11.2 Icelandic Waters ecoregion – Fisheries overview

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Executive summary

The majority of fishing in the Icelandic Waters ecoregion is performed by Icelandic vessels. Around 1750 fishing vessels, from all countries, operate in this ecoregion. Half of these vessels are smaller than 10 m, and mainly operate in inshore waters. The spatial distribution of the larger vessels varies across the ecoregion, while the demersal fisheries are considered largely mixed fisheries, but species composition varies depending on the area and gear used.

Catches are taken from over 40 stocks, five of which are widely distributed pelagics. Total landings peaked in the mid-1990s at two million tonnes, and have since declined to about one million tonnes. Pelagic fish landings have been larger than demersal fish landings since the early 1990s. Total fishing effort has also declined substantially.

Cod is mainly taken in trawl and longline fisheries and accounts for the highest landings of demersal species, followed by saithe, golden redfish, haddock, and Greenland halibut; these are mainly taken by demersal trawls. Capelin, herring, and mackerel are caught by pelagic trawls and seines, and account for the largest portion of the pelagic landings. Discarding is prohibited for most commercial stocks; there are, however, no reliable estimates available on discards.

Stocks with the main distribution area in the ecoregion are assessed for stock status and fishing pressure. Spawning-stock biomass has been assessed to be above $B_{trigger}$, while the exploitation rate has declined in recent years and is now at F_{MSY} or HR_{MSY} in most cases.

Incidental bycatch of harbour porpoise, seals, and seabird species occur in several fisheries, especially in gillnet fisheries.

Introduction

The Icelandic Waters ecoregion covers the shelf and surrounding waters inside the Icelandic Exclusive Economic Zone (EEZ) (Figure 1). The region is located at the junction of the Mid-Atlantic Ridge and the Greenland–Scotland Ridge, just south of the Arctic Circle. The ocean and coastal shelves are heavily influenced by oceanic inputs where water masses of different origin mix; further details can be found in the ecosystem overview (ICES, 2018).

The fisheries within the ecoregion catch more than 40 stocks of fish and marine invertebrates. The main demersal species include cod, haddock, saithe, golden redfish, Greenland halibut, plaice, Atlantic wolffish, tusk, and ling. The main pelagic species are capelin and summer-spawning herring, as well as widely distributed species such as Norwegian spring-spawning herring, blue whiting, and mackerel. *Nephrops*, Northern shrimp, and sea cucumber are the main invertebrate stocks that are exploited in Icelandic waters.

The fisheries for most stocks in this ecoregion are managed by the Icelandic Government, while management of some shared stocks is conducted through the North East Atlantic Fisheries Commission (NEAFC), or by coastal state agreements (between Iceland, Greenland, the Faroe Islands, and Norway).

Pelagic fishing for capelin, herring, mackerel, and blue whiting, using pelagic trawl and purse-seine, accounts for the largest catches (by weight). The most important demersal fisheries are the bottom-trawl fisheries for cod, haddock, saithe, and redfish conducted on the continental shelf all around Iceland. Owing to the widely distributed nature of herring, mackerel, and blue whiting, these stocks are not presented in the "Status of fisheries resources" section of this document.

This overview covers ICES Division 27.5.a, and parts of divisions 27.2.a, 27.5.b, 27.12.a, 27.14.a, and 27.14.b (hereafter, the area prefixes are omitted), and provides:

- a short description of each of the national commercial fishing fleets in the ecoregion, fishing gears, and patterns. At present fisheries for diadromous species such as salmon and recreational fisheries are not included;
- a summary of the status of the resources and the level of exploitation relative to agreed objectives and reference points; and
- an evaluation of the effects of fishing gear on the ecosystem through physical contact on subsurface and bottom habitats, and on the bycatch of protected species.

Scientific names of all species are included in Table A3 in the Annex.

