireland—boast a rich and diverse mix of environments and wildlife that have shaped the cultures along their shores. For millennia, the natural bounty of these waters has spurred development of coastal communities and enabled the expansion of fisheries in pursuit of food and profit.

In recent decades, however, the scale of that expansion has increased dramatically. Calls by scientists and environmentalists to reduce fishing pressure have been ignored too often by politicians who put short-term economic and political gains ahead of long-term sustainability. As a consequence, many fish stocks collapsed throughout the region, leaving fishing communities devastated. In response, the European Union (EU) recently agreed to a reform of its fisheries management, the Common Fisheries Policy (CFP), that should prove a successful first step in restoring and maintaining the health of fisheries and fish stocks, and of the communities and marine ecosystems that depend on them.

This report takes an in-depth look at the seas in north-western Europe, their characteristics, their histories and the roles that their fisheries have played in the booms and busts of communities at the water's edge. An understanding of these distinct regions—and the critical part played by their fish stocks —emphasizes the importance of effective implementation of the reformed CFP, which requires an end to overfishing throughout Europe where possible by 2015 and at the latest by 2020. Now is the time to start making sure the policy goals move from rhetoric to reality.

A region rich in marine wildlife and history

The North Sea coast is home to upward of 60 million people—13 per cent of the EU's population.[1] That includes densely populated areas, such as the Netherlands, where on average roughly 500 people live in every square kilometre, as well as largely rural places such as the Shetland archipelago off Scotland, where only 16 of some 100 islands are inhabited.[2]

Further west, the coastline of the Irish Sea features one of the most industrialized parts of the region—England's Merseyside, which includes Liverpool—and a stretch of coast with nearly one quarter of the estuaries of the entire United Kingdom. Both the North and Irish Seas are relatively shallow and to a large extent encircled by land, their waves encountering borders as varied as the fjords of Norway, the tidal inlets of the Wadden Sea, and the extraordinary basalt formation known as Giant's Causeway in north-east Ireland.

In contrast, the deeper Celtic Sea has relatively little coastline; it washes against the southern coast of Ireland and touches the tips of Cornwall, Wales and Brittany, but is otherwise limited in extent by the lines drawn in ocean maps. The waters to the west of Scotland and Ireland cover the largest area in this region and encompass the most variety of all, from the sparsely populated Western Isles to the Firth of Clyde (the site of herring fisheries as early as the fifteenth century), west to cold depths that shelter deep-water corals and fish that can live for 100 years or more.

Amid the contrasts, one constant remains: The waters and coastal zones of north-western Europe have long enjoyed—and despite urbanization, industrialization and overfishing, in many cases continue to enjoy—thriving concentrations of marine life. The Celtic Sea supports about 300,000 breeding pairs of 15 seabird species.[3] The Monach Isles in the Outer Hebrides host the second-largest breeding population of grey seals in the world.[4] Massive deep-sea coral reefs on the Porcupine Bank, 320 km west of Ireland, include living thickets that stand up to four times the height of many similar cold-water corals.[5] The Wadden Sea in the North Sea's south-east corner is the site of the largest unbroken system of intertidal sand and mud flats in the world, and its salt marshes host around 2,300 species of flora and fauna.[6]

These diverse marine ecosystems have long played critical roles in the culture and economy of north-western Europe. Shell and skeletal cod remains in north-east Ireland suggest the existence of marine fisheries in the Irish Sea dating back some 9,000 years.[7] Around 1000 CE, Basque fishers began venturing as far north as Norway, Iceland and the Faroe Islands, catching cod and preserving it with salt.[8] By the seventeenth and eighteenth centuries, the Dutch herring fishery absorbed more capital and employed as many people as the country's merchant fleet, the richest in Europe at that time.[9]

Cod has remained an iconic species in the region for centuries.

A history of overfishing

So great was the region's bounty that in 1813, Henry Schultes, a British political commentator, wrote that "the seas which surround us afford an inexhaustible mine of wealth".[10] Almost 100 years later, writer Walter Wood rejoiced that, "despite the vast growth of the fishing industry, the total quantities of fish rise annually".[11] Yet by the time of that second proclamation, the first warning signals were already being sounded. In 1900, for example, Walter Garstang of Britain's Marine Biological Association noted of the North Sea that years of excessive fishing had led to steadily diminishing returns for the work required.[12]

Two wars then slowed the expansion of the region's fishing industry and the toll of overfishing, but that interruption would prove only temporary. Today, declines vary from sea to sea: North Sea fisheries, for example, have been and continue to be fished by many states, with one succeeding another as the dominant actor; in the Irish Sea, Irish and British vessels bring in the great bulk of landings. The open-ocean fisheries to the west of Scotland and Ireland pose a challenge, unique in the region, because EU fisheries must seek agreements on quotas in international waters with counterparts from Iceland, Norway, the Faroe Islands, Greenland and Russia. But the broader narrative—of rapid increases in fish landings followed by sharp declines as fish stocks collapse under the pressure of intensive fishing—has played out time and again.

The examples, and their socio-economic and ecological consequences, make for disheartening reading:

- In the North Sea, the first herring stock collapse took place in 1955; more herring stocks began collapsing in the late 1960s, and in 1977 the North Sea herring fishery had to be suspended for four years.[13] Catches of cod in these waters peaked at over 300,000 tons in the early 1970s, declined in the 1980s and 1990s, and then plunged until, by 2003, the International Council for the Exploration of the Sea (ICES), the intergovernmental organization focused on marine and fisheries science, called for a closure of the cod fishery. Although the fishery is now conducted under the aegis of a management plan, the stock remains overfished and its biomass is critically low.
- In the Irish Sea, once-extensive fisheries for herring are now a tiny fraction of their former size, so much so that the majority of the catch is taken by just three trawlers. ICES has recommended zero catch of cod since 2004, while it was only in 2012 that EU fisheries ministers set what is known as the total allowable catch (TAC) in the coastal waters of western Scotland at zero.
- In the Celtic Sea, the level of fishing has changed the relative abundances of species of different sizes, fundamentally transforming the composition of the sea's ecosystem.[14] For example, these waters have experienced significant declines in large fish species, such as cod and angler fish, and increases in smaller size species such as blue whiting, megrim and whiting.
- West of Scotland and Ireland, the blue whiting fishery was the largest in the north-east Atlantic in 2003; by 2011, it had collapsed to such an extent that scientists recommended zero catch that year.[15] An Irish fishery for orange roughy, supported by subsidies, began in 2000, peaked in 2002 and had ended by 2009.

Overfishing and the early Common Fisheries Policy

Since 1983, the Common Fisheries Policy has been used to manage fishing by EU members and fisheries in EU waters. The CFP cannot be held responsible for management failures that predate its launch, but it has not yet proven effective in restoring fish stocks to sustainable levels. Indeed, certain aspects of the policy have contributed to mismanagement of fish stocks in the region. For example:

- Scientific advice was not always available to help pre-empt rapid exploitation of fisheries, and even when it was, it often was not used to guide management decisions. The final word on setting catch limits under the CFP falls to the EU Council of Ministers, which frequently weights short-term political considerations over long-term ecological or economic ones.
- Fisheries managers remain dependent on information from fishing vessels, information that is not always available or reliable. ICES, for example, has estimated that "unallocated removals"—unreported catch and unauthorized landings known as "black" landings—have at times accounted for as much as 40 per cent of North Sea cod catches.[16]
- Even when restrictive measures are put in place to allow for rebuilding of stocks, the fishing industry and its supporters often work to overturn them, denying the measures time to take full effect. For example, a reduction in fishing for Celtic Sea cod after 2005, combined with an extraordinarily large number of young fish entering the population in 2010, led to a rapid increase in the stock's size. Catch limits were almost immediately increased, the stock declined again, and an opportunity for recovery was lost.
- An overarching problem, though, has been that neither the original CFP nor the policies that preceded it were intended to regulate fisheries from the perspective of sustainability or ecosystem protection.

> Fishing at or below maximum yield maximizes average yield in the long term.

Officials adopted the first set of European Economic Community (EEC) regulations on fisheries in 1970. These rules grew out of a belief that the ocean was largely inexhaustible and a conviction that fisheries management was about maximizing catches and profits. The drafters focused primarily on structural and market measures to increase productivity and growth.

After the CFP was launched in 1983, capacity in the fishing fleets continued to increase to meet these objectives—and fish stocks continued to decline. Even as the fisheries policy underwent a series of reforms intended to place greater emphasis on sustainability, many of the more ambitious measures that might have allowed fish stocks to recover were thwarted by an emphasis on short-term political and economic considerations. As a consequence, by 2007, 94 per cent of assessed EU stocks were classified as overfished.[17]

Fisheries policy reform: A way forward

In 2008, the European Commission published a "Mid-Term Review of the Common Fisheries Policy" that rebuked the policy, its structure and its implementation, setting in motion a process that has resulted in a substantially reformed CFP that entered into force in January 2014. The policy now includes, among other mandates, a clear time frame for ending overfishing and an obligation to land unwanted catch. If correctly implemented, these measures could fundamentally transform commercial fisheries in the region, allow overfished stocks to recover, and return the seas of north-west Europe to a state where they are once again full of life.

Correct implementation, however, is the key. Though they have agreed to phase out overfishing by 2015 where possible and by 2020 at the latest, ministers actually increased the degree of overfishing in 2012 and 2013. Going forward, some EU member states are likely to seek delays in, or exceptions to, implementation of the new standards, or request quota adjustments that would result in yet more overfishing.

Years of combined effort by the European Commission, Parliament and Council—with widespread pressure from civil society—resulted in the reformed CFP. The policy can succeed only if those charged with implementing the reforms maintain their focus, and the public keeps pushing decision makers to ensure the law works in practice as intended. That would allow the recovery of fish stocks and lead to stable, sustainable fisheries in a region that supports abundant marine life and thriving communities.

The North Sea

On a map of the world, the North Sea is not especially notable, a small patch of water just about managing to keep the British Isles at arm's length from the European mainland and southern Scandinavia. But for centuries, the North Sea has been a centre of culture, trade, transport and industry, a passageway between communities and a pathway for ships heading farther north or south.

Map 2

North Sea

The North Sea is located between Great Britain and the mainland of north-western Europe and covers an area of 750,000 square kilometres

In antiquity, Roman forces traversed the North Sea to invade Britain, even as they dismissed it as the stormiest stretch of water on Earth. In the seventh and eighth centuries, the monastery on Lindisfarne off north-east England was an important centre of Christian evangelizing, and the place where a monk named Eadfrith produced the first Old English version of the Gospels.[18] In the twelfth and thirteenth centuries, the Hanseatic League, the northern European trading bloc that held power and influence in the Baltic and North Sea regions for some 300 years, boasted major trading areas along the North Sea coast, notably London and Bruges. And with the growth of Holland and England as major world powers, the North Sea became one of the most travelled and commercially valuable areas of ocean on the globe.

The North Sea saw the northward flight of the Spanish Armada in 1588, the Battle of Jutland in 1916 (the largest naval battle in history in terms of the number of vessels involved), and the Shetland Bus operations that provided a vital link between the Allies and Nazi-occupied Norway during World War II. The sea has yielded immense natural resources: The discovery of significant subsea deposits of oil and natural gas in the late 1960s led to the development of an offshore oil and gas industry that has become one of the largest economic sectors in the region, particularly in Norway and the United Kingdom.[19] But much of the human history of the North Sea has been inextricably entwined with fisheries.

There is evidence that at least some fishing with nets and lines took place in north-western European waters during Mesolithic times (between 11,000 and 5000 B.C.E.), and a study of farm mounds in Norway showed that Iron Age Norse communities exploited marine resources to supplement marginal agriculture.[20] True commercial fishing in these waters appears to have started around 1050 C.E., interestingly, during the Medieval Warm Period, when the local productivity of cod and haddock was likely depressed and conditions were presumably conducive to successful agriculture. Rapid growth in urban populations, the spread of Christianity—which permitted fish to be eaten on fast days—and, perhaps most important, declines in freshwater fish—may have helped prompt the fisheries' inception.[21]

The use of salt to preserve fish began in the twelfth century and led to trade between those who could provide fish and those who could provide the salt: The Hanseatic League, for example, began in 1241 with an alliance between the cities of Lübeck, which controlled access to the Baltic Sea herring fishing grounds off present-day Sweden, and Hamburg, which had access to mines that produced salt to preserve those herring.[22]

Although peoples from many places fished for herring, the Dutch proved the most successful. Their fleets dominated the fishing industry in the area for over 200 years from the mid-1500s—so much so, that it has been said Amsterdam is built on herring bones. In the century between 1550 and 1650, the Dutch Republic was Europe's most modern economy and leading trading nation. Still, during this period, the Dutch herring fishery absorbed more capital and employed as many people as the country's merchant fleet.[23]

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In the middle of the nineteenth century, Danish fisheries developed a technique for using seine nets further out at sea; they previously had been used only close to shore. Starting around 1880, Denmark began exporting fish by rail across Europe. The early twentieth century saw a huge expansion in the Danish fleet. From 1920 to 1950 the Danish "blue fleet" was the overwhelmingly dominant force in North Sea fishing.[24] Denmark remains responsible for more than one third of North Sea landings, followed by Norway, the United Kingdom, the Netherlands, Germany, Sweden and France.[25]

At the same time as the genesis of the more efficient Danish seine fisheries, steam power allowed development of more powerful engines, leading to more substantial vessels towing larger gear. By 1890, much of the North Sea was trawled, in many places more than once a year.[26] At the turn of the twentieth century, Walter Garstang of Britain's Marine Biological Association observed, "The complaint of the fishermen, however, for many years past has been that the bottom fisheries have been annually and steadily diminishing in return for the same labour expended upon them".[27]

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>
> **Walter Garstang,** *Britain's Marine Biological Association*

One hundred years later, fishing has contributed to profound changes in the region's ecosystem. Some highly migratory species that were reasonably common historically in the North Sea have either disappeared completely—such as bluefin tuna—or have become very rare, for example, halibut. Most sharks and rays persist only in low numbers or have disappeared entirely from large parts of the North Sea. Oyster beds in the North and Wadden Seas, targeted by bottom trawlers and described as abundant in the nineteenth century, no longer exist.

Bottom trawling has fundamentally altered the sea floor. Industrialization and development have brought great change to coastal and marine habitats, and the composition of fish species is fundamentally different than several decades ago. Despite such change and pressure, the North Sea remains an important focus of fisheries in north-western Europe.

North Sea: Geography, Environment, Ecology and Wildlife

The North Sea is bordered by such varied coastlines as the fjords of Norway, the chalk cliffs of south-eastern England and the tidal inlets of the Wadden Sea, and by upward of 60 million people—13 per cent of the European Union's population.[28] The concentrations of that population range from the largely rural Shetland archipelago, of which only 16 of approximately 100 islands are inhabited, to the Netherlands, where on average about 500 people live per square kilometre.[29]

Occupying a south-eastern portion of the North Sea, the Wadden Sea contains the largest unbroken system of intertidal sand and mud flats in the world. Its salt marshes host around 2,300 species of flora and fauna, while its marine and brackish areas are home to 2,700 more. The sea is an important staging, moulting and breeding area for as many as 6 million seabirds at any one time.[30] All told, more than 10 million seabirds make their way to the North Sea at various times of the year, and about 4 million breed there, frequently in dense colonies along its coasts.

Over much of the last century, many of these seabird populations showed a marked increase in numbers, likely the result of a combination of protections from hunting, expansion in fishing that benefited birds—such as fulmars—that feast on discards. Predatory birds, such as skuas, also thrived because of the general increase in their seabird prey. More recently, however, some species have had poor breeding success in at least some locations, probably tied to overfishing of forage fish or natural and human-induced climatic changes.[31]

Even with localized breeding failures, many seabirds exist in numbers that represent substantial proportions of their world population: North Sea coasts support over 50 per cent of the worldwide number of common

terns (*Sterna hirundo*) and great skuas (*Catharacta skua)*. Twelve other species, such as the black scoter (*Melanitta nigra*) around the Flemish Banks, are present in numbers exceeding 10 per cent of their total estimated populations.[32]

North Sea coasts support over 50 per cent of the total worldwide number of common terns.

The single most common marine mammal appears to be the harbour porpoise, numbers of which have been estimated at about 300,000. Several other dolphin species are also frequently present, as are sperm whales, particularly during their southward migrations from November to March.[33]

Populations of harbour seals (*Phoca vitulina*) along the continental coast reached an all-time low in the 1970s, when long periods of extensive hunting were followed by reproductive declines tied to chemical pollution. They then showed strong signs of recovery that were interrupted in 1988 and 2002 by outbreaks of phocine distemper virus, or PDV. Although the recovery resumed following the 1988 outbreak, harbour seal populations at Orkney, Shetland and the Scottish North Sea coast have declined since 2002 for reasons that remain unclear.[34]

About 230 species of fish live in the North Sea, with the diversity of species generally higher inshore and in the western North Sea. The major commercial fisheries primarily target 13 species of fish and crustaceans—cod, haddock, whiting, saithe, plaice, sole, mackerel, herring, Norway pout, sprat, sandeel, Norway lobster and deep-water prawn. Forty species are managed through an EU system of total allowable catches (TACs).[35] These populations have shown a high level of natural variability historically, driven by the North Atlantic Oscillation—a large-scale periodic variance in atmospheric conditions—and consequent climate shifts. For example, natural climate cycles are believed to be behind the "gadoid outburst" in the 1960s, which saw a relative abundance of North Sea haddock, cod and saithe, though levels declined in the 1990s.[36]

Scientists believe those previous climate fluctuations boosted North Sea populations of *Calanus finmarchicus*, a species of zooplankton that is a major component of the diet of larval cod. However, there is now strong evidence that anthropogenic warming is taking a toll, drowning out the varying natural signals of the North Atlantic Oscillation and thinning the layer of cold bottom water in which this plankton species thrives.

That causes the population to shrink and the cod larvae and other fish to feed on less nutritious "junk" phytoplankton, greatly diminishing the likelihood of their survival.[37]

The Norway lobster, also known as the Dublin Bay prawn and langoustine, is the most important commercial crustacean in Europe.

The coastal environment of the North Sea has undergone, and continues to undergo, profound changes as a result of human activity. The Dutch coastline in particular has been greatly altered by decades of land reclamation and storm surge protection that has caused the disappearance of many natural transition zones between freshwater habitats and coastal waters. Fully three millennia of habitat alteration have led to the Wadden Sea being described as "a sea whose coastline and islands have been most strongly influenced by humans",[38] although it is now subject to a comprehensive monitoring, management and protection regime and is listed as a UNESCO World Heritage Site.[39]

Offshore oil and gas extraction and transport can lead to localized chronic pollution, as well as severe accidents, such as the sinking of the *MV Braer.* The tanker ran aground off Shetland in 1993, spilling almost 85,000 tons of crude oil. Chemical pollutants—deposited via rivers or atmospherically from Europe's northern industrial regions, or via anti-fouling paints on ships' hulls—can affect the reproductive, behavioural and immune systems of wildlife from fish to marine mammals to birds. In addition, run-off from agricultural fertilizers and sewage can lead to the growth of harmful algal blooms and coastal "dead zones".[40]

Meanwhile, the waters of the North Sea are warming. As a result, some species are shifting their range northward, with potential consequences for fisheries. For example, there have been northerly shifts in catches of mackerel and horse mackerel, while the southern boundary of haddock catches has shifted northward by 130 km over the past 80 to 90 years.[41]

Conversely, some species that prefer shallow, warmer waters, such as sole and lesser-spotted dogfish, have apparently been extending their range southward. Teasing the climatic role in some of these changes from other contributors, such as fishing pressure, is not easy. Meanwhile, groundfish in the North Sea are inhabiting ever-deeper water (at one point, by as much as 3.6 metres per decade on average) as ocean

temperatures increase.[42] The North Sea region has also seen increasing numbers of fish, such as red mullet, European anchovy, sardine, bluemouth, and snake pipefish—species that have been absent or barely recorded for decades and which are generally associated with warmer waters.[43]

Fisheries in the North Sea

Following a boom period immediately after World War II, commercial catches of virtually all North Sea fish declined sharply over the latter years of the twentieth century. On average, the North Sea supported total reported landings of over 3 million tons per year from the late 1960s to the early 1990s, with a peak of 4.4 million tons in 1968. Those figures have declined markedly, and the mean trophic level of the reported landings—where the species rank as predators and prey—has shown a steady decline since 1970, an indication of "fishing down the food web".