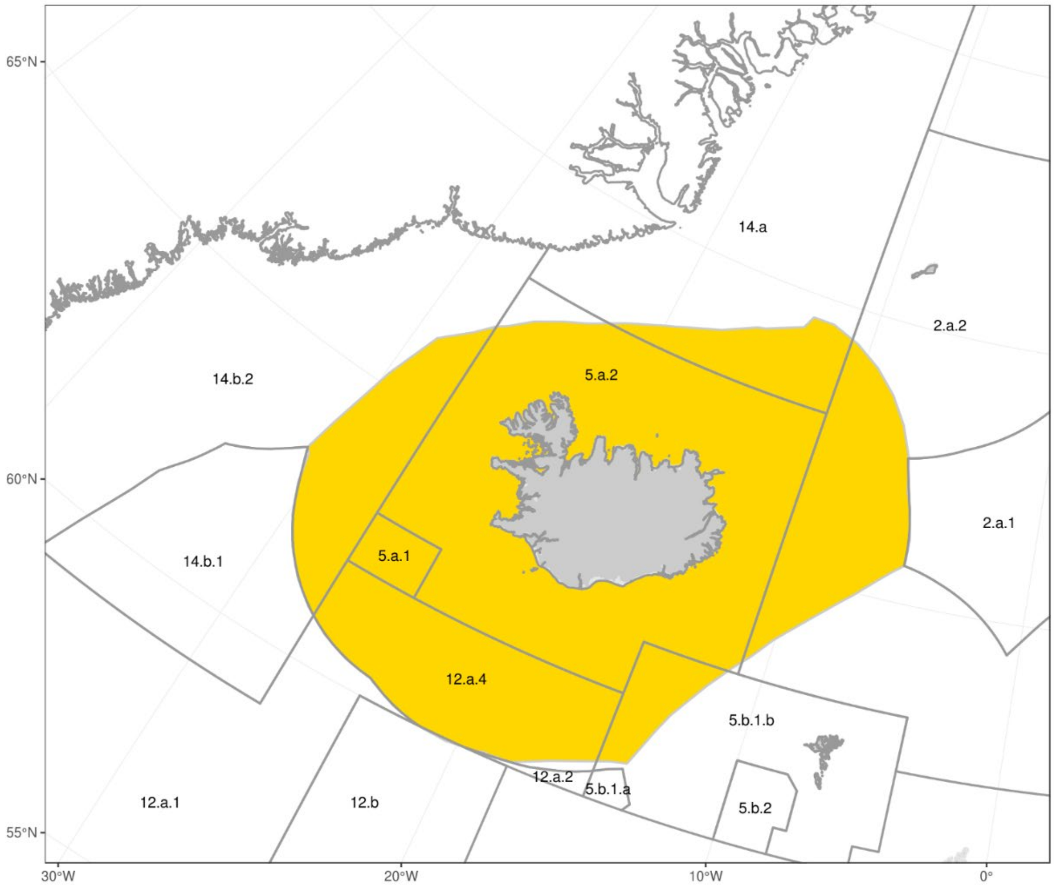


Figure 1 The Icelandic Waters ecoregion (highlighted in yellow). The relevant ICES statistical areas are shown.

Who is fishing

The majority of fishing in the Icelandic Waters ecoregion is performed by Icelandic vessels. Vessels from Norway, Greenland, and the Faroe Islands are also allowed to fish within the Icelandic EEZ through coastal state and bilateral agreements. Since 1978, a 200 nautical mile EEZ has been established which excludes foreign vessels not subject to those agreements (Figure 2). Around 1750 vessels operate in Icelandic waters. The following paragraphs highlight features of the fleets and fisheries of the different countries that operate within the Icelandic EEZ.

Iceland

Currently, the Icelandic fleet consists of around 1640 vessels of various sizes and types. About 50 bottom trawlers (30–80 m) operate in Icelandic waters; these vessels mainly fish for cod, haddock, saithe, redfish, and Greenland halibut. Between 20 and 25 pelagic vessels (60–90 m length) fish for capelin, herring, mackerel, and blue whiting using pelagic trawls and purse-seines. Roughly 45 demersal seiners (10–45 m length) operate in Icelandic waters, fishing for cod, haddock, plaice, and other flatfish species. The number of intermediate-sized vessels (mostly 10–50 m length) using static gear, i.e. longline and gillnet, or small otter trawls, fishing for *Nephrops*, Northern shrimp, cod, and haddock, is around 650. Approximately 850 small vessels (handline vessels < 10 m length), fishing mainly for cod and lumpfish have participated in the fishery in recent years. Two large vessels (50 m length) participate in the fin whale hunt, whereas 3–5 small vessels (< 10 m) participate in the minke whale hunt.

The Faroe Islands

Through a coastal states agreement, the Faroe Islands have a quota of the Iceland–Greenland–Jan Mayen capelin stock, which they are allowed to fish within the Icelandic EEZ. From 2015 to 2018, 4–6 pelagic vessels using pelagic trawls were directed to capelin. There is a bilateral agreement (revised annually) between Iceland and the Faroe Islands allowing Faroese longliners to fish for demersal species in the Icelandic EEZ. Since 2011, around 15 Faroese longliners have operated in Icelandic waters, fishing mainly cod, haddock, ling, and tusk.

Greenland

Through a coastal states agreement, a quota of the Iceland–Greenland–Jan Mayen capelin stock is assigned to Greenland, which can be taken within the Icelandic EEZ. From 2015 to 2018, between 1 and 3 pelagic vessels, using pelagic trawls and purse-seines, have operated in Icelandic waters.

Norway

Through a coastal states agreement, a quota of the Iceland–Greenland–Jan Mayen capelin stock is assigned to Norway, which can be taken within the Icelandic EEZ. From 2015 to 2018, between 46 and 67 pelagic vessels, using pelagic trawls and purse-seines, have operated in Icelandic waters. There is a bilateral agreement between Iceland and Norway for two Norwegian longliners to catch demersal fish, mainly ling and tusk.

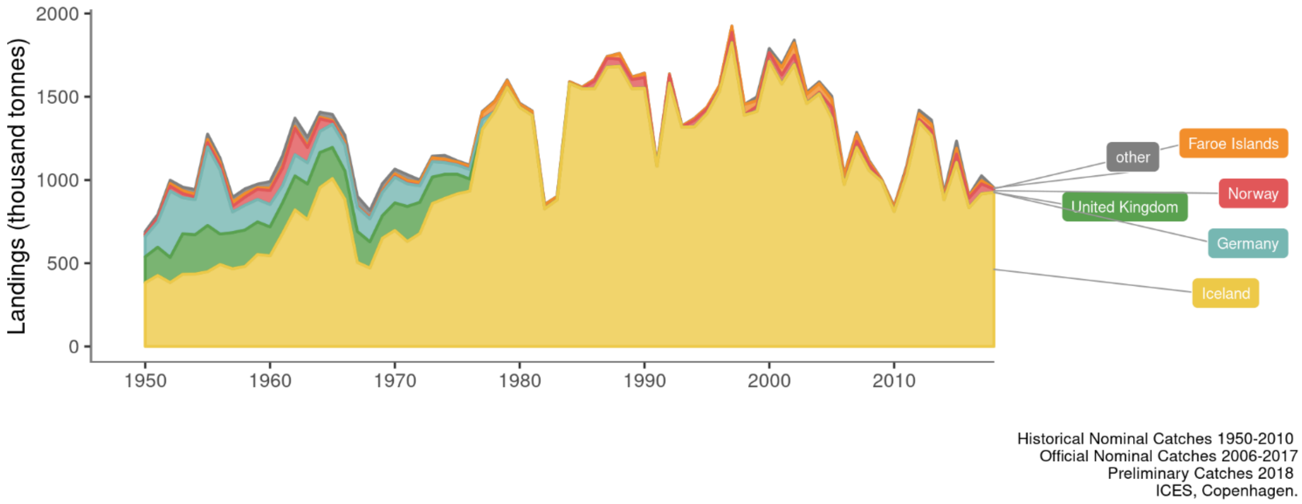


Figure 2 Landings (thousand tonnes) from the Icelandic Waters ecoregion in 1950–2018, by country. The five countries with the highest landings are displayed separately, while the remaining countries are aggregated and displayed as "other".