The most famous casualty has been the North Sea cod stock. Catches of this fish peaked at over 300,000 tons in the early 1970s, declined in the 1980s and 1990s and then plunged to below 30,000 tons.[44] Other fisheries—such as those for herring and mackerel—also have experienced sharp declines at different times, with management efforts showing varied degrees of success in restoring fish numbers and fisheries.

> The mean trophic level of reported landings in the North Sea has shown a steady decline since 1970, an indication of "fishing down the food web".

The collapse of key fisheries has caused cultural and economic hardship throughout the region. For example, for hundreds of years, Great Yarmouth was a major English fishing port. Today, barely any fishing vessels set out from its docks, a direct consequence of the collapse of the southern herring stock.[45] In 1970, Grimsby was home to over 400 trawlers; by 2013, only five remained based there, and the town's limited fisheries industry today relies on selling and processing imported Icelandic fish.[46] In 1866, the fishing fleet out of Oostende, Belgium, caught 13,686 tons of cod alone. Between 2003 and 2009, despite significant increases in the power of fishing vessels, the total annual catch of all fish species caught by the fleet totalled between 6,184 and 8,624 tons. By that time, fewer than 1,000 people worked in the region's fisheries sector.[47]

> For hundreds of years, Great Yarmouth was a major English fishing port. Today, barely any fishing vessels set out from its docks, a direct consequence of the collapse of the southern herring stock.

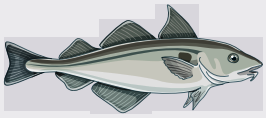
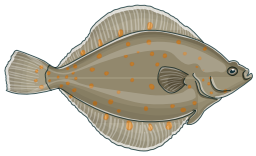
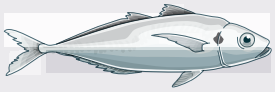
Even as their numbers declined, pelagic schooling fish such as herring remained catchable; the biggest obstacle was finding the diminishing schools still in those waters. The introduction of echo-sounding sonar in the 1950s allowed fleets to meet that challenge. Not coincidentally, 1955 saw the first herring fishery collapse off the East Anglia coast of England. Even so, herring fishing continued elsewhere and hit a peak of 1.2 million tons in the North Sea in 1966. By 1975, catches had fallen to 200,000 tons, and it was estimated that fisheries removed 70 per cent of herring from the North Sea each year. In 1977, fishing states agreed to a moratorium on herring fishing in the North Sea, although catches resumed in 1981. The estimated size of the spawning stock biomass has been trending upward since then, albeit with periods of further declines. Still, it remains significantly below its immediate post-war level. Since 2008, the stock has been subject to a management plan jointly agreed to by the EU and Norway. ICES considers the fishery to be sustainable, though recruitment has been consistently poor since 2002, probably as a result of environmental changes, and fishing mortality is trending slightly upward.

Grimsby Harbour in 1949 was home to significant numbers of trawlers; by 2013, only five remained.

Table 1

Top Commercial Species in the North Sea

Basic indicators of fisheries' sustainability

Common name	Latin name	Illustration	Is fishing sustainable? (fishing mortality compared to maximum sustainable yield)*	Is the fish stock healthy? (total biomass compared to biomass MSY trigger)
Cod	*Gadus morhua*		✗	✗
Haddock	*Melanogrammus aeglefinus*		✓	✓
Whiting	*Merlangius merlangus*		Unknown	Unknown but biomass decreasing
Saithe	*Pollachius virens*		✓	✗
Plaice	*Pleuronectes platessa*		✓	✓
Sole	*Solea solea*		✗	✓
Herring	*Clupea harengus*		✓	Unknown but biomass very high
Horse mackerel	*Trachurus trachurus*		Unknown but likely not sustainable	Unknown but likely not healthy

* Maximum sustainable yield (MSY) is the largest average yield, or catch, that can theoretically be taken from a species' stock under constant environmental conditions without having an impact on the long-term stability of the population.

Source: International Council for the Exploration of the Sea (ICES), 2014

As several fish stocks have declined in the North Sea, the fishing fleet has drastically decreased in Oostende, Belgium.

Following the 1977 herring ban, many ship owners went bankrupt. The Dutch fleet had 50 herring trawlers at that time but only 12 when the ban was lifted. Similar fleet reductions occurred elsewhere. The ban hit the German canning industry hard, and fish processors in Scotland also suffered. The lack of supply, exacerbated by a closure of the herring fishery west of Scotland in 1979, resulted in a change in consumer behaviour. In the United Kingdom, the kipper (smoked herring) became less popular; when the fishery resumed in 1981, a large part of the traditional market for herring had disappeared. Prices were low, and some of the first catches had to be sent for reduction to fishmeal. After the closure, Dutch traders had sought new suppliers of their traditional maatjes. They found them in Denmark and Norway, as fishing in the Skagerrak and Kattegat was allowed to continue. Scandinavian fishers soon learned how to serve the Dutch market, and after the North Sea fishery reopened, Dutch suppliers had permanently lost the market.[48]

Herring are plankton-eating, low-trophic-level fish targeted by fisheries using midwater trawls or purse seines. Cod, meanwhile, is a carnivorous fish and is caught by bottom trawls in a mixed fishery that also targets haddock and whiting. It is frequently caught as by-catch of fisheries for Norway lobster, plaice, and sole.[49] Yet both species followed the familiar pattern of increase, peak and bust: In the case of cod, catches peaked at around 600,000 tons in 1980 before decreasing sharply. The cod catch made a brief resurgence in the early 1990s and then fell to its lowest levels in 2003-2005.[50]

The introduction of restrictive measures in 2008 as part of a cod rebuilding plan (including time and area closures, gear restrictions and fleet reductions) caused severe hardships, which, according to a 2013 study, could have been avoided if the fishery had been subject to more precautionary management earlier. Indeed, that study argued, the overall economic value of the North Sea cod fishery from 1986 through 2010 was roughly one third of what it would have been had more scientifically based management measures been in place to avoid the boom-and-bust cycle.[51]

Figure 1

North Sea Herring

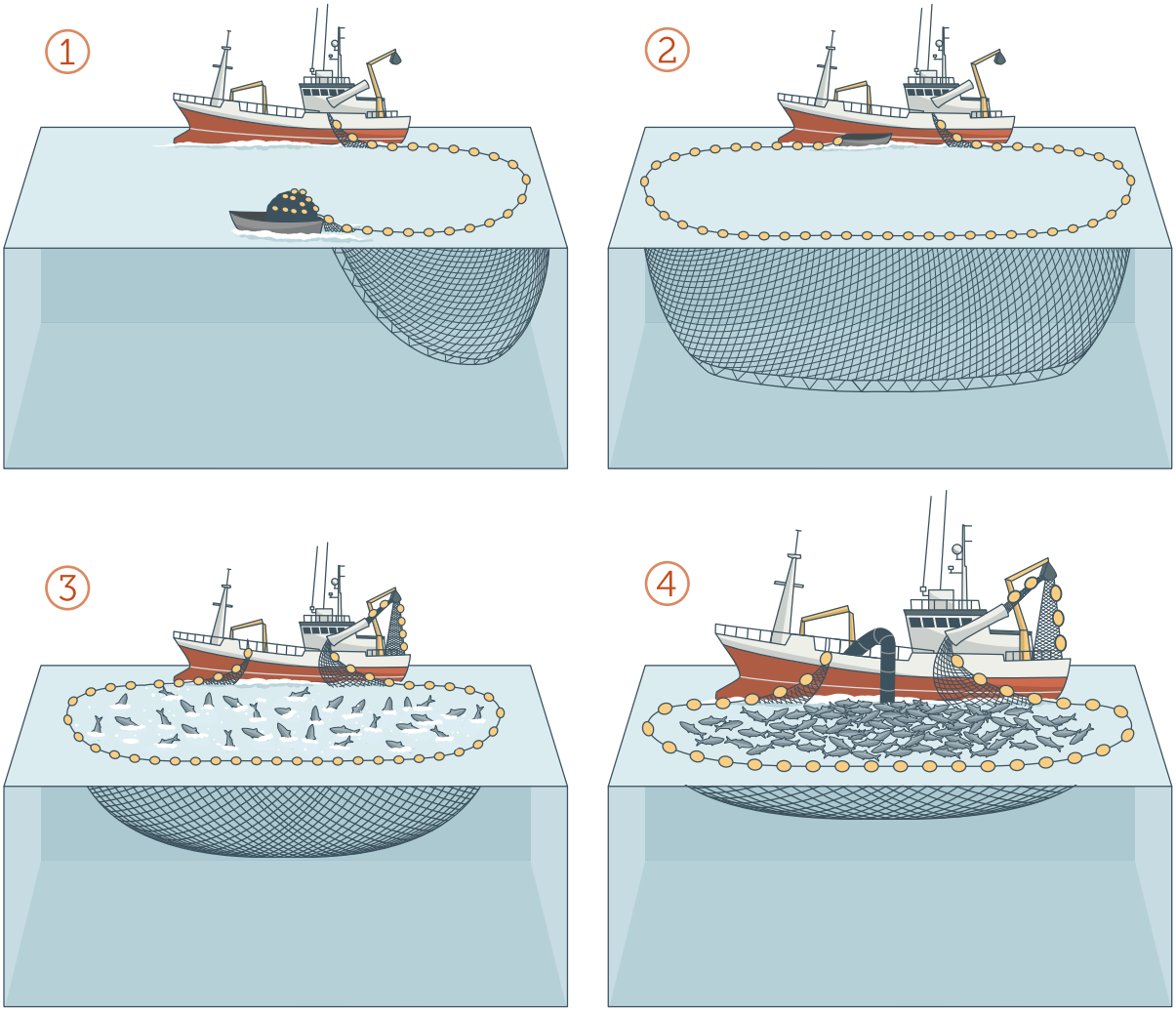
Fishing mortality and spawning stock biomass, 1947-2013

Source: International Council for the Exploration of the Sea (ICES), 2014

Figure 2

Purse Seine

A purse seine, a wall of netting framed with floatline and leadline, is used in the water column to encircle and catch shoaling pelagic fish

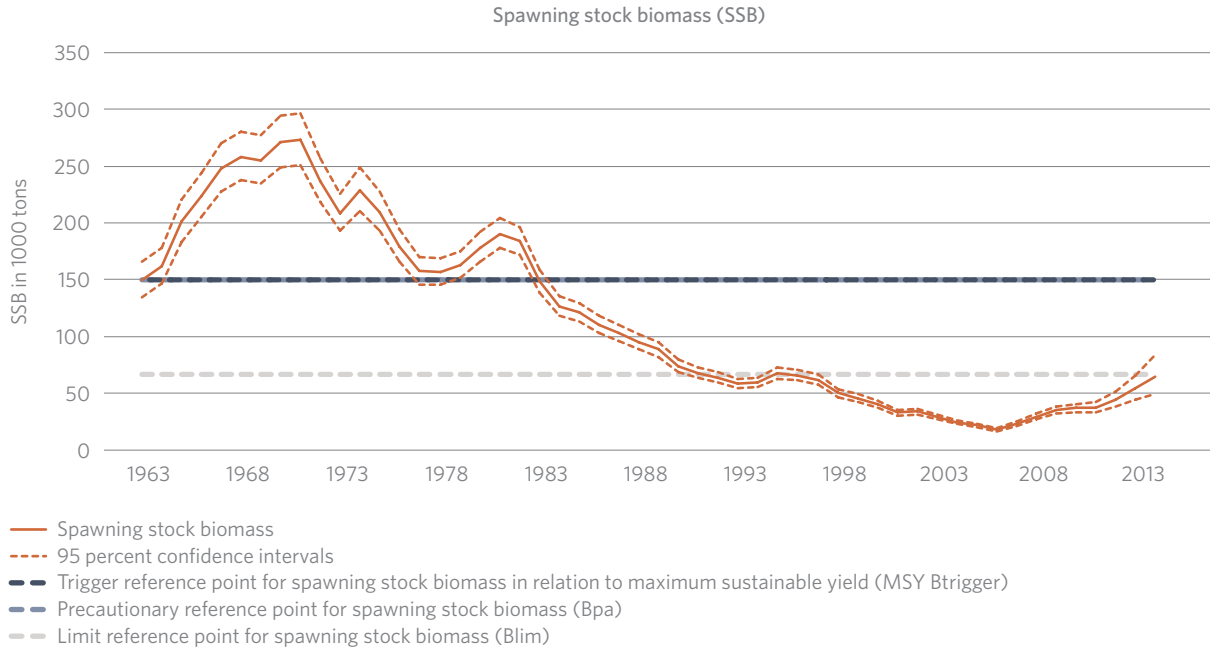


Cod's fate had been predicted in a 1997 paper by R.M. Cook, which warned that "without a substantial reduction in the rate of fishing, the North Sea cod stock may well collapse".[52] Six years later, another study showed that intense fishing pressure was resulting in "marked genetic changes in the declining North Sea cod". In 2003—and again in subsequent years—ICES called for a closure of the North Sea cod fishery.[53]

Figure 3

North Sea Cod

Spawning stock biomass, 1963-2014



Source: International Council for the Exploration of the Sea (ICES), 2014

> The cod collapse had been predicted in a 1997 paper, which warned that "without a substantial reduction in the rate of fishing, the North Sea cod stock may well collapse."

Despite this advice, the fishery remained open. The EU did adopt a cod recovery plan in 2004, which included limits on the number of days that fleets that caught cod could spend at sea, but the plan failed to arrest the decline of the stock, which reached a record low biomass in 2006.[54] Two years later, a new plan further limited fishing effort. Despite an increase in the agreed total allowable catch in 2009, these measures, along with growing numbers of young cod entering the population, did have some qualified success: 2013 saw a number of headlines trumpeting a "cod comeback". [55]

Such proclamations proved premature, however, as the stock, despite showing signs of increase, remained far smaller than it had been in the 1960s. As a European Commission assessment highlighted in 2013, "Serious concerns remain about North Sea cod. Despite recent increases in stock size and reductions in fishing mortality, the stock is close to the limit biomass and less than half the precautionary level … The actions taken to date have not been sufficient. More needs to be done".[56]

Efforts to develop and implement successful fisheries management plans—for cod, herring or any other species—continue to face significant obstacles. A case in point is mackerel. After the North Sea fishery collapsed in the 1970s, fisheries managers imposed strict measures—including a continued prohibition on direct catches in the most northern waters—but the North Sea component of the mackerel spawning stock saw only small increases until 1999. The numbers then dropped again after 2005.[57]

The reasons for this remain unclear but may be related to the fact that distribution of the north-east Atlantic mackerel stock as a whole has shifted to both the south and north-west. As a result, states such as Iceland and the Faroe Islands have also begun fishing for mackerel. In the absence of agreed-upon catch limits among all relevant states, national fishing limits have been set (in the case of the EU, in a bilateral agreement with Norway). The total, however, has often been higher than the limits advised by ICES.[58]

> ICES has estimated that "unallocated removals"—unreported catch and what are known as "black" landings—have at times accounted for as much as 40 per cent of North Sea cod catches.

Furthermore, managers remain dependent on information from fishing vessels, which is not always reliable. ICES has estimated that "unallocated removals"—unreported catch and what are known as "black" landings—have at times accounted for as much as 40 per cent of North Sea cod catches.[59] The coming into force of the United Kingdom Buyers and Sellers Register in 2006 helped stop a majority of such unallocated removals in that country.[60] Still, the Scottish "black fish" scandal, in which three Shetland-based companies were found in 2005 to have caught and landed over 60 million British pounds worth of undeclared herring and mackerel over a number of years, illustrated the extent to which controls could be evaded. The companies engaged in different levels of subterfuge to hide their tracks, including the installation of underground pipelines, secret weighing machines and extra conveyor belts, and computers to allow them to land 170,000 tons above their EU quota of mackerel and herring between 2002 and 2005. But their principal tactic was basic enough: They simply falsified their logbooks.[61]

The complexities of the marine environment, including the fact that fisheries fundamentally change that environment, complicate management decisions. The North Sea fishery for sandeels, for example, has long been associated with declines in seabird breeding success.[62] The sandeels are prey for seabirds, as well as fish such as haddock and whiting. Studies suggest that, during times of high sandeel mortality in fisheries, those fish increasingly feed on bottom-dwelling invertebrates instead.[63]

These fisheries-induced changes in the marine environment can have affects not just on ecology, but also on political, commercial and management considerations. Before the 1960s, for example, the Norway lobster, or *Nephrops*, was rarely considered a target for commercial fishing. Now, though, it has become one of the region's most significant fisheries. Given that cod eat *Nephrops*, this lobster's population growth was in large part prompted by cod's decline. On the other hand, the *Nephrops* would suffer from increasing cod numbers if that stock were recovering.

Similarly, juvenile herring serve as prey for mackerel and horse mackerel, among others, and, as they age, primarily by gadoids such as cod, and seabirds. As adults, though, herring prey upon, among other things, cod eggs. The impact of adult herring on cod recruitment—the number of young fish coming in to the population—was likely insignificant when cod biomass was higher, but now that cod levels are substantially reduced that may no longer be the case.

Summary

- The North Sea has been heavily fished for hundreds of years.
- Several species, including cod and herring, have undergone cycles of boom, bust and recovery.
- Despite recent claims that cod stocks are "recovering", that recovery is from a massively depleted level. Cod populations are still believed to be far below historic levels.
- Management has been complicated by an absence of data. Up to 40 per cent of the cod catch, for example, is thought to have been unreported for many years.
- The extent of overfishing in the North Sea has been so great that it has fundamentally transformed the ecosystem.
- The competing ecological requirements of different species raise questions about whether it is possible—or, for the industry, desirable—to have healthy stocks of every species.

The Celtic Sea

There are no land features to divide the Celtic Sea from the open Atlantic Ocean to the south and west. Generally, it can be said to be limited to the north by the Irish Sea, to the north-west by the southern coast of Ireland, to the west by the continental slope of the Porcupine Seabight, to the north-east by the western edge of the Bristol Channel, and to the east by the western Channel. Its south-eastern extent gently brushes the western promontory of Brittany and touches the coasts of south-west Wales and northern Cornwall.

In the tenth century, Vikings built what would be Ireland's first city at Waterford. Around the same time, a Norse settlement arose at the site of what would become Youghal, for centuries one of the most important ports in Ireland, and a significant fishing town. By 1834, 250 fishing boats in the harbour employed some 2,500 men. The fishing history of nearby Cork is reflected in the nearly 230-year-old English Market where today, "in a nod to increased gentrification and expanded tastes, mackerel, cod and plaice [have been] joined by marlin, octopus, anchovy and other exotica".[64]

On the sea's eastern boundary, the coastal towns and villages along the western shores of Brittany boast ties to the ocean and to fishing that are deep and long lasting. Commercial fisheries have operated out of Concarneau for hundreds of years, and the town remains one of the most important fishing ports in France. Small trawlers operate daily out of Le Guilvinec, Brest is a centre of French maritime research, and Lorient remains the principal port for whitefish trawlers in the Celtic Sea.

Trawlers from Le Guilvinec fish off the coast of Brittany, a site of commercial fishing for hundreds of years.

The Celtic Sea: Geography, environment, ecology and wildlife

The waters of the Celtic Sea reached their current levels around 5,000 years ago; the sea is 90 to 100 metres deep in the north-east and roughly 100 to 150 metres deep in the shelf waters of the central sea, which also host a number of shallower banks. The sea is little more than 350 metres at its deepest point.

Map 3

Celtic Sea

The Celtic Sea is bordered on its north by the southern coast of Ireland, and to the east by England and northern France

The Celtic Sea area is extremely important for seabirds, including the northern gannet.

The Celtic Sea area supports about 300,000 breeding pairs of 15 seabird species. That includes internationally important populations of northern gannet and Manx shearwater, as well as notable numbers of guillemot, lesser black-backed and herring gulls, kittiwake, puffin and razorbill.[65] The harbour porpoise is the most abundant cetacean, with bottlenose and common dolphins also seen in large numbers. The minke whale, long-finned pilot whale and Risso's dolphin are regularly encountered, while grey seals are present at relatively low densities and the harbour seal is uncommon.[66] [67]

The common dolphin is one of the most abundant cetaceans in the Celtic Sea.

The numerous migratory fish species that spawn here include mackerel and horse mackerel; in the waters above the continental shelf, the main pelagic fish species are herring, pilchard and sprat. Although more than 100 species live on or near the water's floor, 99 per cent of groundfish biomass in the sea is composed of 25 species.[68] Basking sharks, seen throughout the area, have been depleted by fisheries and are now listed as endangered on the International Union for Conservation of Nature (IUCN) Red List; EU vessels are prohibited from fishing for, transhipping or landing them.[69]

Different pelagic fish species have risen and fallen in number over the centuries in response to natural climatic fluctuations. Historically, pilchard have been more abundant and extended farther to the east when the climate was warmer. Herring, meanwhile, were generally more abundant in cooler times, a pattern for at least 400 years. In the late 1960s, the waters of the Celtic Sea cooled, spawning of pilchard declined, and mackerel increased greatly in abundance. These changes prompted development of fisheries for mackerel and then other pelagic fish.

Now, however, the Celtic Sea, as with waters throughout the north-east Atlantic, is warming. The temperature increases over the past quarter of a century or so have coincided with declines in the abundance of cold-water fish species, including cod and haddock, as well as apparent increases in species such as boarfish. Teasing apart the relative impacts of climate change and natural climate variability, and related oceanographic and atmospheric processes and cycles such as currents, wind mixing and salinity, is difficult. Differentiating the role of these factors from those of fishing and other human influences is, of course, even more so.

Fishing has affected the Celtic Sea, not only through its removal of fish, but also through the incidental catch or by-catch of marine mammals and seabirds. The effects cascade throughout the food web. Decades of trawling and dredging have altered the seabed profoundly in many places, resulting in habitats that contain a lower diversity and abundance of marine life than a century ago. Other factors also contribute to the shifting environment. Among those are climate change; a massive influx of invasive, or "foreign", species (typically through ballast water, hull fouling and aquaculture); ocean acidification; and, to a lesser extent in the Celtic Sea, eutrophication, or increases in organic matter. Combined with the impact of fishing, the net result has been substantial changes in the Celtic Sea and its fisheries, including the decline of some previously abundant species and the growth of significant fishing on species that previously had not been exploited.[70]

Fisheries in the Celtic Sea

Fisheries in the Celtic Sea region are generally focused in three main areas: the Celtic Deep (north-west of Cornwall), the continental shelf edge, and a region in the central part of the sea 100 to 125 metres deep that encompasses a field of large seabed banks. The nature of each fishery appears to be strongly influenced by the physical geography of the marine environment.

The Celtic Deep, for example, contains one of the few areas of muddy sediments in this sea and proves to be ideal habitat for the Norway lobster, *Nephrops norvegicus*, a shrimp that requires a cohesive mud seabed to dig the burrows that help it shelter from predators and strong currents. The shelf edge, from the west of France to the west of Ireland and west and north of Scotland, is used by spawning stocks of mackerel, horse mackerel, hake and blue whiting, among other species. Migrating fish make use of warm-water currents along the shelf edge as they travel to spawning grounds. So do the larvae that swim away from those grounds after hatching.

At the same time, localized vertical mixing of nutrients supports a community of relatively larger-celled phytoplankton and higher numbers of diatoms than are found either on the shelf or in adjacent deeper waters. They provide a vital food source for fish larvae and larger zooplankton. Finally, the central Celtic Sea boasts a field of large seabed banks surrounded by water depths between 100 and 125 metres; the

topography of the region likely results in localized upwellings that create nutrient-rich hotspots and ultimately support the diversity of demersal and pelagic fish, squid and shellfish that are the focus of fisheries here.[71]

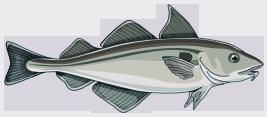
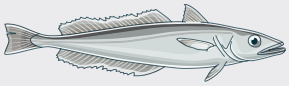
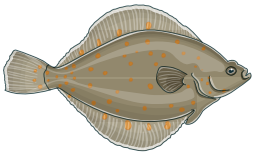
> In 1946, cods and hakes constituted slightly more than 78 per cent of landings; by 1998, that figure was just under 14 per cent.

In the decades after the Second World War, total annual landings ranged from roughly 51,000 to 200,000 tons. That more than doubled to almost 490,000 tons between 1969 and 1976, but collapsed in the mid-1970s before climbing again in 1988. Since then, landings have remained relatively stable, generally between 230,000 and 365,000 tons.[72]

Table 2

Top Commercial Species in the Celtic Sea

Basic indicators of fisheries' sustainability

Common name	Latin name	Illustration	Is fishing sustainable? (fishing mortality compared to maximum sustainable yield)	Is the fish stock healthy? (total biomass compared to biomass MSY trigger)
Cod	*Gadus morhua*		✗	✓
Haddock	*Melanogrammus aeglefinus*		✗	✓
Whiting	*Merlangius merlangus*		✓	✓
Hake (northern)	*Merluccius merluccius*		✗	✓
Plaice	*Pleuronectes platessa*		Unknown but fishing mortality stable	Unknown but biomass stable
Sole	*Solea solea*		✗	✓

Source: International Council for the Exploration of the Sea (ICES), 2014

But these overall figures disguise changes in the composition of the fisheries. For example, cod landings varied from 6,700 to 11,000 tons per year from the end of World War II until the period 1988-1990, when they peaked at 20,000 tons. After that, however, landings decreased markedly; during much of the 1990s, they fell far short of agreed total allowable catches. By 2005, the limit, at 6,200 tons, was less than one third of what it had been in 1996. Landings, however, were half of that: 3,100 tons.[73] [74]

Added to the pressure on many fish populations has been the high level of by-catch in many fisheries, most of which are discarded—thrown back into the sea dying or dead. For example, in the demersal, or bottom-dwelling, whitefish-mixed fishery—for cod, haddock and whiting—discard rates for these species have reached 27, 44 or 20 per cent, respectively. Fish that are undersized, underage or surplus to quota are simply tossed overboard. Currently, up to 40 per cent of the catch hauled aboard by bottom trawlers fishing for *Nephrops* is discarded, and many of those discards are whitefish.[75] Fishermen throw back this catch for various reasons, including having used unselective gear, surpassing quotas or replacing catches of lower economic importance with more valuable fish. Even when the discard issue is addressed by requiring fish to be landed, the high levels of by-catch in these fisheries will remain a concern.

> By 2005, the cod total allowable catch, at 6,200 tons, was less than one third of what it had been in 1996, but landings were half of that figure, at 3,100 tons.

Although Celtic Sea fisheries focused mainly on cod and other whitefish in the years after the war, new fisheries opened up throughout the 1960s and 1970s, targeting pelagic species such as mackerel, horse mackerel and blue whiting. Among the factors that led to these shifts were the development of echo-sounders that enabled vessels to find dispersed pelagic schools as well as declines in already-targeted fish. In 1946, cods and hakes constituted slightly more than 78 per cent of landings; by 1998, that figure was just under 14 per cent. At the same time, the proportion of the catch made up of small pelagic species increased enormously: horse mackerel, for example, went from 0.03 per cent in 1946 to over 50 per cent by 1998.

As existing fisheries declined, new fisheries grew in importance. Almost all of the new fisheries focused on fish that fed on zooplankton, in contrast to the post-war fisheries that concentrated on higher-trophic level species—hake, haddock and small sharks, as well as cod. Indeed, many of these predatory fish feed primarily on species that are now being harvested by the fishery. That implies that modern vessels are operating a full trophic level lower than their post-war counterparts.[76] Studies have shown that fishing species at lower levels of the food web can have large impacts on other parts of the ecosystem, particularly when these species constitute a high proportion of the biomass in the ecosystem or are highly connected in the food web.[77]

> Any serious attempt to fundamentally redress the situation ... by 2020 would likely require fishing rates in the Celtic Sea to be reduced to below 80 per cent of the current rate.

Using a gauge known as the large fish indicator, or LFI (which describes the proportion of a fish community represented by fish above a given size), a study of catches and sizes in the Celtic Sea between 1986 and 2004 showed that fisheries in the region had changed the relative abundances of species of different sizes. That indicated a fundamental transformation in the composition of the Celtic Sea ecosystem.[78] A related study found that any serious attempt to address the situation, and return the LFI to 1986 levels by 2020, would likely require a reduction of fishing rates to below 80 per cent of the current rate. [79] Even under the

most optimistic scenario, in which exploitation is reduced to below 40 per cent of the current rate, it would take several decades for this indicator to return to the levels observed in the Celtic Sea when the assessment began. And at that point the numbers were likely lower than several decades earlier. Such sharp reductions, however, would likely hurt the fishing industry, and could cause immense societal and economic shocks throughout the region.

In 1998, ICES formally adopted the precautionary approach as a basis for advice to fisheries managers in order to halt declines in the more severely depleted stocks and to encourage the general recovery of demersal stocks. Six years later, the Irish, British and French fishing industries agreed to close selected important cod spawning areas to fishing for part of the year. In 2007, the European Commission's Scientific, Technical and Economic Committee for Fisheries concluded that the closure helped reduce the fishing effort by French whitefish trawlers in the Celtic Sea, and that change was likely the main factor in an apparent decline in fishing mortality after 2005.[80]

The reduction in mortality, combined with a highly successful recruitment year for Celtic Sea cod in 2010, led to a rapid increase in the cod stock and raised the prospect of sustainable management of the species after decades of overfishing. Instead, the TAC—which, as recently as 2008 had been recommended by ICES to be set at zero—more than doubled from slightly more than 4,000 tons in 2010 to more than 10,000 tons in 2012. As fishing mortality increased, cod recruitment fell to levels well below the average recorded by ICES since 1971. As a result, ICES in 2014 recommended a sharp decrease in the catch, proposing that landings should be no more than 3,544 tons. Similar scenarios have played out for sole, haddock and hake. All had experienced recoveries since the mid-2000s but are now enduring increased mortality and decreasing biomass. The haddock stock, in particular, is "declining rapidly", according to ICES.[81] A possible window of opportunity to fish the stock sustainably had closed, and short-term thinking continued to result in constant pressure on fish stocks.

Summary

- Fishing in the Celtic Sea has taken a toll on a number of commercial species. Some, including cod, are severely depleted.
- The reduction in the abundance of large fish which prey upon fish, such as cod and hake, together with increases in smaller pelagic species and Norway lobster, which feed on lower levels of the food web, has led to significant declines in the mean trophic level.
- Attempts to encourage recovery of cod stocks have been hampered by quick increases in fishing at early signs of stock increases, which then cause renewed declines.

The Irish Sea

In 1185, Giraldus de Barri, or Gerald of Wales, the Norman churchman and chronicler, wrote that the first people to set foot on the coast of Ireland did so in hopes of avoiding the biblical deluge. Alas, the flood proved unsparing, and they "did not succeed in putting off the general, not to say universal, disaster".[82]

Map 4

Irish Sea

The Irish Sea is rimmed by Scotland on the north, England on the east, Wales on the south and Ireland on the west

There is a more secular history, one that begins about 10,000 years ago. Through a combination of land and ice bridges, Britain and continental Europe remained connected, but to the west, water levels in the Irish Sea had risen to such an extent that Ireland was already an island. Still, the land would not reach present levels for several millennia more. At around that time, the earliest settlers arrived, nomadic hunters from European parts unknown.

Gerald of Wales asserted that the Irish Sea, "surging with currents that rush together, is nearly always tempestuous, so that even in summer it scarcely shows itself calm for a few days to them that sail". Still, archaeological evidence suggests that the Irish Sea was "a body of water which united rather than divided the landscapes of either shore", and "a natural terminus for sea-routes bringing trade and invasion from western Europe, the Mediterranean and even at times Scandinavia".[83]

> The Irish Sea was "a body of water which united rather than divided the landscapes of either shore."

At least some of those earliest travelers settled in Ireland. One small collection of dwellings at Mount Sandel in north-east Ireland, the earliest known inhabited site in the country, dates back to 7000 B.C.E. With the island thickly forested, these settlers would have likely looked to the coast, a supposition supported by archaeological evidence: shell middens on raised beaches along the east coast of what is now Northern Ireland and skeletal cod remains from a site near Cushendum suggest that sea fishing was taking place here as far back as nine millennia ago.[84]

Fisheries have played a pivotal role in the Irish Sea's history. According to the marine historian John de Courcy Ireland, the citizens of medieval Dublin, Drogheda and Youghal could raise taxes on herring and salmon to pay for maintenance of their fortifications. An Italian map of Ireland from 1339 shows three fishing banks off the coast of Wicklow. Salmon and herring were listed among Irish exports as early as 1437; and de Courcy Ireland writes that by the fifteenth century, "the Irish sea fisheries were famous throughout western Europe and greedily coveted by foreigners". Records from 1567 suggest Waterford was exporting fish to Galicia, Portugal, Andalucia and Biscay.[85] And herring was Ireland's chief export to Chester until the middle of the fifteenth century, while its prime import from that location was the salt used for curing herring.[86]

In the early seventeenth century, however, the English government, at that time ruling over Ireland, placed a tax on salmon, pilchards and herring exported to places other than England. According to de Courcy Ireland, that began a decline in the Irish industry, "while French, Spanish, Scottish and English fishermen throve from fishing in our waters, and the government of the Netherlands was allowed special fishing rights here in return for paying £30,000 to the ever-impecunious Charles I"—a sum roughly equivalent to 40 million British pounds today.[87] In particular, the Dutch were keen to expand their fishery operations and exploit the variety in Irish waters, especially salmon, hake, pilchards, ray, conger and ling—the last a source of valuable oil.[88]

Over the ensuing centuries, Irish fisheries ebbed and flowed, not just in response to the status of fish stocks, but also as a reflection of the prevalent political and economic conditions of the time. For example, the Great Famine of 1845-1852 saw the deaths of approximately 1 million Irish and the emigration, primarily to the United States, of roughly a million more. That caused the country's population to drop by about 25 per cent and somewhat inevitably resulted in a temporary decline in the Irish fishing fleet. Yet there were pockets of productivity.

Fifteen years after the famine ended, a thriving offshore summer herring fishery began operating out of east coast ports, until around 1889, when landings diminished as well as the value of the fishery. And, starting around 1862, a spring mackerel fishery, pioneered by fleets from the Isle of Man, attracted international and

Irish fleets while avoiding the decline that hit the herring fishery, perhaps because fishing pressure was lower: inshore herring boats were not suitable for the offshore mackerel fishery, but mackerel boats would join in the summer herring fishing.[89]

On the eastern side of the sea, Holyhead, Whitehaven and Fleetwood are among the most significant fishing ports remaining in north-west Great Britain for English and Welsh vessels.[90] The east coast of Ireland still has a number of significant fishing ports, notably Skerries, Howth, Wexford and Arklow, the last of which remains home to the largest fleet of modern merchant ships in Ireland and the British Isles.[91] In Northern Ireland, trawlers primarily operate out of Kilkeel, Ardglass and Portavogie.[92]

The history of Kilkeel, Ardglass and other County Down ports of Northern Ireland are representative of the rise and fall of Irish Sea fisheries, particularly the fishery for herring. In 1877, a total of 876 boats worked out of Howth, a major landing station in County Down. Of that fleet, 26 per cent were Irish-owned, 20 per cent were owned by companies from the Isle of Man, 26 per cent Scottish and 28 per cent from Cornwall. Official figures between 1864 and 1919 showed 225,000 tons of herring (an average of 4,000 tons a year) landed in County Down ports, although this may understate the full extent of the fishery as boats that operated out of County Down also landed their catches in Liverpool, Holyhead and Glasgow. Even contemporary fishermen in Kilkeel claim to be able to recall "days when you couldn't have fitted one more boat into that harbour. On a Saturday morning down here you would have met everyone from the town down here with their families. There were butchers selling their meat, grocers selling their fruit and veg and just about everything else you could think of. This town thrived on fish".[93]

> Today, the herring fisheries are greatly diminished, fisheries for species such as cod have come and largely gone, and the largest fishery in the sea is for a species of prawn.

Today, the herring fisheries are greatly diminished, fisheries for species such as cod have come and largely gone, and the largest fishery in the sea is for a species of prawn.

Kilkeel harbour remains the home port for the largest fishing fleet in Northern Ireland.

Irish Sea: Geography, environment, ecology and wildlife

The Irish Sea covers an area of roughly 45,000 km^2. Most of its waters are less than 50 metres deep but some reach depths of 300 metres—in the North Channel, for example, and then curving southward to the St. George's Channel and out into the Celtic Sea and the Celtic Deep. It is narrow—approximately 240 km at its widest between Dundalk and Morecambe Bay—and is just under 300 km north to south.

The section of the Irish Sea coast that includes Liverpool Bay is home to almost a quarter of the current extent of estuaries of the United Kingdom. In all, 14 estuaries open into the sea here, all but one occupying an area of more than 5,000 hectares.

The Mersey estuary is one of many in the Irish Sea.

It also includes one of the most industrialized parts of the region along the Mersey estuary, and the relatively undeveloped Isle of Man. The second-largest island in the Irish Sea, the isle is dominated by rocky shores on the east and south-west coasts and sandy beaches to the north-west. The largest island in the sea, Anglesey, is not at first glance clearly an island, separated as it is from the north-west coast of Wales by the Menai Strait. At its narrowest, the strait is just 250 metres across. Two bridges connect the island to the mainland. The coasts of Anglesey and its environs are rocky, and their limestone habitats support many seabird communities.

Across the sea, the east coast of Ireland also is important habitat for seabirds, primarily in the estuaries and inlets; in both the central and north-east coasts are long stretches of both rocky and sandy beaches and, in the far north-east is the unique basalt formation known as Giant's Causeway.[94]

Giant's Causeway is an important area for seabirds.

Brown shrimp, cockles and edible mussels support local fisheries in Morecambe Bay and the Dee estuary. The estuaries also serve as nurseries for flatfish, herring and sea bass. Muddy seabeds in deeper waters are home to populations of Norway lobster. A wide variety of invertebrate species live in the Irish Sea region, including molluscs such as the horse mussel *Modiolus modiolus* and the reef-building intertidal polychaete honeycomb worm *Sabellaria aveolata*. Both help create shoreline habitat for other marine and coastal fauna and flora.

Leatherback turtles migrate as far north as the Irish Sea to take advantage of the region's abundant jellyfish population.

Seabird species in the Irish Sea include breeding and visiting colonies of sea ducks, common scoters, gannets, Manx shearwater, puffins, kittiwakes, shags and razorbills, among others. Leatherback turtles are frequently sighted in pursuit of swarms of their jellyfish prey. Common and grey seals both reside here, and the most common cetaceans are harbour porpoises, bottlenose dolphins and common dolphins.

The Irish Sea is a critical breeding ground for many regional seabirds such as the Manx shearwater.

Fishing in the Irish Sea

Some of the most significant historical fisheries in the Irish Sea region are but fractions of what they once were. Some Irish Sea salmon fish runs—for so long of great importance both culturally and nutritionally—were all but wiped out by the early 1970s by combinations of overfishing, industrial development and habitat alteration. In the River Liffey, for example, a run that once numbered thousands of fish dropped to fewer than 220.[95] The bulk of the country's salmon fisheries are now concentrated on the west coast—although here, too, as elsewhere across much of the North Atlantic, salmon have undergone significant declines.