Catch over time

Fisheries within the Icelandic Waters ecoregion catch a wide range of species, including those considered to be demersal, benthic, pelagic, widely distributed, and deep water. The principal species targeted in the commercial fisheries are cod, haddock, saithe, two redfish species, Greenland halibut, capelin, herring (Icelandic summer-spawning herring and Norwegian spring-spawning herring), mackerel, and blue whiting. The fisheries for cod, haddock, saithe, and redfish species use mainly demersal trawls, longlines, and gillnets; herring, capelin, mackerel, and blue whiting are mainly caught by pelagic trawls and purse-seines. Other target species that have local economic importance include plaice, lemon sole, ling, tusk, Atlantic wolfish, lumpfish, Northern shrimp, *Nephrops,* and a newly developed fishery for one species of sea cucumber.

Landings

Total landings from Icelandic waters doubled, from 750 thousand tonnes in the early 1950s to about 1.5 million tonnes in the late 1960s (Figure 2). This was due to increased herring catches; with the collapse of the Norwegian spring-spawning and the two local Icelandic herring stocks in the late 1960s, however, total landings fell to a similar level to the early 1950s and consisted of mainly demersal species. Total landings increased again from the early 1970s to the mid-2000s, when it peaked at about 1.8 million tonnes. This increase was driven by the exploitation of pelagic species previously not fished in the Icelandic Waters ecoregion: a capelin fishery starting in the early 1970s, a blue whiting fishery starting in the late 1990s, and mackerel fishing beginning in the mid-2000s. Total demersal landings decreased in the same period, until the mid-1990s, due mainly to decreased landings of cod. Since the mid-2000s, total landings have decreased to around 1.1–1.3 million tonnes annually because of decreased pelagic landings (mainly capelin).

The demersal fisheries show a generally declining trend from the early 1950s to the mid-1990s, and have been stable since then (Figure 3). Cod, haddock, saithe, and golden redfish account for the highest landings of demersal species (Figure 4). Landings of pelagic fish have fluctuated during the same period. Since the early 2000s the relative importance of capelin has decreased while the relative importance of blue whiting, Norwegian spring-spawning herring, and mackerel has increased. Crustacean fisheries (*Nephrops* and Northern shrimp) have decreased substantially since the early 1990s, due mainly to decreased landings of Northern shrimp.

Pelagic fisheries, using pelagic trawl and purse-seines, generally account for the largest proportion of the total landings; these are followed by the demersal trawl and seine fisheries, and then by the longline and gillnet fisheries (Figure 5). Reduced pelagic catches were caused by the collapse of various pelagic fish stocks.

Around 200 minke whales were landed annually between 1973 and 1986, until the moratorium on all commercial whaling was declared by the International Whaling Commission (IWC). Commercial whaling for minke whales was resumed in 2007, annual landings have varied but with a decreasing trend. The landings on minke whales peaked in 2009 with 81 animals, but only 6 animals in 2018. Annual landings of fin whales were 150–300 animals between 1948 and 1985. After resuming commercial fin whaling in 2009, the landings have been on average 140 animals per year. There was no fin whaling during 2011–2012 and 2016–2017.

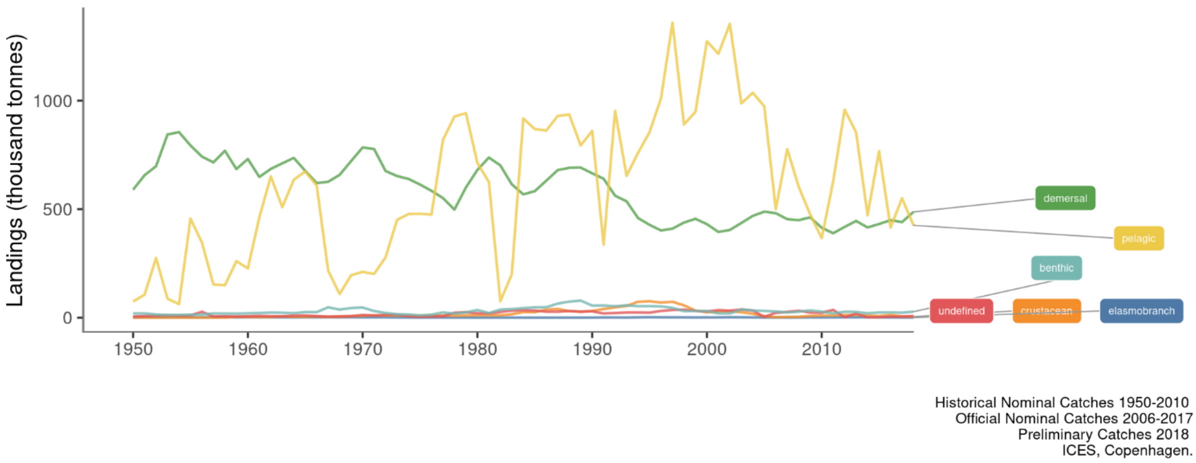


Figure 3 Landings (thousand tonnes) from the Iceland Waters ecoregion in 1950–2018, by fish category. Table 2 in the Annex details which species belong to each fish category.

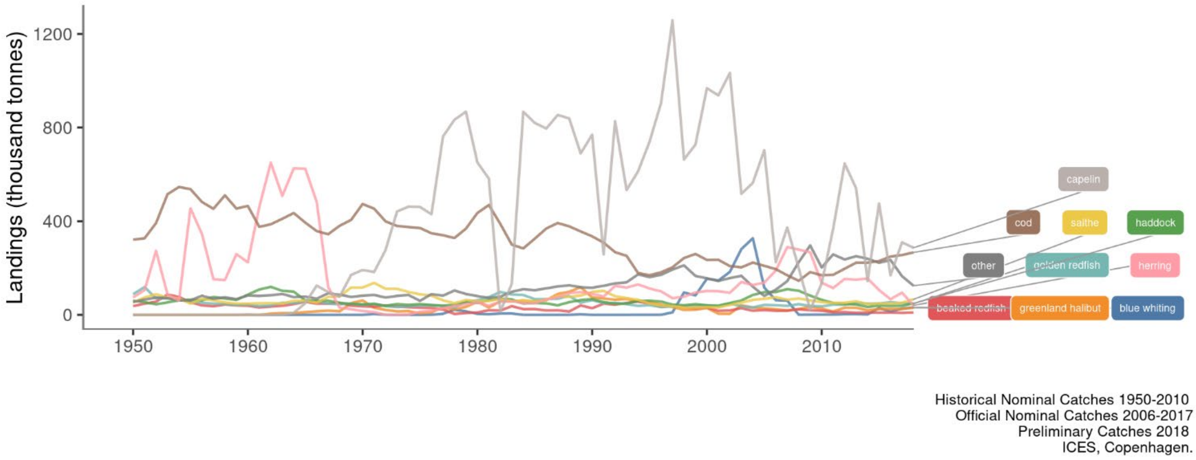


Figure 4 Landings (thousand tonnes) from the Icelandic Waters ecoregion in 1950–2018, by species. The nine species with the highest landings are displayed separately; the remaining species are aggregated and labelled as "other".

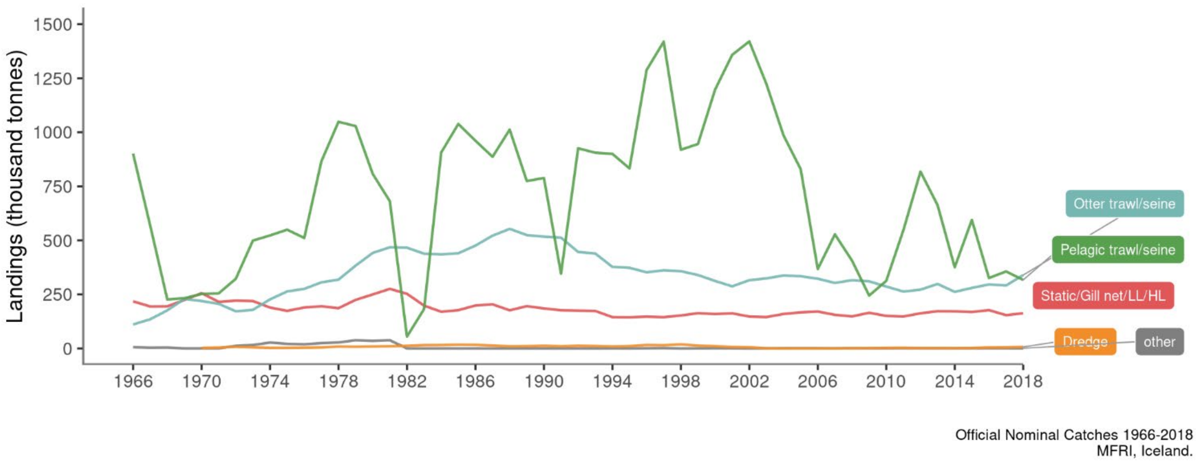


Figure 5 Landings (thousand tonnes) of the Icelandic fleet from the Icelandic Waters ecoregion in 1966–2018, by gear type (LL = longline; HL = handline).

Discards

Discarding is banned for species within the individual transferable quota (ITQ) system, and are subject to total allowable catches (TACs). Fishing vessels are therefore required by law to land all catches of those species. Species that have low or no commercial value, and are not restricted by a TAC, can be discarded. Estimates of discards based on highgrading (i.e. discarding fish of low value) for cod and haddock are available for the period 2001–2015. Discards of cod are estimated to range from 0.05 to 2.40% of the total catch in tonnes during this period. The discard rate of haddock is similar.

Description of the fisheries

Fisheries within the Icelandic Waters ecoregion use a variety of fishing gears to catch a wide range of species, including those considered to be demersal, benthic, pelagic, widely distributed, and deep water. The bulk of the fisheries, both pelagic and demersal, occurs at depths less than 500 m. There has been an overall reduction in fishing effort since 1991 (Figure 6) for all fisheries, except those using handlines where it has increased. The spatial distribution of fishing effort by gear type is depicted in Figure 7.

Otter trawlers account for the majority of the fishing effort (Figure 6). Otter trawl fishing occurs on the continental shelf and slope in the ecoregion, but is highest close to the continental slope northwest of Iceland (Figure 7). In some areas, and depending on vessel size and fisheries, otter trawling is not allowed within 3–12 nautical miles of land. Static gears (longlines, gillnets, and handlines) account for the next highest levels of effort. These fisheries occur on the continental shelf and slope all around Iceland. Pelagic trawl and seine efforts have fluctuated during the period 1991–2018, without any clear long-term trend. Pelagic trawl and seine fisheries operate throughout the ecoregion, but vary both spatially and temporally depending on the target species. Demersal seine effort occurs mainly in relatively shallow waters in the southern and western part of the ecoregion. Dredge fisheries are concentrated on sea cucumber grounds west and east of Iceland, as well as on sea urchin and scallop grounds in the west.