These declines can largely be traced to the discovery in the 1950s that, when Atlantic salmon leave rivers and head to sea, they congregate in the waters off Greenland and the Faroe Islands, a discovery that led to development of purse-seine fisheries targeting salmon in the ocean. By the 1980s, salmon catches had fallen by 75 per cent, and concern over those declining catches prompted the creation of the North Atlantic Salmon Conservation Organization. Atlantic salmon numbers remain a concern, and the past 15 or so years have seen fewer salmon returning to their spawning grounds from the ocean.[96] [97] As a consequence, the status of Irish Sea salmon stocks was described in 2014 as being "poor".[98]

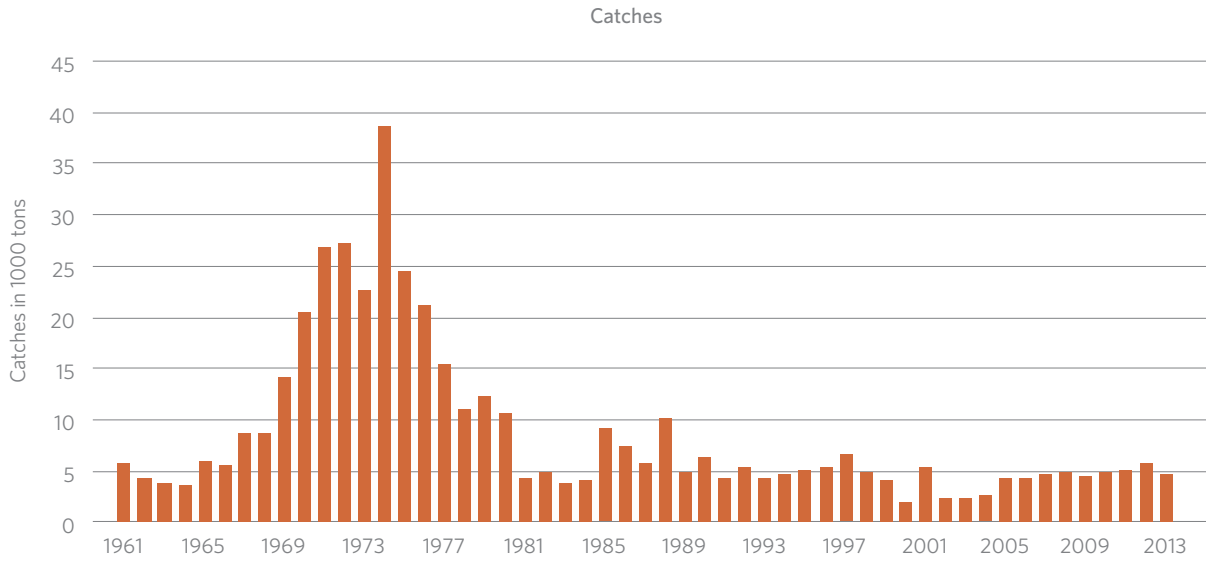
The primary pelagic fishery in the Irish Sea still targets herring, but the size of that fishery is very different from its peak years. Today the bulk of the landings are made by a trio of trawlers from Northern Ireland.[99] In 14 of the 27 fishing years between 1987 and 2013, landings by UK vessels varied from a peak of 7,593 tons in 1988 to a low of 1,782 tons in 2004. During those years, boats from the Republic of Ireland did not catch any herring. The totals during those years frequently failed to reach the set fishing limits.

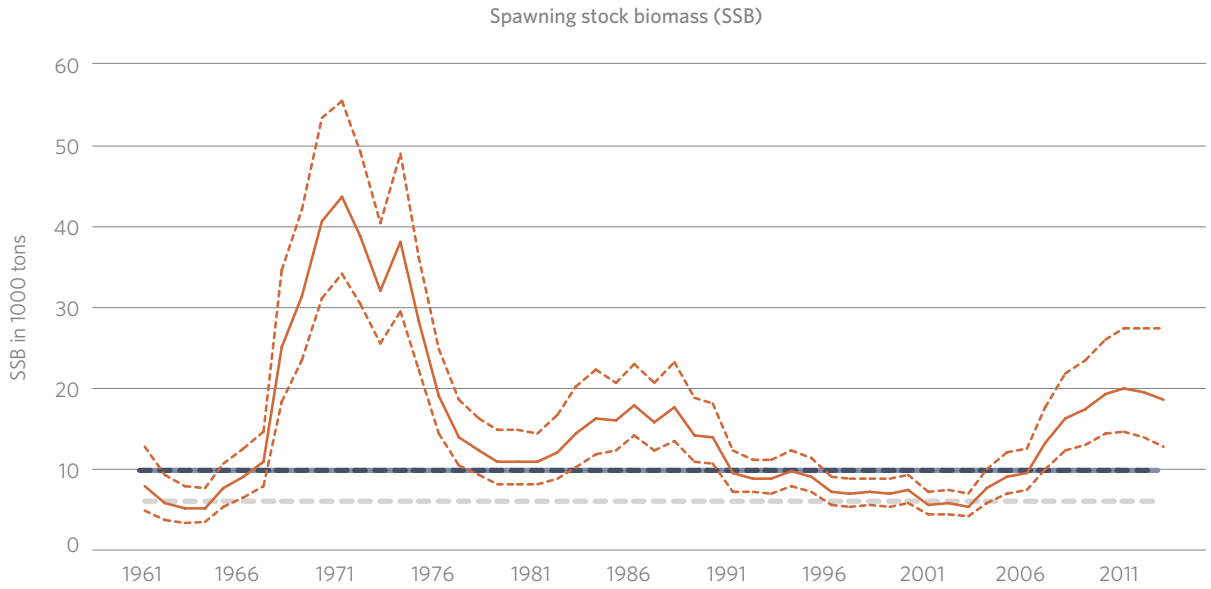
Earlier, in the late 1960s and early 1970s, herring catches had risen considerably, as Soviet, French and Dutch vessels joined those from Britain and Ireland. The expansion was fuelled by a large increase in the herring stock as a result of highly successful recruitment between 1963 and 1969.[100] [101] However, having plummeted in the late 1970s and early 1980s following greatly increased catches, the Irish Sea herring stock has risen to its highest point in 30 years, but it is still a long way from the highs of the early 1970s.

Figure 4

Irish Sea Herring

Catches and spawning stock biomass, 1961-2013





Spawning stock biomass
95 percent confidence intervals
Trigger reference point for spawning stock biomass in relation to maximum sustainable yield (MSY Btrigger)
Precautionary reference point for spawning stock biomass (Bpa)
Limit reference point for spawning stock biomass (Blim)

Source: International Council for the Exploration of the Sea (ICES), 2014

The herring fishery is considered to be relatively "clean", with little by-catch of other fish or marine wildlife. The same is not true for most of the other fisheries in the Irish Sea, many of which are highly non-selective. Some actively set out to catch multiple species, while others take high levels of by-catch that for many years have been discarded. These fisheries target bottom-dwelling species such as cod, plaice and sole, using gear that, in the process of catching fish, often severely damages the sea floor habitat. In this way, Irish Sea fisheries are profoundly altering the region's ecosystem, both because of the high volumes of fish that are being removed and the extensive habitat destruction.

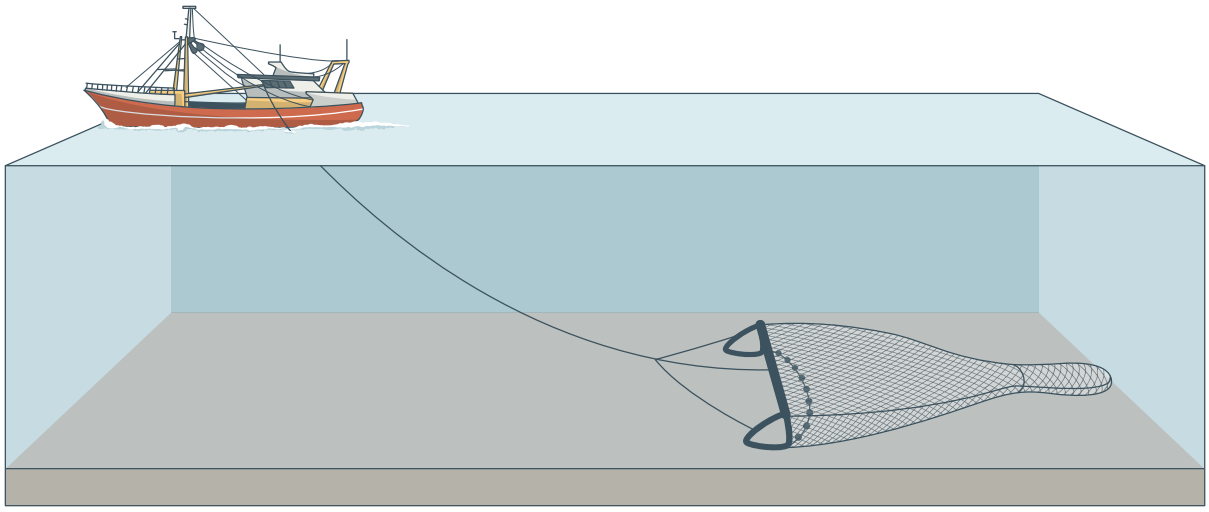
Irish Sea fisheries are profoundly altering the region's ecosystem, both because of the high volumes of fish that are being removed and the extensive habitat destruction.

The nature of these fisheries can pose particular management challenges. Plaice is caught primarily in a mixed fishery with sole, and, unlike plaice, the sole stock in the Irish Sea is low and decreasing rapidly, its status likely worsened by the presence of Belgian trawlers that target it specifically. Indeed, so severe is the state of sole stocks that ICES says that all catches should be avoided. Environmental factors also may be contributing to the decline of a stock that may be in imminent danger of collapse.

Figure 5

A Beam Trawl

Ships tow a cone-shaped net, kept open and horizontal by a beam, along the sea floor



The early 1980s saw the growth of a mixed fishery that focused primarily on whiting, a cod-like fish eaten fresh or processed in fish fingers or fish cakes. The fishery caught over 2,000 tons annually in its initial decade. But the whiting stock soon plummeted, and catch limits were reduced to under 500 tons. Whether fishing alone is responsible for the changes in the stock is unclear, but the result has been large numbers of very small whiting, which mature at a much smaller size than previously recorded.[102]

Fleets were already catching cod, along with haddock, in the fishery, so they shifted the focus to cod, though the results were no less deleterious. ICES began urging significant catch reductions in 1994 and has advised zero catches since 2004.

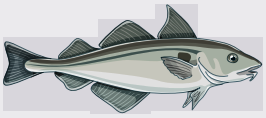
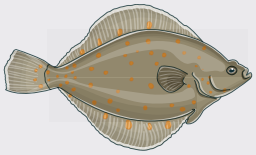
The Irish Sea sole stock may be in imminent danger of collapse.

In 2000, the European Union implemented a series of closures as an emergency measure to protect spawning cod. One year later, the area of the closures was reduced; the closures continue to be criticized because they included "derogations", which allowed for certain other fisheries, notably Norway lobster, or *Nephrops*, to continue catching cod as by-catch.

Table 3

Top Commercial Species in the Irish Sea

Basic indicators of fisheries' sustainability

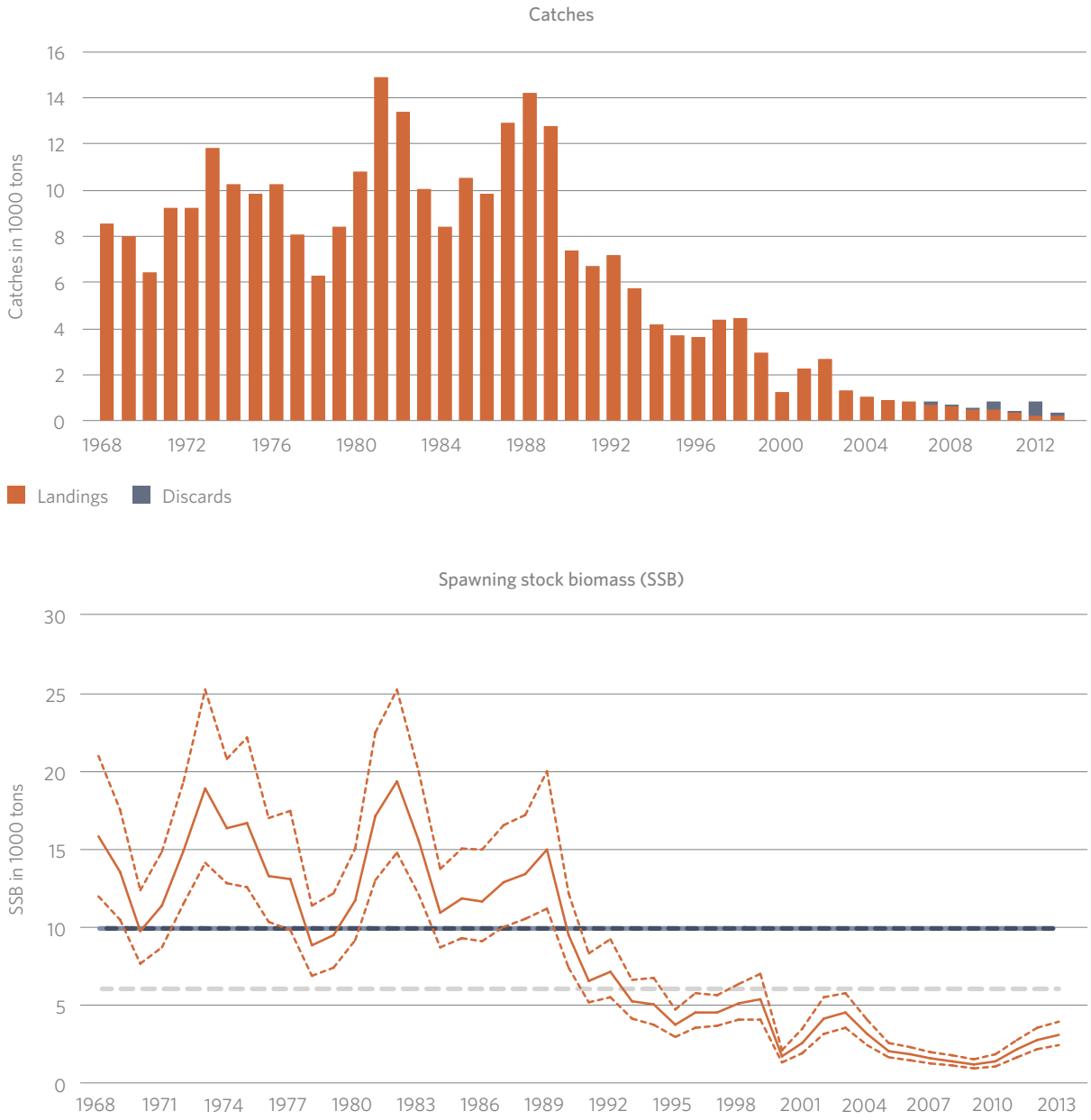
Common name	Latin name	Illustration	Is fishing sustainable? (fishing mortality compared to maximum sustainable yield)	Is the fish stock healthy? (total biomass compared to biomass MSY trigger)
Cod	*Gadus morhua*		✗	✗
Haddock	*Melanogrammus aeglefinus*		Unknown	Unknown but biomass increasing
Whiting	*Merlangius merlangus*		Unknown but likely not sustainable	Unknown but stock likely not healthy
Plaice	*Pleuronectes platessa*		Unknown but likely sustainable	Unknown but biomass stable
Sole	*Solea solea*		✗	✗
Herring	*Clupea harengus*		✓	✓

Source: International Council for the Exploration of the Sea (ICES), 2014

Figure 6

Irish Sea Cod

Catches, 1968–2013, and spawning stock biomass, 1968-2014



Source: International Council for the Exploration of the Sea (ICES), 2014

ICES has advised zero catch for Irish Sea cod since 2004.

Despite ICES' urgings and the fact that the stock is clearly severely depleted, fisheries ministers have continued to allow targeted fishing for cod in the Irish Sea, albeit on a limited basis. In 2014, the total allowable catch was 214 tons; in 1987, it had been 15,000 tons. The majority of cod catches here are now by-catch from the Norway lobster fisheries. Because cod prey on *Nephrops*, the stock's decline has facilitated the growth of the lucrative fishery for a species that is now frequently referred to as 'the most important commercial crustacean in Europe'.

Despite ICES' urgings and the fact that the stock is clearly severely depleted, fisheries ministers have continued to allow targeted fishing for cod in the Irish Sea.

Indeed, *Nephrops* is now the target of the majority of vessels in the Irish Sea, which use mostly otter trawls in a mixed fishery that also catches whiting, haddock, cod and plaice. The fact that these by-catches have included both adult and juvenile fish places extra pressure on those stocks and complicates their recovery.

Recovery efforts for the cod stock could also be complicated by waters warming because of climate change, given that it is one of the most southerly stocks in the species' range, as well as other factors, such as ecosystem alterations through the fishery. Theoretical modelling of the stock's response to predicted increases in sea surface temperatures suggests that Irish Sea cod can be guaranteed to withstand the likely effects of climatic variability only at levels substantially higher than the stock's present size.[103] Cod stocks have been driven so low, and mortality remains sufficiently high, that even the increase in their Norway lobster prey has not resulted in a robust recovery. However, given that declines in cod stocks have led to an increase in Norway lobster, and given that this fishery is now the largest in the Irish Sea and one of the most lucrative in Europe, it is uncertain how much incentive there is for the fishing sector to enable the cod stock to recover.

Summary

- Once-extensive Irish Sea fisheries for herring are a fraction of their former size, but reduced fishing pressure has helped start a recovery in herring stocks.
- Many other stocks are at extremely low levels, with environmental factors possibly exacerbating the effects of overfishing. Cod, whiting and sole are all severely depleted.
- Many stocks are caught in mixed fisheries, which complicates management. In addition, declines in predatory species such as cod may facilitate the growth in fisheries of species typically their prey, such as Norway lobster.

The North-East Atlantic, west of Scotland and Ireland

From the highly indented coast of Scotland's Western Isles and the rocky Atlantic shores of Ireland to the Porcupine and Rockall Banks, this region encompasses coastal regions and the cold, dark waters of the deep sea. Massive schools of blue whiting and mackerel inhabit the water column, while long-lived orange roughy gather around undersea mountains near the deep seabed.

The earliest known settlements in both Scotland and Ireland date back to approximately 7000 B.C.E., with the great bulk in coastal regions. Still, some researchers have said that evidence of earlier settlements may have been erased by a postglacial rise in sea levels.[104] Excavations at sites such as Oronsay in Scotland's Western Isles and Ferriter's Cove on the Dingle peninsula in south-west Ireland have revealed the presence of shells and fish bones, indicating that the inhabitants of these settlements were eating and catching shellfish and fish such as saithe several thousand years ago.[105] [106]

Map 5

North-East Atlantic, West of Scotland and Ireland

The fishing grounds west of Scotland and Ireland are home to blue whiting, mackerel and orange roughy

Beginning in the fifteenth century, herring fisheries were established west of Scotland in waters that became increasingly important as Scottish fishing fleets struggled to compete with Dutch herring fisheries in the North Sea. There were reportedly between 600 and 900 herring boats operating in the Firth of Clyde in the fifteenth century; by the eighteenth century, the export of cod from Lewis was "substantial", and later that century the region also saw the development of a haddock fishery. By the mid- to late nineteenth century, the number of boats catching herring out of Stornoway for part of the season peaked at almost 1,400; the great majority of those vessels were from east coast ports.[107]

That same period saw the resurgence of a deep-water trawling fleet on the Dingle peninsula in south-west Ireland—the first on the country's Atlantic coast—which had initially been established in the 1830s. After a brief early flourish, the fleet declined as a result of competition from more experienced British counterparts, before being reignited when Isle of Man fishermen, among others, encountered mackerel stocks while fishing for herring off West Cork in the Celtic Sea. The pursuit of migratory mackerel led to what has been dubbed the "Golden Age" of the Irish Fishery, which lasted until World War I.[108] Today, Dingle harbour remains one of the principal fishing ports along Ireland's Atlantic coast.[109] To its south, Castletownbere is the country's largest whitefish port, though despite a long history as a deep-water port, it did not become a major centre for commercial fisheries until the 1950s, when trawlers from the Soviet Union—and then its successor states—used it as a port of call and later for processing their catch. The largest port on the island of Ireland is Killybegs in Donegal Bay on the north-west coast, centre of the country's pelagic trawling and processing industry.