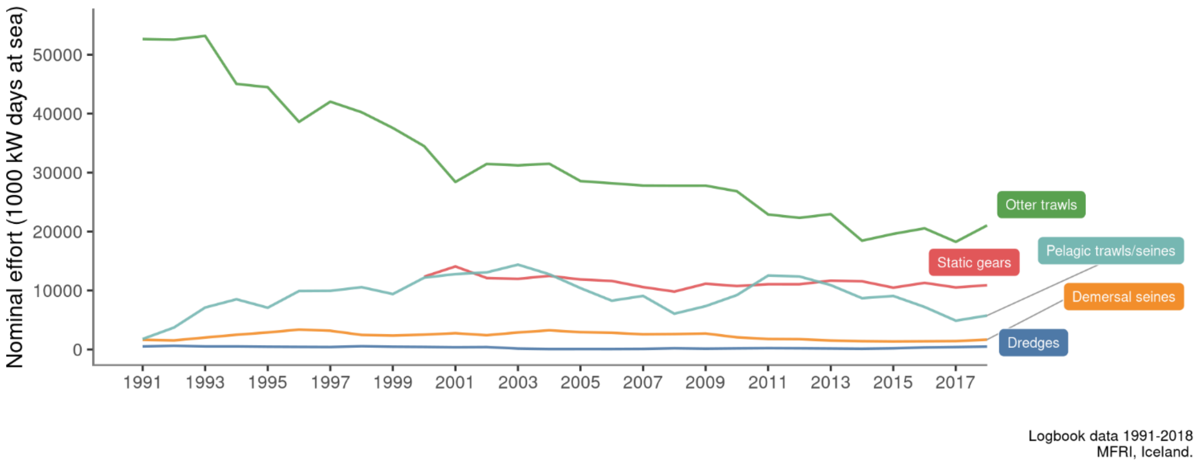


Figure 6 Fishing effort (thousand kW days-at-sea) in the Icelandic Waters ecoregion in 1991–2018, by gear type.

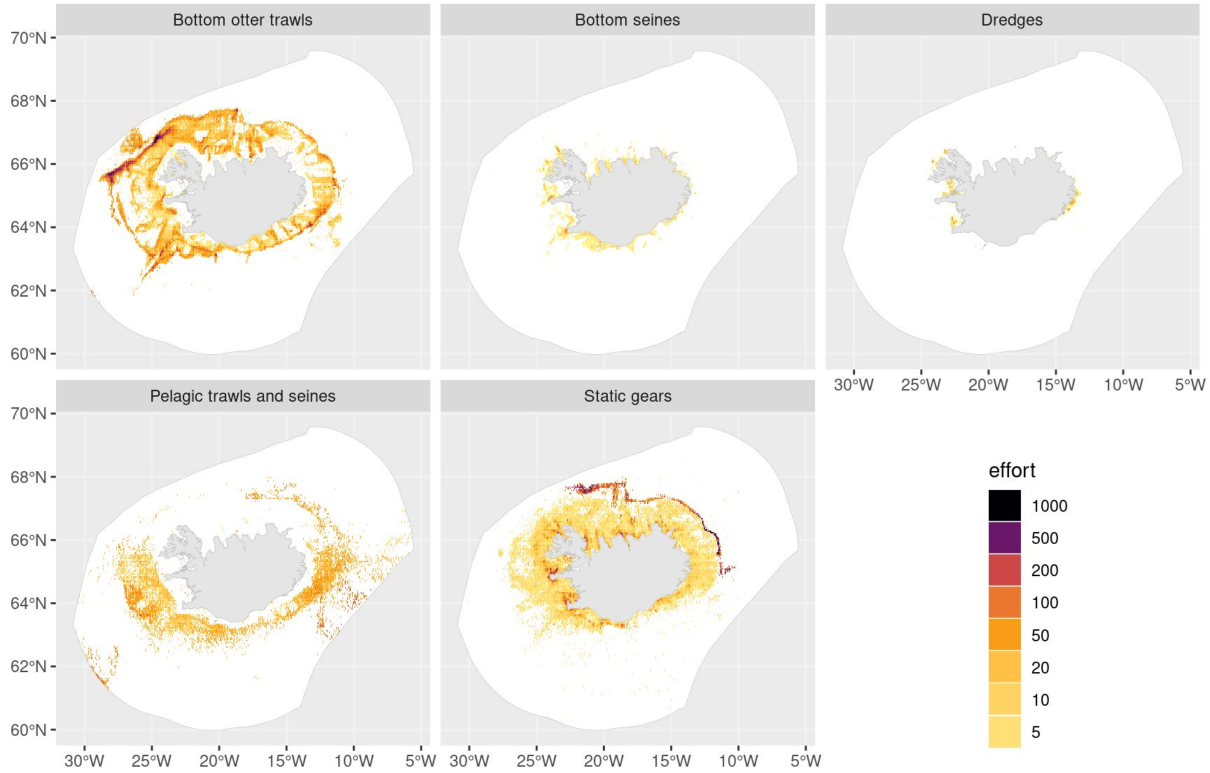


Figure 7 Spatial distribution of average annual fishing effort (mW fishing hours) in the Icelandic Waters ecoregion from 2014 to 2018, by gear type.

Bottom otter trawl fisheries

Otter trawls account for the majority of the fishing effort in the Icelandic Waters ecoregion (Figure 6). Since 1991, the otter trawl effort has decreased substantially. The species composition of the catch depends on the area and depth fished as well as the gear design, including codend mesh size.

Otter trawl effort is highest on the continental shelf edge, particularly west and northwest of Iceland, targeting cod, saithe, and golden redfish and using a mesh size of 135 mm in the codend (Figure 7). There is also a substantial otter trawl fishery for haddock on the continental shelf around Iceland; it is in shallower waters, however, than the fishery targeting cod. In deeper waters (500–1000 m) on the shelf edge, the main target species are Greenland halibut (in the north and east), demersal beaked redfish (mainly southwest and west), and greater silver smelt (south and southwest). Otter trawlers using smaller mesh otter trawls (70–100 mm) primarily target *Nephrops* in areas south and southwest of Iceland, and shrimp (mesh size ~40 mm) north of Iceland.

Demersal seine fisheries

Demersal seine fisheries operate mainly on soft bottom, close to land, west and south of Iceland; they target various flatfish species such as plaice and lemon sole, but also cod, haddock, and Atlantic wolffish. Demersal seine effort has decreased by more than half during the period 1991–2018 (Figure 6).

Static gear fisheries (gillnet, longline, and handline)

Gillnet fisheries operate mainly in shallow waters, and are directed at cod during its migration to the main spawning grounds south and west of Iceland in the first and second quarter. There is also a gillnet fishery conducted in very shallow areas in fjords north and west of Iceland, targeting lumpfish. Gillnet fisheries conducted in deeper areas target Greenland halibut and anglerfish. Total gillnet effort has decreased by more than half in 2018, from a peak in 2004, mainly because of decreased gillnet fishery for cod and saithe. In the most recent three years, gillnet effort targeting Greenland halibut has increased considerably on the continental slope in the northern and eastern part of the ecoregion.

Longline effort has been relatively stable during 2005–2018, whereas handline effort has increased. These fisheries mainly operate in shallow waters, targeting cod and haddock. Longline fisheries in deeper waters target cod, tusk, ling, and blue ling.

Pelagic trawl and seine fisheries

The Icelandic fleet targeting the pelagic fish stocks in the ecoregion (herring, capelin, mackerel, and blue whiting) consists of large vessels that can operate with both pelagic trawls and purse-seines. Since 2005, the majority of the pelagic fish stocks have been taken with large pelagic trawls, whereas the purse-seine fishery has declined.

Capelin
Capelin is mainly caught from January to March, during its spawning migration along the southern and western coasts of Iceland. In some years, capelin has also been caught north and east of Iceland. Prior to 2000, most of the catches were used for fishmeal. This has changed, and part of the catches are now used for human consumption.

Herring
Two herring stocks, the Icelandic summer-spawning stock and the Norwegian spring-spawning stock, are exploited in the ecoregion using mainly pelagic trawls. Most of the catches are used for human consumption.

- The fishery for the Icelandic summer-spawning herring takes place on overwintering areas, mainly west and south of Iceland in autumn and winter (quarters three and four).
- The Norwegian spring-spawning herring stock ranges over a wide area in the North Atlantic, part of which includes the ecoregion. In 2007–2018, between 46% and 90% of the catch by the Icelandic fleet was taken in the ecoregion. The fishery occurs at the feeding grounds east of Iceland from August to November.

Mackerel
The Northeast Atlantic mackerel stock ranges over a wide area, part of which includes the ecoregion. Within the ecoregion, mackerel is mainly caught in pelagic trawls, but 2–5% are caught by handlines. Between 45% and 99% of the Icelandic mackerel catch in 2007–2018 was taken within the Icelandic EEZ. Mackerel is caught during its summer feeding migration (post-spawning) in the western, eastern, and southern parts of the ecoregion. Most of the catches are used for human consumption.

Blue whiting
The blue whiting stock ranges over a wide area, part of which includes the Icelandic Waters ecoregion. In 2000–2018, between 3% and 91% of the blue whiting catch by the Icelandic fleet came from the Icelandic EEZ, although these percentages have been relatively low in recent years (8–20% of the total Icelandic catch in 2006–2018, excluding 2011 when the catch was very limited due to small stock size). Since 2009, the main fishery of the Icelandic fleet has occurred in Faroese waters. The majority of the catches taken in the ecoregion are taken southeast of Iceland, but the fishing season varies between years. The Icelandic fleet targeting blue whiting consists of large pelagic trawlers. Blue whiting is mainly used for reduction into fishmeal and oil.

Deep pelagic beaked redfish
Since 1992, there has been a considerable international pelagic fishery for deep pelagic beaked redfish in the international waters of the Irminger Sea, southwest of Iceland; it has also extended into the Icelandic EEZ, where only Icelandic vessels can operate (Figure 7). This international fishery peaked in 1996 but has decreased considerably in recent years, and is now 20% of what it was in 1996. The Icelandic effort has decreased, from 1996 when 32 factory trawlers participated in the fishery, to 4–5 vessels in the most recent five years. The proportion of deep pelagic beaked redfish that is caught within the Icelandic EEZ varies from year to year, but in 2009–2018 was on average 61% of the Icelandic catch and 11% of the total catch.

Dredge fisheries

Dredges operate in shallow waters, both inshore and offshore, along the western and eastern coasts of Iceland. The most significant dredge fishery is a newly developed fishery, both inshore and offshore, on sea cucumbers. Other species caught in the dredge fishery are sea urchin, Iceland scallop, and ocean quahog; effort towards these species, however, has been low in recent years.

Whaling

The Icelandic minke whaling targets the whales at their feeding grounds, located to the west of Iceland. Since 2009, fin whaling has predominantly taken place off the continental shelf west of Iceland, but in 2014 and 2015 whaling moved further south and east. For fin and minke whaling, a 90 mm and 50mm harpoon cannon is used, respectively.