Fishing vessels sheltering in Castletownbere from a winter storm.

Today, the western coast of the Scottish mainland and the Western Isles remain sparsely populated. The two largest population centres, Stornoway and Fort William, each have slightly fewer than 10,000 inhabitants, and despite being one of the most important fishing ports in Scotland, Lochinver has a year-round population of just 600. Population density is much greater farther south, in the Firth of Clyde region, which includes a number of small fishing villages as well as larger population centres such as Ayr and Greenock, each of which has more than 40,000 residents.

The region is effectively three contiguous areas: the coastal regions of western Scotland (including its outer islands) and the west of Ireland; the pelagic waters to the west; and the deep-sea region centred over the Rockall and Porcupine Banks.

The west Scotland coast is deeply indented with lochs and rocky headlands with cliffs and areas of sand dunes. It is one of the most pristine coastal areas in the United Kingdom. Offshore, the Western Isles (including the Outer Hebrides) have low but deeply shelving coastlines with rocky embayments and pocket dunes. Ireland's north-west coast is also heavily indented and rocky but has many large bays with fine sandy beaches.[110]

Cold-water fish species such as cod and herring have long thrived in the waters west of Scotland; herring spawning and nursery areas can be found along the north-west Scottish and northern Irish coasts, including the northern and western coasts of the Outer Hebrides. A cod spawning area extends north-east from the tip of the Hebrides, while whiting spawns in The Minch, the stretch of water between the Hebrides and the Scottish mainland, and an extensive mackerel spawning area sits to the west and south of Ireland, although the mackerel in recent years have moved farther north.[111]

> The coasts of the Scottish mainland and Western Isles have been dubbed "one of the most important breeding assemblages of seabirds in the northern hemisphere."

Twenty-three species of seabirds breed along the coasts of the Scottish mainland and Western Isles, which have been dubbed "one of the most important breeding assemblages of seabirds in the northern hemisphere".[112] Of the 50 or so islands in the Western Isles, only 12 are inhabited, and those that are free of introduced predators such as rats boast some of the densest seabird populations in the world. The island of St. Kilda alone is home to over 60,000 breeding pairs of gannets—the world's largest colony of the species—as well as some 65,000 pairs of fulmars, and 45,000 pairs (95 per cent of the British total) of Leach's petrels. Substantial colonies of puffins, guillemots and razorbills, among other species, can also be found in the region.[113]

The islands and sea cliffs of Ireland's west coast play host to some of the world's largest breeding seabird colonies. Little Skellig, off the coast of County Kerry, supports some 30,000 breeding pairs of northern gannet, with many thousand more non-breeding birds in attendance. Islands off the west coast support some of the largest breeding colonies of the European storm petrel. Ireland's bays, estuaries and coastlines are important stops for migrating birds such as brent geese from Canada, white-fronted geese from Greenland, whooper swans from Iceland, golden plovers, black-tailed godwits and Bewick's swans from Siberia.[114]

A total of 15 species of cetaceans have been identified in the region, with the Atlantic white-sided dolphin and harbour porpoise most frequently sighted during surveys.[115] Scotland has been called "arguably the best place in the world to see Atlantic grey seals," and 90 per cent of the British grey seal population is found around its coast, including in the Western Isles.[116] The Monach Isles in the Outer Hebrides are home to the second-largest breeding population of grey seals in the world.[117]

Farther west, the Rockall Plateau is an extensive shallow area measuring some 220,000 km^2 and rising from the seabed to reach between 65 and 220 metres below the sea's surface.[118] On its eastern edge, the plateau's slopes are steep and drop to depths of up to 2,500 metres in the Rockall Trough, home to a number of deep-sea fish species, including ling, blue ling, tusk, roundnose grenadier and orange roughy. The Rockall Bank is an elevated feature of the plateau's edge, lying immediately west of the trough, which extends upward toward

and ultimately breaks the surface of the ocean. The resultant peak, a 20-metre islet named simply Rockall, has been called "the most isolated small rock in the oceans of the world".[119] It is the subject of a territorial dispute involving Denmark, Iceland, Ireland and the United Kingdom, each of which has designs not only on the region's fishing grounds but also on possible seabed oil, gas and mineral wealth.[120]

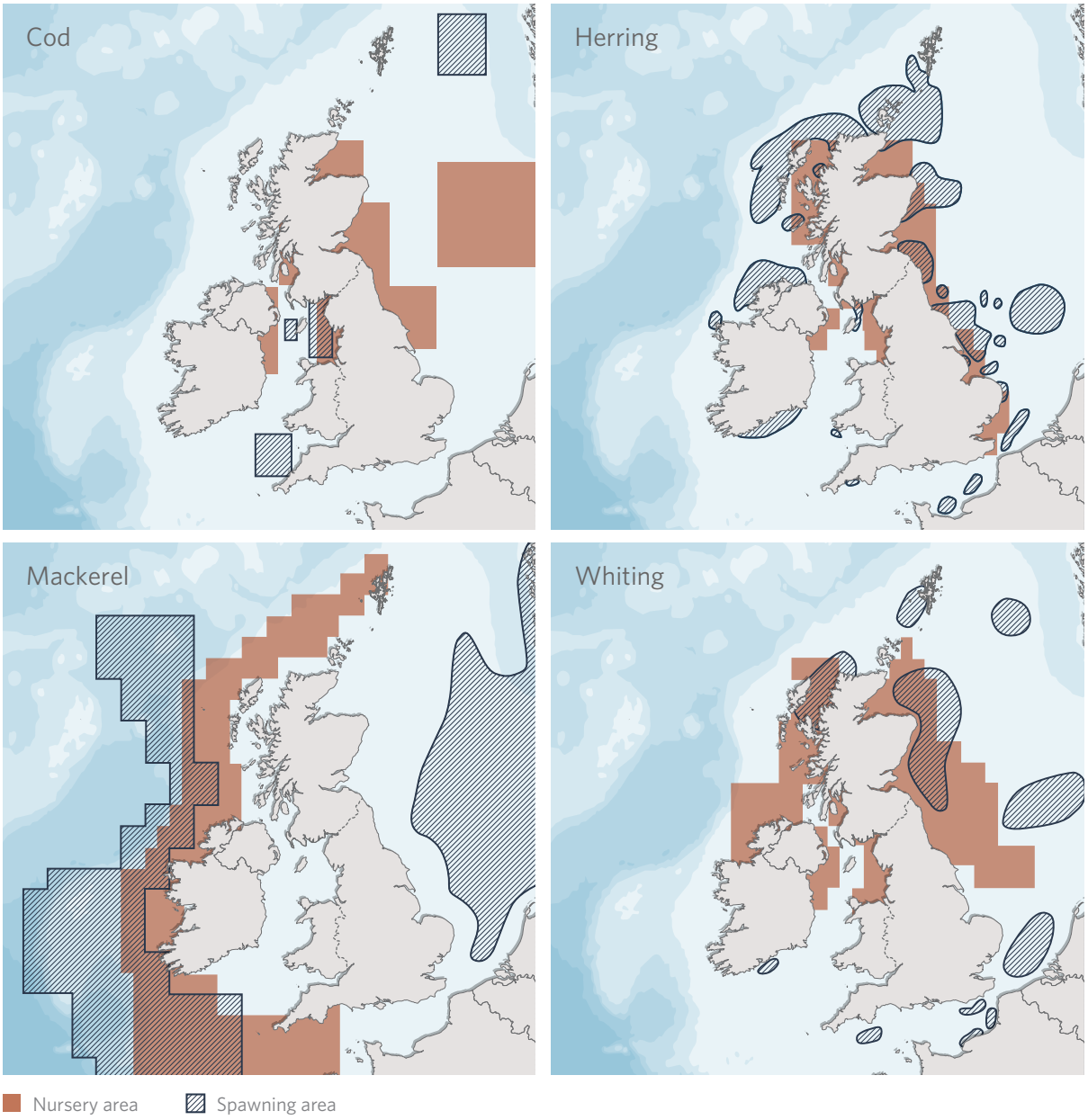
The Skelligs of Ireland's south-west coast.

The Rockall Bank region is also home to a unique series of seamounts known as Darwin Mounds, which lie at depths of approximately 1,000 metres, are composed mostly of sand, and support extensive colonies of cold-water corals *Lophelia pertusa*. The mounds are considered especially significant ecologically because virtually all previous records of *L. pertusa* reported them growing on rocky, rather than sandy, substrate. Because of concerns that bottom trawling was damaging the mounds—and, more pertinently, the corals they support—the European Commission in 2004 imposed a ban on trawling in the region, the first time it had closed a fisheries area for nature conservation, rather than strictly for fisheries management.[121]

Map 6

Spawning and Nursery Grounds of Commercially Important Species

The spawning and nursery grounds for cod, whiting, herring and mackerel.



Centre for Environment, Fisheries and Aquaculture Science, UK, 2010

Ninety per cent of the Atlantic grey seal population in Britain is found on the Scottish coast.

The Darwin Mounds were discovered only in 1998, demonstrating scientists' limited knowledge of these deep-sea ecosystems and the difficulties encountered when studying them. Several deep-water coral reefs off East Rockall Bank were documented for the first time as recently as 2010.[122] One year earlier, a massive deep-sea coral reef was discovered off the south end of the Porcupine Bank, 320 km off the west coast of Ireland. These latter reefs have been described as "pristine, thriving and hence spectacular examples of cold-water coral reefs", where "living coral thickets stood up to 2 m high where ordinarily they are less than half a metre in height".[123]

Fishing in the west of Scotland and Ireland

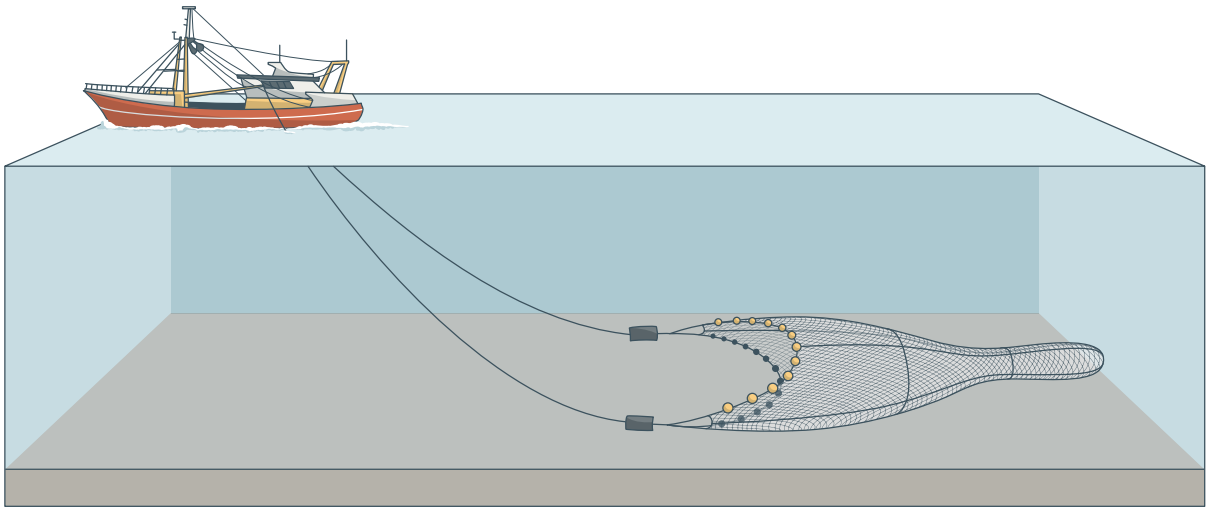
Fisheries in the region cover a large area, from the coastal inlets west of Scotland to the Rockall Plateau far out to the west. Some species—including cod, haddock and whiting—are, or have been, caught in both areas; others, such as herring, have been caught exclusively in coastal waters.

Shetland fishermen have fished for cod on the Rockall Bank as far back as 1805, but in the twentieth and early twenty-first centuries, haddock has been the major target for a fishery prosecuted almost entirely by trawls. Interest in the area has been sporadic, and fishing pressure has fluctuated, less in line with haddock abundance on Rockall and more with its population in coastal waters. For example, the incentive to travel to Rockall has declined in years when coastal haddock have been abundant. Fisheries management there faces additional complications because it is partly in international waters and under the jurisdiction of the North-East Atlantic Fisheries Commission. The principal non-European Union state fishing for haddock on the bank has been Russia, whose fleets were first sighted in the area in 1969.

Figure 7

Bottom Trawl

A bottom trawl uses a cone-shaped net kept open horizontally by two trawl doors, that is towed by one or two boats, along the sea floor.



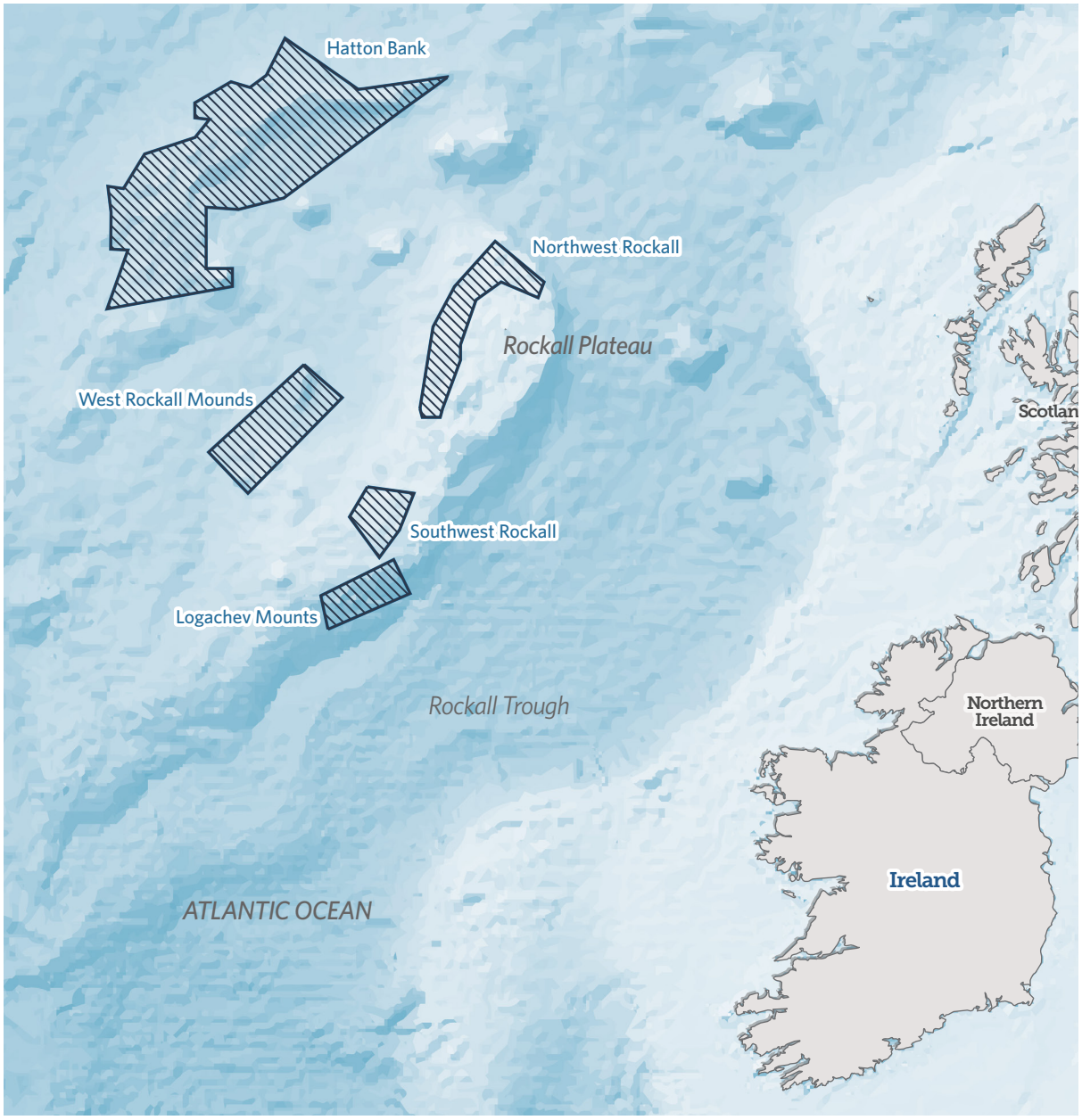
In 2001, following the discovery that juvenile haddock tend to concentrate in the south-west area of Rockall Bank, the EU and the Russian Federation agreed to establish a Rockall Haddock Box where trawling would be banned to protect juveniles in the area of the bank under the commission's jurisdiction. The next year, the EU extended the measure to the area of the fishing grounds that fell under its jurisdiction. In 2007, to protect cold-water corals from the impact of trawling, the North-East Atlantic Fisheries Commission closed North West Rockall, Logachev Mounds and West Rockall Mounds.[124] Fishing effort has greatly reduced since then, and in 2009 the spawning stock biomass of Rockall haddock was its highest in a decade. However, fisheries are just one influence on fish populations, and haddock recruitment, which is highly variable, has been extremely low since 2007. That factor, combined with continuing high catches, has caused the stock to shrink again. One reason for this decline seems likely to be warming waters, which lead to declining populations of the zooplankton that young haddock eat.

Management of the haddock fishery on Rockall required the cooperation of other states beyond the European Union. Regional fisheries management organizations exist to pull together disparate national priorities and agendas and develop multilateral management programmes that can work. Problems arise, however, when states cannot reach agreement and pursue their own agendas.

Map 8

Rockall Plateau

Shetland fishermen have fished for cod on the Rockall Bank as far back as 1805

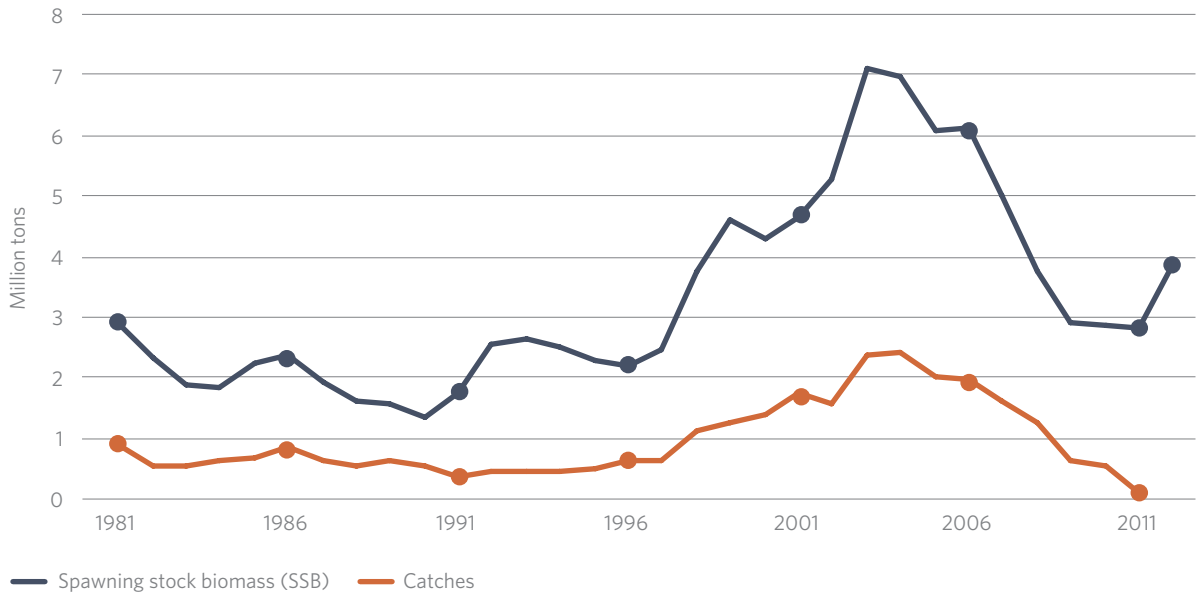


Bottom fishing closures

Figure 8

North-East Atlantic Blue Whiting

Catches and spawning stock biomass, 1981-2011



Source: Bjørndahl and Ekerhovd, using ICES data, in Marine Resource Economics 29:1 (2013).

For example, the fishery for blue whiting—a schooling pelagic fish found at highest concentrations along the edge of the continental shelf west of the British Isles and on the Rockall Bank plateau—was for a while the largest in the north-east Atlantic. At its start in the 1970s, the Soviet Union and Norway dominated the fishery, though they were later joined by the EU and the Faroe Islands. Catches remained relatively stable through the 1980s and 1990s but increased rapidly after 1998. Although the fishery nominally operated under a total allowable catch system after 1994, coastal states for many years set their own quotas, which did not always follow scientific advice. For example, in 2003, catches reached a record high of 2.4 million tons. That was about four times the limit of 600,000 tons recommended by ICES.[125]

The introduction of powerful new trawlers from Iceland in the mid-1990s contributed significantly to the increased catch. Icelandic vessels had played only a small role in the overall catch to that point, but by 2003 their catch had grown to 501,000 tons. Starting in 1999, the EU, Norway, Russia, Iceland and the Faroes attempted to reach agreement on management of blue whiting, but they were unable to do so for six years. At one point, the parties presented demands for their own quota shares along with what they thought the others' shares should be. The total amounted to almost double the possible total allowable catch.[126]

When the fishing states reached a management agreement in 2005, it was to a large extent the biological response of the blue whiting stock itself, rather than any proactive measures by the industry, that was the catalyst. The massive increase in catches from 1998 onward had followed eight consecutive years of highly successful recruitment classes. That enabled the spawning stock biomass to increase from approximately 3 million tons in the 1980s to a peak of 7 million tons in the mid-2000s.[127] In 2005, however, recruitment returned to the smaller pre-1995 levels. That, combined with catches that had increased by 500 per cent over the course of a decade, led to a calamitous drop in the spawning stock biomass.

The states involved in the fishery agreed to a management plan that meant a reduction in the catch by 75 per cent between 2004 and 2009, but even this was not enough as recruitment dropped to historically low levels. In 2011, ICES recommended that the fishery—which just a few years earlier had been the largest in the region—be closed.[128]

The case of blue whiting provides an illustration of how short-term thinking can combine with competing national priorities and the natural responses of fish stocks to a changing environment to bring about a sudden change in a previously successful fishery. Another example is mackerel.

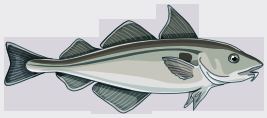
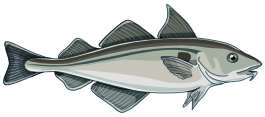
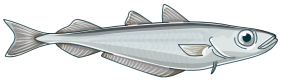
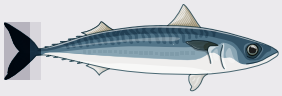
As noted in the North Sea chapter, the large spawning stock of mackerel has shifted northward, possibly a result of environmental changes related to climate change. Traditionally, the fishing areas with higher catches of mackerel have been in the northern North Sea, around the Shetland Islands, and off the west coast of Scotland and Ireland. The southern fishery off Spain's northern coast also has accounted for significant catches. As a result of the stock's northward shift, significant catches have in recent years also been taken in Icelandic and Faroe Island waters. Almost no catches were reported in these areas before 2008. In 2012, they constituted about half of the total reported landings.

The mackerel fishery off the west coast of Scotland and Ireland has grown in importance in recent years.

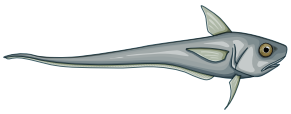
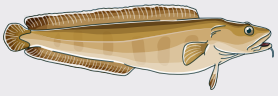
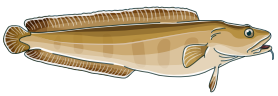
Table 4

Top Commercial Species of West Scotland and Ireland

Basic indicators of fisheries' sustainability

Common name	Latin name	Illustration	Is fishing sustainable? (fishing mortality compared to maximum sustainable yield)	Is the fish stock healthy? (total biomass compared to biomass MSY trigger)
Cod west of Scotland	*Gadus morhua*		✗	✗
Haddock west of Ireland	*Melanogrammus aeglefinus*		✗	✓
Whiting west of Scotland	*Merlangius merlangus*		Unknown but fishing mortality very low	Unknown but biomass very low
Cod Rockall	*Gadus morhua*		Unknown	Unknown
Haddock Rockall	*Melanogrammus aeglefinus*		✗	✗
Whiting Rockall	*Merlangius merlangus*		Unknown	Unknown
Blue whiting	*Micromesistius poutassou*		✓	✓
Mackerel	*Scomber scombrus*		✓	✓

Continued on next page

Common name	Latin name	Illustration	Is fishing sustainable? (fishing mortality compared to maximum sustainable yield)	Is the fish stock healthy? (total biomass compared to biomass MSY trigger)
Herring west of Scotland	*Clupea harengus*		✗	Unknown but biomass likely high
Herring west of Ireland	*Clupea harengus*		✗	Unknown but biomass very low
Horse mackerel	*Trachurus trachurus*		✗	✓
Orange roughy	*Hoplostethus atlanticus*		Unknown but fishing mortality decreasing	Unknown but biomass very low
Roundnose grenadier	*Coryphaenoides rupestris*		✓	✓
Blue ling	*Molva dypterygia*		✓	Unknown but biomass increasing
Ling	*Molva molva*		Unknown but fishing mortality stable	Unknown but biomass stable
Tusk	*Brosme brosme*		Unknown	Unknown but biomass high
Tusk Rockall	*Brosme brosme*		Unknown	Unknown but biomass stable low

Source: International Council for the Exploration of the Sea (ICES), 2014

Catches from Greenland were reported for the first time in 2011 and increased in 2012.[129] Although the EU, Norway and the Faroe Islands have agreed on a management plan since 2008, ICES has expressed concerns over the total allowable catches that the parties have assigned themselves. In March 2014, Norway, the EU and the Faroes agreed to a TAC of 1.24 million tons for the year as part of a new five-year management plan. Greenland has declared a catch limit of 100,000 tons in its waters, and Iceland a catch limit of 147,721 tons for its fisheries. Further significant catches are also assumed to be taken by Russia. ICES has noted that both the agreed TAC and the sum of the declared catch limits exceed the advised fishing mortality.[130] In 2012, the independent Marine Stewardship Council, which had previously certified mackerel as an environmentally responsible fishery, suspended that certification. The fishery has applied for a new certification.[131]

> Although pelagic fish such as mackerel and blue whiting can be pushed irreversibly beyond their limits, their resistance is higher than more slow-reproducing fish such as cod.

Although pelagic fish such as mackerel and blue whiting can be pushed irreversibly beyond their limits, their resistance is higher than more slow-reproducing fish such as cod. They have the capacity, if fishing pressure is sufficiently reduced, to rebound from stock depletions, assuming positive environmental conditions and recruitment. For other fish species that is not the case.

The orange roughy population is widespread over continental slopes, ocean ridges and seamounts around the world in water depths of 180 to 1,800 metres. In the eastern Atlantic, it is found from Iceland to Morocco. Like most species in the cold waters of the deep, it grows slowly, matures late and is long-lived: orange roughy generally do not reach maturity until around age 25, and may live to be 180 or older. This, along with their tendency to congregate around seamounts, makes them especially vulnerable to overexploitation.

Seamounts—undersea mountains that rise from the seabed but do not break the surface—are hotspots of marine life. They tend to concentrate water currents and can have their own localised tides, eddies and upwellings where cold, nutrient-rich, deep water moves up along the seamount's steep sides. Because of these strong localised currents and upwellings, the plankton biomass is often high over seamounts. That, combined with the constant influx of prey organisms, means seamounts attract large numbers of fish.[132] Fishing fleets that know where these seamounts are located can target them with bottom trawls. And because of the slow-growing nature of the organisms that live on and around the seamounts, these fisheries can experience "boom and bust" cycles over just a few years.

In 1989, French trawlers began targeting orange roughy in the waters west of Scotland, concentrated on the Hebrides Terrace Seamount east of the Rockall Plateau. The fishery peaked two years later with landings of 3,500 tons. The fleet caught approximately that same amount in total over the next 20 years.[133]

In 1991, a French fleet also began fishing for orange roughy west of Ireland, and in 2000, with support from subsidies to encourage an Irish deep-water fishery, Irish vessels joined in. The programme saw the introduction of 29 new vessels; 16 were between 16 and 46 metres long, which allowed Irish fishermen to compete on equal terms in offshore fishing grounds.[134]

The fishery peaked in 2002 with total landings of 5,465 tons. Of that, 5,114 tons were brought in by Irish vessels. The following year, total landings dropped to 541 tons. The imposition of a TAC on what had been a quota-free fishery was one factor in the decline in landings. Increasing fuel prices, which disproportionately affected large trawlers, also contributed and caused some vessels to leave the fishery. Still, the total landings were a long way short of the TAC of 1,349 tons, suggesting the orange roughy fisheries around seamounts in the region had been fished out. There have been no directed orange roughy fisheries in the north-east Atlantic since 2009.

Overfishing in this region has not been confined to deep cold waters or to stocks that are targeted in international waters by multiple states.

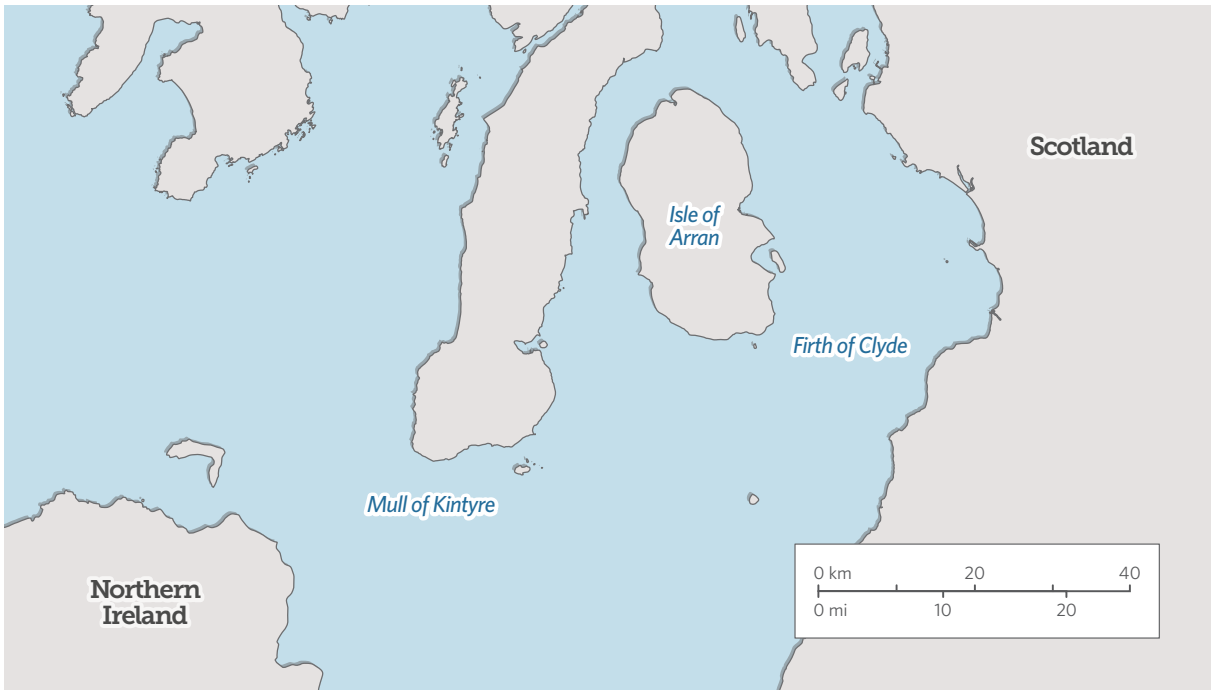
Going back to the nineteenth century, the Firth of Clyde, among other parts of the waters west of Scotland, supported a number of fisheries, primarily prosecuted by fleets from the east of the country and catching species such as herring, cod, haddock, turbot and flounder. Many of these fish were caught with different forms of seine nets. As demand increased, fleets turned to less selective forms of fishing, including bottom trawling. It didn't take long before fish landings began to decline. The Firth of Clyde was closed to large trawling vessels in 1889 upon the recommendation of local fishermen and scientists.

By the 1950s, the seine net fishery for herring was the most important and valuable in the Firth. Within a few years, however, herring landings were in decline, with catches consisting mainly of juvenile fish. By 1962, there was such a lack of herring during the autumn that fishing was stopped for the season.

Map 9

Firth of Clyde

From 1984 to 2009, landings of cod and whiting in the Firth declined by 99 percent

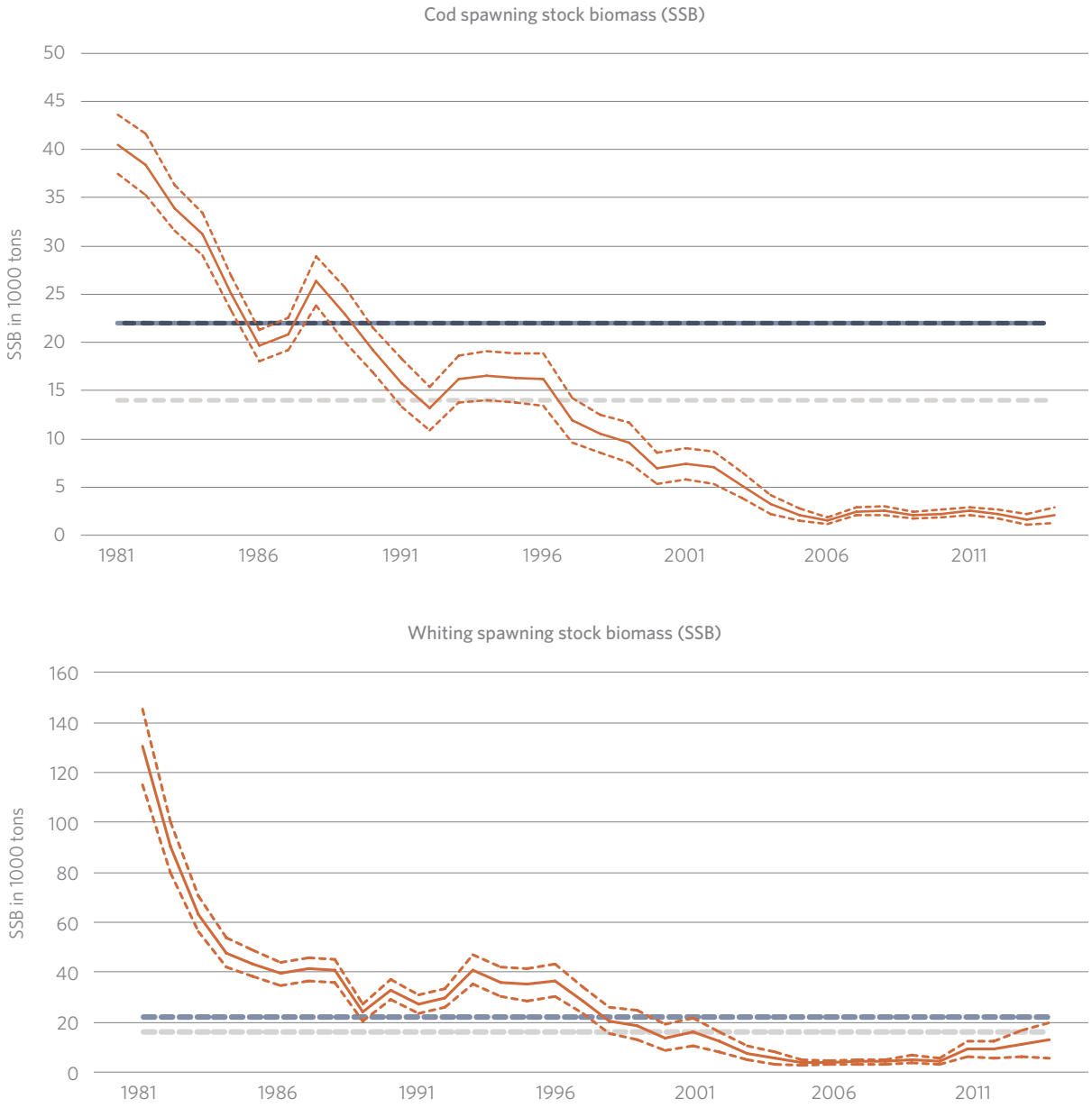


As the herring fishery declined, pressure mounted to reopen areas in the Clyde that had been closed to bottom trawling. Fishermen argued that they needed to expand and diversify into other stocks, such as demersal fish species, scallops and the growing *Nephrops* fishery. In 1962, the Firth was opened to trawling for *Nephrops*, though the ban remained within three miles off the coast. The fishery included a high by-catch of whitefish, which were landed and sold. As those landings increased, so did pressure from the industry to repeal the trawl closures close to the coast. That repeal finally came in 1984, but it did not lead to increased catches. In fact, the opposite occurred. Between 1984 and 2009, landings of both cod and whiting in the Firth declined by 99 per cent.[135] Since 2003, the only landings of fish in the Clyde have been as by-catch from the *Nephrops* fishery.[136]

Figure 9

West of Scotland Cod and Whiting

Spawning stock biomass, 1981 - 2014



Source: International Council for the Exploration of the Sea (ICES), 2014

The physical and ecological effects of overfishing in the Clyde have resulted in a profoundly altered, simplified ecosystem in which *Nephrops*, crabs, scallops and other invertebrates now thrive. *Nephrops* alone now generate almost as much income as all finfish combined did in the past. That could provide little incentive to encourage the recovery of cod or other fish that prey on the prawns.

Although the impact on fish populations is especially severe in the Firth of Clyde, the cod population throughout waters west of Scotland is under severe pressure. Cod is targeted as part of a mixed fishery that also catches haddock, with by-catches of whiting. EU fisheries ministers agreed on a long-term management plan for cod in 2008. In 2009, technical emergency measures were put in place to further reduce fishing, including a strict 30 per cent by-catch limit. This regulation has led to a significant increase in net mesh size, intended to decrease by-catch. Even so, stock status continued to deteriorate and in 2012, EU ministers set the TAC for cod at zero. But cod is still being caught because the whitefish fishery continues for haddock. Similarly, stocks of whiting remain heavily depleted because of high by-catches in the Norway lobster fishery. Although catches of whiting remain very low—1,175 tons in 2013, compared to 12,400 landed in 1987—and the stock appears to be increasing, ICES continues to recommend zero directed catch of whiting.[137]

Summary

- Fisheries in the waters west of Scotland cover a wide geographical area, from coastal inlets to the deep sea.
- Even when management measures have been established, environmental factors can continue to affect fish populations: on Rockall, haddock numbers are declining, apparently as a result of climate change.
- Because some fisheries in this region are conducted in international waters, regulation is dependent on agreement from states involved, which is not always forthcoming.
- Mackerel and blue whiting are two fisheries in which the EU and other parties have failed to agree or act on management plans or quotas.
- The region includes deep-sea areas, with fragile cold-water coral ecosystems and long-lived and vulnerable species such as orange roughy, which were overfished in just a few years.
- A 1984 opening of areas in the Firth of Clyde that had been closed to trawling resulted in the collapse of finfish fisheries.

Conclusions and Recommendations

Fish and fisheries have long been a vital element of food and commerce for people in north-western Europe. As far back as 9,000 years ago, people were already heading out to sea and finding ways to catch fish. The first commercial fisheries in the North Sea date back to at least the eleventh century; fourteenth-century maps reveal the location of fishing areas in the Irish Sea, which, 100 years later, were said to be "famous throughout western Europe".