Fisheries management

Fisheries management within the Icelandic EEZ is under Icelandic legislation. The Ministry of Industries and Innovation is responsible for the management of Icelandic fisheries, and for the implementation of relevant legislation. The Ministry issues regulations for commercial fishing for each fishing year, including an allocation of TAC for each of the stocks subject to such limitations. The fisheries for some stocks are managed based on agreements by NEAFC and by coastal states. Fisheries advice is provided by the Marine and Freshwater Institute of Iceland (MFRI), and by ICES.

A system of transferable vessel quotas was introduced in 1984. An individual transferable quota (ITQ) system was established for the fisheries in 1990, and they were subject to vessel catch quotas. Since the 2006/2007 fishing season, all vessels operate under the TAC system. Individual vessel owners have substantial flexibility in exchanging quota in this system, both between vessels within individual companies and between different companies. The latter can be done via either a temporary or permanent transfer of quota.

Some flexibility is also allowed by individual vessels with regard to transfer of quota among species, with the exception of cod and Greenland halibut. These measures, which are accounted for more or less instantaneously, are likely to result in a weaker incentive to discard and misreport than can be expected if individual vessels are restricted by strict quota measures alone. They may, however, also result in fishing pressures of individual species that differ from that intended under the single-species TAC allocation.

With some exceptions, it is required by law to land all catches. Consequently, no minimum landing size is in force. To prevent fishing of small fish, various measures such as mesh-size regulations and the closure of fishing areas are in place. Support measures to the general system of management include real-time area closures: A short-term (usually two weeks) immediate closure system has been in force since 1976, with the objective of protecting juvenile fish. In 2018, 97 areas were closed. Longer-term closures can be established if needed, thus directing the fleet to other areas. The Directorate of Fisheries and the Coast Guard supervise these closures, in collaboration with the MFRI. There are also seasonal area closures, where the major spawning grounds of cod, Atlantic wolffish, plaice, and blue ling are closed during the main spawning season.

There are also designated protected areas, and these areas are closed for fisheries that may affect relevant habitats and species (Figure 8). There are 10 small areas southeast of Iceland that are closed for all fishing to protect cold-water corals. A large area west of Iceland is closed for otter and pelagic trawling, to protect juvenile golden redfish. In 2019, three areas southeast of Iceland were closed for otter trawling to protect *Nephrops*.

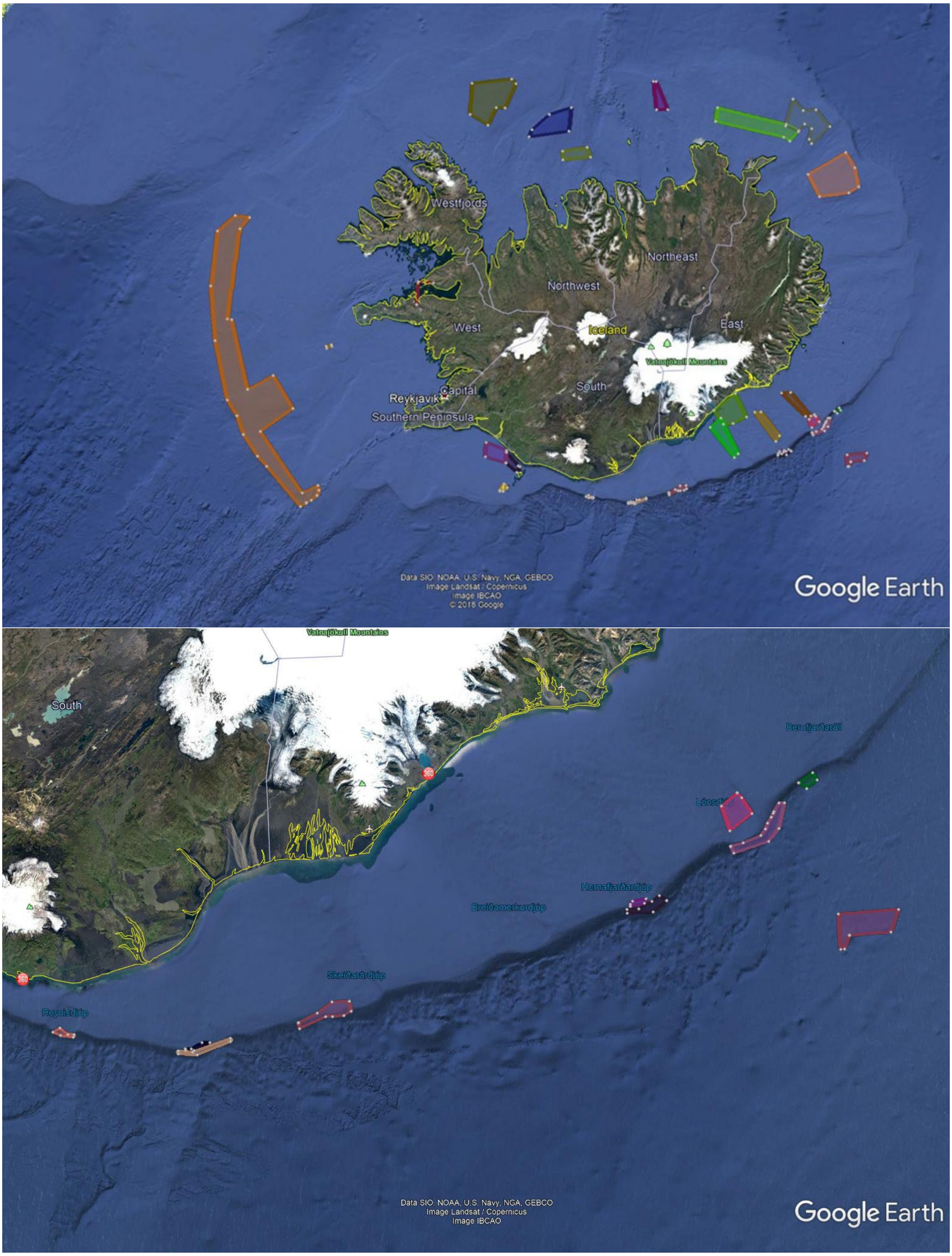


Figure 8 Top: Permanently closed areas for otter trawling. Bottom: Permanently closed areas for all fishing to protect cold-water corals.