But if commercial fisheries are a long-standing feature of life in north-western European waters, so too is overfishing. In both the North and Irish Seas, cod stocks have been massively depleted. Although cod has shown signs of recovery in the North Sea in recent years, numbers are still far short of estimated pre-fishery populations. A recovery of cod in the Celtic Sea was followed by a rapid increase in fishing, so much so that the cod stock is once more declining.

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Stronger management measures have resulted in improved status for several fish stocks in the region, but the situation today has deteriorated for others. Although overall levels of landings in the Celtic Sea have remained relatively stable since 1989, the numbers mask the fact that this has required increased amounts of effort. In addition, the trophic level of the fish being caught has plummeted, a consequence of large, predatory fish becoming depleted.

Indeed, changes in trophic levels are widespread in north-western European waters. In 1957, fishing fleets caught over 4 million tons in the north-east Atlantic (including the North and Baltic Seas but excluding the Mediterranean); in 2005, although the total catch was virtually identical, the most important species were quite different—only four of the top ten in 1957 remained in the top ten nearly a half century later.

Arguably the most significant change has been the rise in importance of Norway lobster, which has emerged from obscurity to become a major fishery throughout north-west European waters and is now the most important commercial crustacean in Europe. The *Nephrops* fishery began in response to declining catches of other species and has been aided by the continued low numbers of species such as cod, which prey on the crustaceans. Indeed, overfishing, along with habitat destruction caused by practices such as bottom trawling, has profoundly altered the ecosystems of much of the region, so that crustaceans such as *Nephrops*, or even shellfish, have become dominant species, assuming a position once held by cod and other predatory fish.

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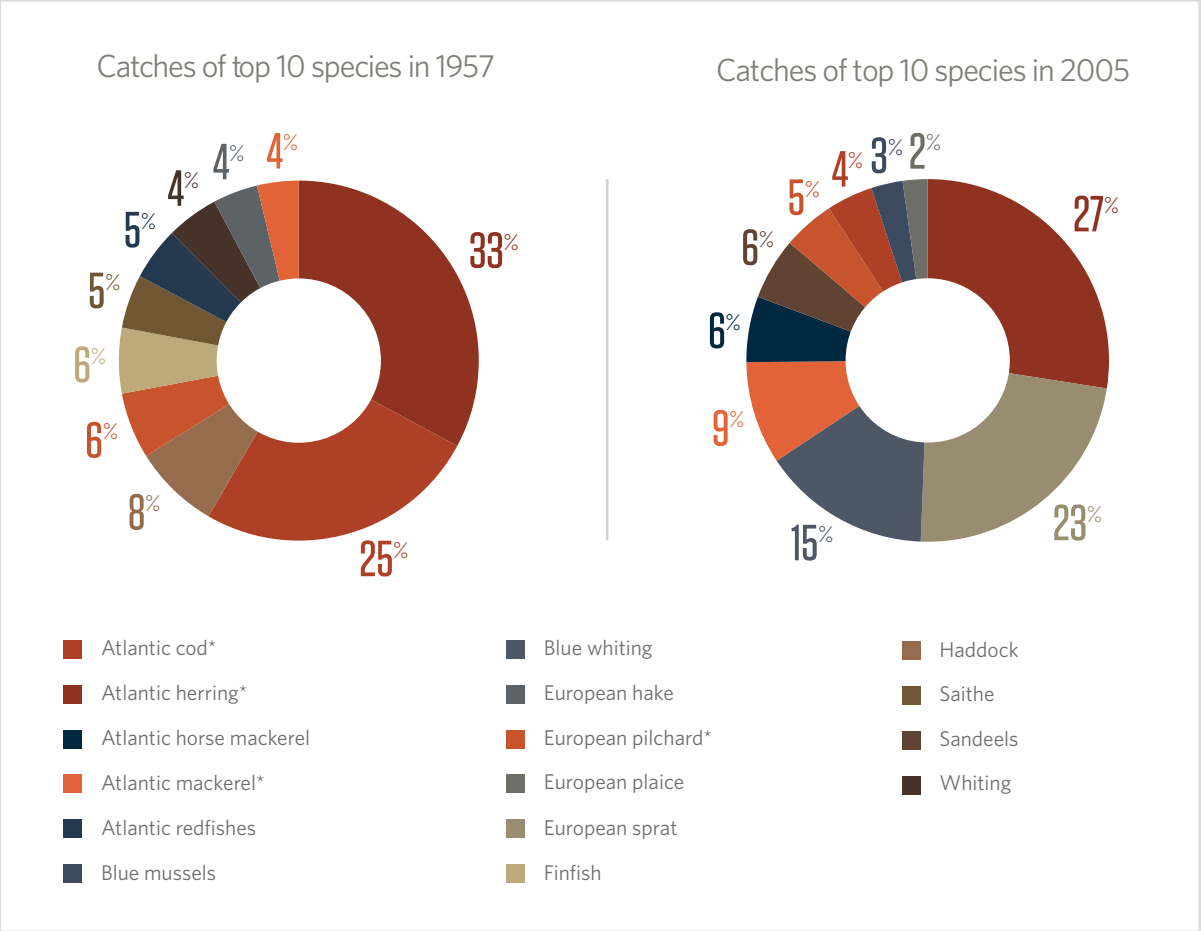
Figure 10

EU Catches in the North-East Atlantic

Differences in the top 10 species caught in Europe and adjacent waters in 1957 and 2005.



*Species that are in the top catches for 1957 and 2005

Source: FISHSTAT data for UN Food and Agriculture Organization major fishing area 27.

Such fishery collapses have taken place for decades. But the fact that the declines have, in many cases, continued, or that numerous previously overfished stocks have not recovered since establishment of the Common Fisheries Policy, has led to substantial criticism of the policy's role in enabling and even sanctioning overfishing.

Since its inception in 1983, the Common Fisheries Policy has undergone reforms in each decade. The 2002 round of reforms led to some progress but did not address the fundamental philosophical and political underpinnings that arguably made its failings inevitable. Chief among those was the priority too often given to the industry's short-term economic and social considerations over long-term sustainability.

In response to criticism and the ongoing crises facing fisheries in north-western European waters, the European Union has undertaken another round of reforms to the CFP. This one has the potential to be more fundamentally transformative and to profoundly improve fisheries management in the region. The new CFP contains important elements, such as a call to decentralise decision-making, strengthened provisions to

assess and manage fleet capacity, and a requirement that social, economic and environmental concerns be considered when allocating fishing opportunities. Two key elements stand out because they mark a significant shift in the EU's approach to fisheries management—and because the success of the reformed CFP will stand or fall on the effectiveness of their implementation.

The first is a legal obligation to end overfishing by 2015 where possible and at the latest by 2020. In the past, the establishment of total allowable catches has frequently been a matter for the EU Council, whose members might override scientific advice in the interests of short-term national expediency. Whether the new CFP will effectively banish such ad-hoc quota setting remains to be seen. However, with a legally binding deadline to end overfishing, and widespread public support for sustainable fishing limits, ministers will have to change their approach to fisheries management.

The second major change is the introduction of what is known as a landing obligation to drive more selective fishing, reduce unwanted catches and eliminate the practice of discarding. All catches of commercial species will have to be kept on board, landed and counted against quotas. To allow fishermen to adapt to the change, the landing obligation will be introduced gradually, between 2015 and 2019, for all commercial fisheries in European waters.

Bringing fishing to sustainable levels will have great benefits for fish stocks, marine ecosystems and ultimately fisheries. And that will help the industry and its employees in the medium and long terms. Still, with EU decision-making often focused on short-term outcomes, there will be resistance.

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Some EU member states might argue for a delay in meeting the maximum sustainable yield objective until as late as possible or ask for exceptions, citing concerns over a lack of scientific data or the economic and social well-being of their fisheries. Others may argue for "quota uplifts" to compensate for being forced to land fish that they would previously discard, even without scientific evidence of previous discard rates. This could result in an increase in the total number of fish being caught.

Monitoring and enforcement of the discard ban will be complicated. As a result of negotiations during the reform process, the law is not as strict as originally proposed, and some discards will end up still being permitted.

> It is essential that the public continues to support the decision-makers as they did during the reform process.

It is essential that the public continues to support the decision-makers as they did during the reform process, to ensure the Common Fisheries Policy is fully implemented in a timely manner. This could refill the waters of north-western Europe with the life it once supported and sustain the communities that depend on it.

Annex

A Brief History of the Common Fisheries Policy

Neither the Common Fisheries Policy nor its predecessors were originally intended to regulate fisheries from the perspective of sustainability or ecosystem protection. The 1957 Treaty of Rome established that the European Common Market "shall extend to agriculture and trade in agricultural products". It specifically included fisheries under those agricultural products.

The objectives of the Common Agricultural Policy were explicitly to increase productivity, establish a fair standard of living by increasing the earnings of agricultural workers, assure the availability of supplies and ensure that those products reached consumers at reasonable prices. At that time, commercial fisheries had yet to undergo the massive industrial transformation that would effectively put all fish stocks at risk of over-exploitation.[138] Across the Atlantic, the United States Department of the Interior predicted in 1964 that "the world's ocean could produce at least 500 million tons of fish and seafood products annually, as opposed to 50 million tons today".[139] The prospects seemed limitless; fisheries expansion was the goal.

The 1957 treaty allowed for a wide range of mechanisms to meet those objectives. That included the use of subsidies to increase production, a principle that later resulted in overcapacities within EU fishing fleets that placed extreme pressure on fish stocks in European waters and encouraged fleets to explore waters elsewhere with similar effect.

The basic principles remained enshrined in subsequent iterations of European fisheries policy and continued to inform the political approach to fisheries management. Maximization of production and short-term economic and social considerations were often given priority, even in the face of scientific advice.

Maximum Sustainable Yield and the CFP

The new Basic Regulation, adopted in 2013 following the most recent review, states that the "Common Fisheries Policy shall apply the precautionary approach to fisheries management, and shall aim to ensure exploitation of living marine biological resources that restores and maintains populations of harvested species above levels which can produce the maximum sustainable yield".

Maximum sustainable yield (MSY) is the largest average yield, or catch, that can theoretically be taken from a species' stock under constant environmental conditions without having an impact on the long-term stability of the population. It is usually measured in tons. To ensure more stable fishing limits, reduce risk of overfishing and incorporate economic considerations, the size of fish stocks should be above levels where they can produce the maximum sustainable yield over an indefinite time frame.

The CFP originally formed part of the Common Agricultural Policy but later achieved a separate identity as the European Community evolved. In 1970, member states declared exclusive economic zones (EEZ) in their waters, and new members with substantial fishing fleets entered the Community. As a consequence, they needed to address specific fisheries problems, such as access to common resources, structural measures for the fishing fleet and international relations in fisheries.

In 1983, the EU Council of Ministers adopted a regulation[140] that established a Common Fisheries Policy. The new policy gave the EU exclusive legal competence in almost all matters of fisheries conservation and management beyond territorial waters. The CFP included the principle of equal access to fishing grounds in the EEZs and introduced fishing limits, or total allowable catches, as well as minimum mesh sizes. At the same time, it limited member states' competence to register and flag vessels and to allocate fishing quotas and subsidies, among other things.

Following adoption of the CFP, capacity in the fishing fleet continued to increase with the support of EU funds, and fish stocks continued to decrease. The next scheduled reform, in 1992, aimed to reduce the European Community fleet and to improve gear selectivity. It included catch limits on an annual or multiannual basis and the restructuring of the fisheries sector.

However, the depletion of many fish stocks continued. The CFP was not achieving the objective of conserving marine resources, and the EU was not keeping pace with the progress achieved through international instruments such as the 1995 United Nations agreement on straddling and highly migratory fish stocks.

In 2002, after a process of stakeholders' consultation that included non-governmental organizations for the first time, the European Commission proposed an extensive revision of the CFP. However, partially because of limited public attention after the initial proposal was published and because the European Parliament had no decisive say in fisheries policy, the CFP adopted in December 2002 differed greatly from what the Commission had proposed.

Though the positive changes were reduced, the new policy did introduce the precautionary and ecosystem-based approaches to fisheries and long-term management plans, establish a regional advisory council, and abolish subsidies for the construction of new vessels. Officially, the CFP continued to pursue three objectives that can be difficult to reconcile in the short term, namely to ensure that fishing activities are economically, environmentally and socially sustainable.[141]

As had been the case with previous reforms, the 2002 changes did not stop overfishing; fisheries ministers continued to set fishing limits above scientific advice for many stocks, in response to political and economic pressures. As former UK fisheries minister John Gummer observed of that process: ''If you are a fisheries minister you sit around the table arguing about fishermen—not about fish. You are there to represent your fishermen. You are there to ensure that if there are 10 fish you get your share and if possible a bit more".[142]

In 2007, 94 per cent of EU stocks for which there was an assessment were overfished. They could increase and generate more economic output only if they were allowed to rebuild. One third of assessed stocks were already outside safe biological limits, meaning they were in danger of not being able to recover. In its consultation document from 2009, the commission wrote that, "While a few EU fleets are profitable with no public support, most of Europe's fishing fleets are either running losses or returning low profits".[143]

Subsequently, the commission proposed a far-reaching reform highlighting issues that had received little attention until then, such as the problem of discards, or the dumping of unwanted fish into the sea. As a result of changes in the EU governance structure following adoption of the Lisbon treaty in 2009, the European Council for the first time had to negotiate with the European Parliament—the directly elected representatives of EU citizens—to agree on the final legislation. This process provided the opportunity for individuals and organizations to advocate to ensure that effective reforms took place.

In 2009, The Pew Charitable Trusts and partners initiated the OCEAN2012 coalition, which grew from 5 to 194 organizations in 24 EU member states. The alliance included small-scale fishermen's organizations, leading marine scientists, development agencies, environmental non-governmental organizations,

restaurants, aquaria, and others who shared an interest in sustainable European fisheries. Hugh Fearnley-Whittingstall, a well-known British television chef, launched the "fish-fight" campaign, which attracted more than 870,000 supporters and demanded an end to the practice of discarding.

The Council of Ministers and the European Parliament reached agreement on a new CFP on 30 May 2013; it entered into force on 1 January 2014.[144] Its objective is to ensure that fishing and aquaculture activities are environmentally sustainable in the long term and are managed consistently with the objectives of achieving economic, social and employment benefits. In a major paradigm shift, the CFP now requires that EU member states end overfishing by 2015 where possible, and no later than 2020. It also phases in a landing obligation intended to significantly reduce unwanted catch and, to the extent possible, eliminate discards.

Glossary

Glossary		
By-catch	Fish or other species that are caught unintentionally during fishing operations.	
Collapse of fish stock	Steep decrease in stock biomass to a level where there is a high risk of impaired reproductive capacity.	
Council (or *Council of Ministers*)	In a fisheries context, the fisheries ministers of the European Union, who have had the final say in setting fishing limits.	
Demersal	Demersal fish live and feed on or near the bottom of the sea (the demersal zone). They include cod, flounder, turbot and sole.	
Discards	The portion of fish catch that is thrown overboard, generally dead or dying, often because of economic or legal reasons. Now prohibited for some commercial species under the most recent reform of the EU Common Fisheries Policy.	
Fisheries Management reference points	*Blim*	Limit reference point for spawning stock biomass (SSB). Stocks with SSB below Blim have an increased risk of impaired reproduction.
	Bpa:	Precautionary reference point for spawning stock biomass (SSB) intended to avoid B to fall below Blim.
	MSY Btrigger	Biomass reference point that triggers a management response when stocks fall below that level.
European Commission	The executive body of the European Union, responsible for proposing legislation, overseeing implementation of decisions, upholding treaties and running day-to-day management.	
Gadoid	Family of bony fish, including cod, haddock, whiting and pollock.	
ICES	International Council for the Exploration of the Sea. Headquartered in Copenhagen, ICES is an intergovernmental organization that develops and coordinates marine research in the North Atlantic and provides regular scientific advice to member governments and international regulatory bodies.	
Landing obligation	Under the latest reform of the CFP, the landing obligation requires that catches of several commercial species be kept on board, landed and counted against the quotas (although the ban will be introduced gradually and certain exceptions are allowed).	

Glossary	
Pelagic	Pelagic fish live in the water column, either in shallow, coastal waters or the open ocean. They tend to congregate in large schools. Examples include herring and mackerel.
Seine	Seine nets hang vertically in the water, generally weighted at the bottom and with floats at the top. In pelagic fisheries, they are often used to encircle schools of fish and are "pursed" tight at the bottom before the catch is hauled in.
TAC	Total allowable catch, the amount of each fish species that EU fishing member states may catch each year.
Trawl	A net that is pulled behind one or more fishing boats. Midwater, or pelagic, trawls are pulled through the water column to catch schooling fish; bottom trawls are dragged along the seabed.
Trophic level	The trophic level is a position an organism occupies in the food web. "Low trophic level" fish are generally plankton eaters such as herring; "high trophic level" fish are predators such as cod.
Whitefish	Finned demersal fish such as cod, whiting, hake and haddock.

Endnotes

1 North Sea Region Programme, "North Sea Region Programme 2014-2020: Guidance for Stakeholders", http://www.northsearegion.eu/files/user/File/Public_Consultation/Guidance_for_stakeholders.pdf

2 Trading Economics, "Population Density (People per sq. km) in the Netherlands", accessed 3 November 2014, http://www.tradingeconomics.com/netherlands/population-density-people-per-sq-km-wb-data.html

3 V. Lauria et al., "Influence of Climate Change and Trophic Coupling across Four Trophic Levels in the Celtic Sea", PLoS ONE 7(10): e47408 (2012). doi:10.1371/journal.pone.0047408

4 Scottish Natural Heritage, "Seals in Scotland: Where Are They?" http://www.snh.org.uk/publications/on-line/naturallyscottish/seals/sealsinscotland.asp

5 "New Coral Reef Found Off West Coast," *BreakingNews.ie* (26 May 2009), http://www.breakingnews.ie/ireland/new-coral-reef-found-off-west-coast-412371.html

6 UNESCO, "Wadden Sea", accessed 3 November 2014, http://whc.unesco.org/en/list/1314

7 Wessex Archaeology, "Strategic Environmental Assessment Sea 6: The Irish Sea Maritime Archaeology" (UK Department of Trade, 2005), 18.

8 M. Kurlansky, *Cod: A Biography of the Fish that Changed the World* (New York: Walker & Company, 1997), 19.

9 B. Poulsen, *The Dutch Herring Industry: An Environmental History* (Amsterdam: Amsterdam University Press, 2008), 21.

10 H. Schultes, "A dissertation on the public fisheries of Great Britain, explaining the rise, progress, and art of the Dutch fishery, &c. &c", *Quarterly Review* IX(XVIII) (1813), 265-304.

11 C. Roberts, *The Unnatural History of the Sea* (Washington D.C.: Island Press, 2007), 165.

12 W. Garstang, "The impoverishment of the sea", *Journal of the Marine Biological Association of the United Kingdom* (1900), 3.

13 Roberts, *Unnatural History of the Sea,* 184-198.

14 S. Shephard et al., "Size-selective fishing drives species composition in the Celtic Sea", *ICES Journal of Marine Science* 69(2) (2012), 223–234.

15 T. Bjørndahl and N-A. Ekerhovd, "Management of Pelagic Fisheries in the North-East Atlantic: Norwegian Spring Spawning Herring, Mackerel and Blue Whiting", *Marine Resource Economics* 29:1 (2013), 69-83.

16 ICES, "Cod in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa West (Skagerrak): Advice for 2012", http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2012/2012/cod-347.pdf

17 European Commission, "Communication from the Commission to the European Parliament and the Council Concerning a consultation on Fishing Opportunities for 2015 under the Common Fisheries Policy" (2014), http://ec.europa.eu/dgs/maritimeaffairs_fisheries/consultations/fishing-opportunities-2015/doc/com-2014-388_en.pdf

18 British Library, "Lindisfarne Gospels", accessed 3 November 2014, http://www.bl.uk/onlinegallery/sacredtexts/lindisfarne.html

19 OSPAR Commission, *Quality Status Report 2000, Region II—Greater North Sea*. "Chapter 3: Human Activities", (OSPAR Commission, London, 2000), 40-41.

20 C. Scearce, "European Fisheries History: Pre-Industrial Origins of Overfishing" (ProQuest Discovery Guides, August 2009), http://www.csa.com/discoveryguides/fish/review.pdf

21 J.H. Barrett et al., "The origins of intensive marine fishing in medieval Europe: the English evidence", *Proceedings of the Royal Society B* 271 (2004), 2417-2421.

22 S. Halliday, "The First Common Market? The Hanseatic League", *History Today* 59:7 (2009), http://www.historytoday.com/stephen-halliday/first-common-market-hanseatic-league

23 Poulsen, *Dutch Herring Industry*, 21.

24 S. Byskov, "Herring, Cod and Other Fish: Industrialisation in the Sea", *1001 Stories of Denmark*, accessed 3 November 2014, http://www.kulturarv.dk/1001fortaellinger/en_GB/theme/herring-cod-and-other-fish/article

25 The Sea Around Us Project, "Landings by Fishing Country in LME: North Sea", http://www.seaaroundus.org/lme/22/4.aspx

26 C.M. Roberts and L.C. Mason, *Return to Abundance: A Case for Marine Reserves in the North Sea* (London: WWF, 2008), http://www.wwf.org.uk/filelibrary/pdf/marine_reserves_north_sea.pdf

27 Garstang, "Impoverishment of the sea", 3.

28 North Sea Region Programme, "North Sea Region Programme 2014-2020".

29 Trading Economics, "Population Density (People per sq. km) in the Netherlands".

30 UNESCO, "Wadden Sea".

31 OSPAR Commission. *Quality Status Report 2000, Region II—Greater North Sea*. Chapter 5: Biology (OSPAR Commission, London, 2000), 91-92.

32 Ibid.

33 P.S. Hammond et al., "Distribution and Abundance of the Harbour Porpoise and Other Small Cetaceans in the North Sea and Adjacent Waters" (Cambridge: Sea Mammal Research Unit, National Environment Research Council, 2002).

34 ICES, "North Sea Ecosystem Overview" (International Council for the Exploration of the Sea, 2008), http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2008/2008/6.1-6.2%20North%20Sea%20Ecosystem%20overview.pdf

35 OSPAR Commission. *Quality Status Report 2000, Region II—Greater North Sea*, 90.

36 D.H. Cushing, "The Gadoid Outburst in the North Sea", *ICES Journal of Exploration* 41:2 (1984), 159-166.

37 G. Beauregard and R.R. Kirby, "Climate, Plankton and Cod", *Global Change Biology* 16 (2010), 1268-1280.

38 C.M. Hogan, "Wadden Sea", *Encyclopedia of Earth* (2009), http://www.eoearth.org/view/article/156882/

39 UNESCO, "Wadden Sea".

40 OSPAR Commission. *Quality Status Report 2000, Region II—Greater North Sea*, 93-109.

41 M.R. Heath et al., "Review of climate change impacts on marine fish and shellfish around the UK and Ireland", *Aquatic Conservation* 22:3 (2012), 337-367.

42 N.K. Dulvy et al., "Climate Change and Deepening of the North Sea Fish Assemblage: A Biotic Indicator of Warming Seas", *Journal of Applied Ecology* 45:4 (2008), 1029-1039.

43 Heath et al., "Review of climate change impacts".

44 The Sea Around Us Project, "Landings by Species in LME: North Sea", http://www.seaaroundus.org/lme/22/1.aspx

45 R. Alleyne, "Town's last fishing boat fights tide and time", *Daily Telegraph*, 14 January 2008, http://www.telegraph.co.uk/news/uknews/1575561/Towns-last-fishing-boat-fights-tide-and-time.html

46 M. Townsend, "How climate change spells disaster for UK fish industry," *The Observer*, 26 January 2013, http://www.theguardian.com/environment/2013/jan/26/climate-change-fish-wars-iceland

47 A. Delaney et al., "Assessment of the Status, Development and Diversification of Fisheries-Dependent Communities: Oostende Case Study Report", European Commission, Brussels (2010), http://ec.europa.eu/fisheries/documentation/studies/regional_social_economic_impacts/oostende_en.pdf

48 M. Dickey-Collas et al., "Lessons Learned from Stock Collapse and Recovery of North Sea Herring: A Review", *ICES Journal of Marine Science* 67 (2010), 1875-1886.

49 ICES, "Cod in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa West (Skagerrak): Advice for 2014", http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2013/2013/cod-347.pdf

50 J.L. Andersen et al., "Rebuilding of the North Sea Cod Stock with Special Reference to the Impact of ITQ Management Systems", OECD (2012), http://www.oecd.org/tad/fisheries/North%20Sea%20Cod%20Fisheries.pdf

51 S. Villasante et al., "On the non-compliance in the North Sea cod stock", *Sustainability* 5 (2013), 1974-1993.

52 R.M. Cook, et al., "Potential collapse of North Sea cod stocks", *Nature* 385 (1997), 521-522.

53 R. Froese and M. Quass, "Mismanagement of the North Sea cod by the European Council", *Ocean and Coastal Management* 70 (2012), 54-58.

54 ICES, "Cod in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa West (Skagerrak): Advice for 2014", http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2013/2013/cod-347.pdf.

55 D. MacKenzie, "Cod comeback as North Sea stocks start to recover", *New Scientist*, 11 June 2013, http://www.newscientist.com/article/dn23683-cod-comeback-as-north-sea-stocks-start-to-recover.html

56 European Commission, "Communication from the Commission to the Council Concerning a Consultation on Fishing Opportunities for 2014", (2013), http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0319:FIN:EN:PDF

57 ICES, "Mackerel in the Northeast Atlantic (combined Southern, Western, and North Sea spawning components): Advice for 2014", http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2013/2013/mac-nea.pdf

58 G. Lean, "Why mackerel has been taken off the ethical 'fish to eat' list", *Daily Telegraph*, 22 January 2013, http://www.telegraph.co.uk/earth/wildlife/9818669/Why-mackerel-has-been-taken-off-the-ethical-fish-to-eat-list.html.

59 ICES, "Cod in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa West (Skagerrak). Advice for 2012", http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2012/2012/cod-347.pdf

60 ICES, "Report of the Workshop on the Analysis of the Benchmark of Cod in Subarea IV (North Sea), Division VIId (Eastern Channel) and Division IIa (Skaggerak) (WKCOD 2011) 7–9 February 2011, Copenhagen, Denmark. ICES CM 2011/ACOM:51", (2013), http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2011/WKCOD/wkcod_2011.pdf

61 S. Carrell, "Fishing skippers and factory fined nearly £1m for illegal catches", *The Guardian*, 24 February 2012, http://www.theguardian.com/environment/2012/feb/24/fishing-skippers-fined-illegal-catches

62 F. Urquhart, "Sandeel fishing linked to Scottish seabird decline", *The Scotsman*, 1 December 2013, http://www.scotsman.com/news/environment/sandeel-fishing-linked-to-scottish-seabird-decline-1-3216052

63 Fisheries Research Services, "Sandeels in the North Sea", http://www.scotland.gov.uk/Uploads/Documents/ME01ASandeels.pdf

64 D. O'Drisceoil, "The English Market: Historical Overview", accessed 3 November 2014, http://www.englishmarket.ie/historygallery/historicaloverview-donalodrisceoil/

65 Lauria, et al., "Influence of Climate Change".

66 Hammond, et al., "Distribution and abundance of the Harbour Porpoise".

67 P.S. Hammond, et al., "Background Information on Marine Mammals for Strategic Environmental Assessment 8" (London: UK Department of Energy and Climate Change's Offshore Energy Strategic Environmental Assessment Programme , 2008), https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/197015/SEA8_TechRep_MarineMammals.pdf

68 "Ecosystem Overview for the Celtic Sea", accessed 3 November 2014, http://www.marine.ie/NR/rdonlyres/4ED04155-E5D6-4CD5-A2B5-A39651DAEEE2/0/EcosystemCelticSea.pdf

69 IUCN, "Basking Shark (*Cetorhinus maximus*)", IUCN Red List, accessed 3 November 2014, http://www.iucnredlist.org/details/4292/0

70 J.K. Pinnegar, et al., "Long-term Changes in the Trophic Level of the Celtic Sea Fish Community and Fish Market Price Distribution", *Journal of Applied Ecology* 39 (2002), 377-390.

71 J. Sharples et al., "Fishing and the oceanography of a stratified shelf sea" *Progress in Oceanography* 117 (2013), 130-139.

72 Pinnegar et al., "Long-term changes".

73 S. Guenette and D. Gascuel, "Shifting baselines in European fisheries: The case of the Celtic Sea and Bay of Biscay", *Ocean & Coastal Management* 70 (2012), 10-21.

74 ICES, "Cod in Divisions VIIe–k (Celtic Sea cod): Advice for 2015", http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2014/2014/cod-7e-k.pdf

75 CEFAS, "Discard Atlas of the North Western Waters Demersal Fisheries" (2014), http://www.seafish.org/media/1337323/discardatlas_nww_demersalfisheries_201412.pdf

76 Pinnegar et al., "Long-term Changes".

77 A.D. Smith, et al., "Impacts of Fishing Low Trophic-Level Species on Marine Ecosystems", *Science* 333: 6046 (2011), 1147-1150. doi: 10.1126/science.1209395

78 Shephard, et al. "Size-selective fishing".

79 S. Shephard, et al., "Modelling Recovery of Celtic Sea Demersal Fish Community Size-Structure", *Fisheries Research* 140 (2013), 91-95.

80 ICES, "Cod in Divisions VIIe–k (Celtic Sea cod)" into: ICES, "Cod in Divisions VIIe–k (Celtic Sea cod): Advice for 2015", http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2014/2014/cod-7e-k.pdf.

81 ICES, "Haddock in Divisions VIIb–k: Advice for 2015", http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2014/2014/had-7b-k.pdf

82 Gerald of Wales, translated by J. O' Meara, *The History and Topography of Ireland* (Penguin Books, London, 1982), Kindle Edition.

83 J. Waddell, "The Irish Sea in Prehistory", *Journal of Irish Archeaology* VI 91/92 (1992), 29-40.

84 Wessex Archaeology, "Strategic Environmental Assessment", 18.

85 H. Browne, "Where Will They Get the Fish?" *Dublin Review*, Winter 2008-09 (2009), http://thedublinreview.com/fish/

86 T. O'Neill, "Trade and Shipping on the Irish Sea in the Later Middle Ages", In: M. McCaughan and J. Appleby, eds., *The Irish Sea: Aspects of Maritime History* (Belfast: The Institute of Irish Studies, 1989), 29.

87 http://www.measuringworth.com/exchange/

88 Browne, " Where Will They Get the Fish?"

89 M. McCaughan, "Dandys, Luggers, Herring and Mackerel", In: M. McCaughan and J. Appleby, eds., *The Irish Sea: Aspects of Maritime History* (Belfast: The Institute of Irish Studies, 1989), 125.

90 A.J.R. Cotter et al., "Summary of Commercial Marine Fishing by English and Welsh Vessels ≥ 10 Metres LOA for 2004" (Lowestoft: Cefas, 2006), 134, http://www.cefas.defra.gov.uk/publications/techrep/tech134.pdf

91 "Maritime Arklow", accessed 3 November 2014, http://wicklowcoast.com/maritime-arklow

92 C. Coulter, "Northern Ireland: Agriculture, Forestry and Fishing", *Encyclopaedia Britannica* (updated 5 October 2013, accessed 3 November 2014), http://www.britannica.com/EBchecked/topic/419739/Northern-Ireland/44645/Agriculture-forestry-and-fishing

93 D. Whelan, "Restless Disquiet in Kilkeel—The Town Built on Fishing", *Belfast Telegraph*, 18 February 2014, http://www.belfasttelegraph.co.uk/news/environment/restless-disquiet-in-kilkeel-the-town-built-upon-fishing-30018513.html

94 OSPAR Commission. *Quality Status Report 2000, Region III—Celtic Seas*, OSPAR Commission, London, 2000.

95 "Trout and Salmon Fishing in Ireland", accessed 2 December 2014, http://irelandflyfishing.com/rivers/river-liffey

96 "Management of Salmon Fisheries," accessed 3 November 2014, http://www.nasco.int/fisheries.html

97 "Why Are Salmon Dying at Sea?" accessed 3 November 2014, http://www.marine.ie/home/aboutus/newsroom/PressReleaseArchive/2008/WhyAreSalmonDyingAtSea.htm

98 N. Weir, "Irish Sea Mystery as Fish Stocks Continue to Decline", BBC News, 6 August 2014, accessed 3 December 2014, http://www.bbc.com/news/uk-northern-ireland-28672011

99 ICES, "Report of the ICES Advisory Committee 2008", ICES Advice, Book 5 (2008) .

100 K.M. Brander, *The Management of Irish Sea Fisheries—A Review* Laboratory Leaflet No. 36 (Ministry of Agriculture Fisheries and Food, Lowestoft, UK, 1977), http://www.cefas.defra.gov.uk/publications/lableaflets/Lableaflet36.pdf

101 P.J. Schon et al. Annex 8: Stock Annex Irish Sea Herring VIIa (N). ICES Herring Assessment Working Group Report (2014), http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2014/HAWG/24%20HAWG%20Report%20-%20Annex%2008%20Stock%20Annex%20Irish%20Sea%20Herring%20VIIa%20(N).pdf

102 "Fisheries and Aquaculture" (Department of the Environment, Northern Ireland), accessed 3 November 2014, http://www.doeni.gov.uk/niea/4_fisheries_and_aquaculture.pdf

103 Ibid.

104 J.R. Coull, *The Sea Fisheries of Scotland: A Historical Geography* (Edinburgh: John Donald Publishers, 1996), 23. 308pp.

105 Ibid.

106 "Ferriter's Cove Bronze Age Site", accessed 3 November 2014, http://www.ancientireland.org/ferriter/index.htm

107 Coull, *The Sea Fisheries of Scotland,* 137.

108 D. Graham, "A History of Fishing on the Dingle Peninsula", *Ireland's Dingle Peninsula* (1996), http://www.dingle-peninsula.ie/culture1.html

109 "Fishery Harbours" (Department of Agriculture, Food and the Marine), accessed 3 November 2014, https://www.agriculture.gov.ie/fisheries/fisheryharbours/

110 OSPAR Commission. *Quality Status Report 2000, Region III—Celtic Seas,* Chapter 2: Geography, Hydrography and Climate, OSPAR Commission, London, 2000.

111 OSPAR Commission, *Quality Status Report 2000, Region III—Celtic Seas,* Chapter 5: Biology, OSPAR Commission, London, 2000.

112 J.B. Reid et al., "Seabirds of the Atlantic Frontier, North and West of Scotland", *Continental Shelf Research* 21 (2001), 1029-1045.

113 "Birds of the Outer Hebrides". *Western Isles Wildlife*, accessed 3 November 2014, http://www.western-isles-wildlife.com/birds.htm

114 C. Jones, "Bird Watching in Ireland", *Ireland's Wildlife* (2013), http://www.irelandswildlife.com/bird-watching-ireland/

115 C.R. Weir, et al., "Cetaceans of the Atlantic Frontier, North and West of Scotland", *Continental Shelf Research* 21 (2001) 1047-1071.

116 Scottish Natural Heritage. "Seals in Scotland: Where Are They?" http://www.snh.org.uk/publications/on-line/naturallyscottish/seals/sealsinscotland.asp

117 Ibid.

118 D.G. Roberts et al., "The Western Rockall Plateau: Stratigraphy and Structural Evolution", *Deep Sea Drilling Project*, Vol XLVIII (2007), http://www.deepseadrilling.org/48/volume/dsdp48_55.pdf

119 Fisher, J. "Rockall" (London: Bles, 1956), 12-13.

120 O. Bowcott, "Who owns Rockall? A History of Legal and Diplomatic Wrangles", *The Guardian*, 30 May 2013, http://www.theguardian.com/uk/2013/may/30/who-owns-rockall-legal-history-hancock.

121 E.M. DeSanto and P.J.S. Jones, "The Darwin Mounds: From Undiscovered Coral to the Development of an Offshore Marine Protected Area Regime," *Conservation and Adaptive Management of Deep-Sea Coral Ecosystems* (2007), 147-156, http://www.homepages.ucl.ac.uk/~ucfwpej/pdf/DarwinBMS.pdf

122 "New Discovery of Deep-Water Coral Reefs in UK Waters" (British Geological Survey, 2010), accessed 3 November 2014, http://www.bgs.ac.uk/research/highlights/2010/ukcoral.html

123 "New Coral Reef Found Off West Coast", *BreakingNews.ie* (26 May 2009), http://www.breakingnews.ie/ireland/new-coral-reef-found-off-west-coast-412371.html

124 A.W. Newton et al., "Rockall and the Scottish Haddock Fishery", *Fisheries Research* 94 (2008), 133-140.

125 Bjørndahl and Ekerhovd, "Management of Pelagic Fisheries".

126 Ibid.

127 M.R. Payne et al., "The Rise and Fall of the NE Atlantic Blue Whiting (*Micromesistius poutassou*)", *Marine Biology Research* 8 (5-6) (2012), 475-487.

128 Ibid.

129 ICES, "Mackerel in the Northeast Atlantic (combined Southern, Western, and North Sea spawning components): Updated Advice for 2014", http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2014/2014/mac-nea_update_2014.pdf

130 Ibid.

131 Marine Stewardship Council, "Mackerel fisheries unite to start MSC reassessment", accessed 12 February 2015, http://www.msc.org/newsroom/news/mackerel-fisheries-unite-to-start-msc-reassessment/?searchterm=mackerel.

132 T. Morato et al., "Seamounts are Hotspots of Pelagic Biodiversity in the Open Ocean", *Proceedings of the National Academy of Sciences* 107:21 (2010), http://www.pnas.org/content/107/21/9707.full.pdf

133 ICES, "Orange Roughy (Hoplostethus atlanticus) in the Northeast Atlantic: Advice Summary for 2013 and 2014", http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2012/2012/Orange%20roughy.pdf

134 N. Foley et al., "The Rise and Fall of the Irish Orange Roughy Fishery: An Economic Analysis", *Marine Policy* 35:6 (2011), 756-763.

135 R.H. Thurston and C.M. Roberts, "Ecological Meltdown in the Firth of Clyde, Scotland: Two Centuries of Change in a Coastal Marine Ecosystem", *PLoS One* 5(7): e11767 (2011). DOI: 10.1371/journal.pone.0011767

136 Ibid.

137 ICES, "Whiting in Division VIa (West of Scotland): Advice for 2015". http://ices.dk/sites/pub/Publication%20Reports/Advice/2014/2014/whg-scow.pdf

138 M. Allsop et al., *State of the World's Oceans* (New York: Springer, 2009), 37.

139 M.L. Weber, *From Abundance to Scarcity: A History of U.S. Marine Fisheries Policy* (Washington, D.C.: Island Press, 2002), 14.

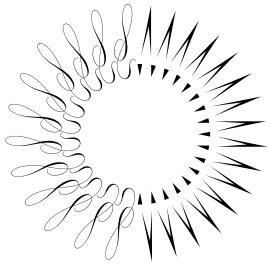
140 European Council. "Council Regulation (EEC) No 170/83 Establishing a Community System for the Conservation and Management of Fishery Resources", 25 January 1983.

141 European Council. "Council Regulation (EC) No 2371/2002 on the Conservation and Sustainable Exploitation of Fisheries Resources under the Common Fisheries Policy", 20 December 2002.

142 B. O'Leary, et al., "Fisheries mismanagement", *Marine Pollution Bulletin* 62(12) (2011), 2642-2648.

143 Commission of the European Communities, "Green Paper: Reform of the Common Fisheries Policy", COM(2009)163 final, 22 April 2009.

144 European Union. "Regulation (EU) No. 1380/2013 of the European Parliament and of the Council on the Common Fisheries Policy, amending Council Regulations (EC) No. 1954/2003 and (EC) No. 1224/2009 and repealing Council Regulations (EC) No. 2371/2002 and (EC) No. 639/2004 and Council Decision 2004/585/EC", 11 December 2013.



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