Management plans have been implemented for cod, haddock, saithe, ling, tusk, golden redfish, capelin, and the Icelandic summer-spawning herring. These provide harvest control rules, safeguards to ensure that stocks remain within safe biological limits, and annual TAC change constraints. Before adoption, these plans were evaluated by ICES to ensure they were precautionary and in many cases conform with the ICES MSY approach.

Directed fisheries of Atlantic halibut, basking shark, dogfish, and porbeagle are prohibited, and all live specimens must be returned to the sea.

Management of whaling is based on the advice from MFRI, which is built on assessments on stock size undertaken by the scientific committees of the North Atlantic Marine Mammal Commission (NAMMCO) and the IWC.

Status of the fisheries resources

Twelve stocks in the ecoregion are analytically assessed by ICES and were evaluated against harvest rate (HR), maximum sustainable yield (MSY), and precautionary approach (PA) reference points. The status of these stocks has also been assessed relative to safe biological limits, i.e. $F < F_{pa}$ and $SSB > B_{pa}$ with the exception of capelin, which is assessed and managed on the basis of acoustic measurements and escapement strategy. For stock-specific information, see Table A1 in the Annex.

The most recent status of these stocks relative to safe biological limits is presented in Figures 9 and 10. Of these 12 stocks, nine are exploited at rates at or below F_{MSY} or HR_{MSY}. Mean spawning-stock biomass (SSB) of all stocks is above $B_{trigger}$, except for Icelandic spring-spawning herring. While the fishing mortality and biomass ratios are currently in a desirable condition for many of these stocks, three stocks in the ecoregion have current fishing mortality rates above F_{MSY} or HR_{MSY} (haddock, golden redfish, and Greenland halibut).

The stock status relative to F_{MSY} or HR_{MSY} and MSY $B_{trigger}$ for all eight stocks with analytical assessment is shown in Figure 11. For the five gadoid stocks, all are above MSY $B_{trigger}$, but haddock is the only one fished above HR_{MSY}. Saithe and ling are almost four times MSY $B_{trigger}$, and cod is almost three times MSY $B_{trigger}$. Greenland halibut and golden redfish are also above MSY $B_{trigger}$ but are fished above F_{MSY}. The Icelandic spring-spawning herring has the worst status, as SSB is below MSY $B_{trigger}$ but is fished below HR_{MSY}.

Mean fishing mortality for demersal and benthic fish stock groups has shown a declining trend since the mid-1990s (Figure 12). Fishing pressures of other species show the same trend and are currently at low values (Figure 12). Trends in biomass of gadoids show biomass indices that are two to three times higher than their lowest observed value. The biomass levels for three flatfish species, plaice, lemon sole, and witch, are currently around two times higher than the lowest observed value. Biomass of Atlantic wolffish is currently about two times higher than the lowest observed value, whereas the biomass index for spotted wolffish has decreased and is at its lowest level in the time-series.

Temporal trends in F and HR, and spawning-stock biomass (SSB) relative to MSY reference points, are shown in Figure 12. Also shown is F relative to F_{proxy}, and a biomass index for stocks where reference points have not been defined. For most stocks, marked improvements in stock status have occurred since 2000; in many cases fishing mortality ratios have declined below target reference points. Since 2000, the SSB and biomass ratios have shown an increasing trend and the mean values are now in most cases above reference points. Note that although the mean fishing mortality and biomass ratios are in a desirable condition, this does not imply that all stocks are in that condition.

A few species have been critically impacted by the fishery in the ecoregion. One of these species is Atlantic halibut. The biomass survey index for Atlantic halibut decreased between 1985 and 1995, and has since then remained at a low level. Additional management measures, a mandatory release of viable halibut and a landing ban, were introduced in 2012. Spotted wolffish is another species where the biomass is currently at its lowest observed level. Both of these species are currently bycaught in fisheries directed at other species.

Stocks of invertebrates in the ecoregion show a declining trend in biomass, and in some cases the stocks are at their lowest observed level. For some of the stocks, however, no reliable biomass estimates are available. Trends in biomass of Northern shrimp stocks show considerable decrease in indices of all nine stocks since the mid-1980s. Out of eight inshore shrimp stocks, five have collapsed to a very low level. The stock size of the three other inshore stocks are currently about 30% of the highest value, but above biomass reference points; a limited fishery is therefore allowed. The offshore Northern shrimp stock (the largest stock), has decreased by half since the mid-1980s but is currently 40% above biomass reference points. *Nephrops* are considered to be at a critically low level. The fishable biomass of *Nephrops* has decreased so substantially since 2009 that only a monitoring fishery is allowed. There is limited information on stock status of common whelk, sea urchin, and ocean quahog, but fisheries for these stocks have declined considerably in recent years. The Iceland scallop stock, in the main fishing area west of Iceland, collapsed in the early 2000s and no commercial fishery has been allowed since 2003. The collapse is linked to poor recruitment, combined with intensified fishing and high natural mortality due to protozoan infestation. A new fishery for sea cucumber developed to the west and east of Iceland, but little is known about stock status for this species.

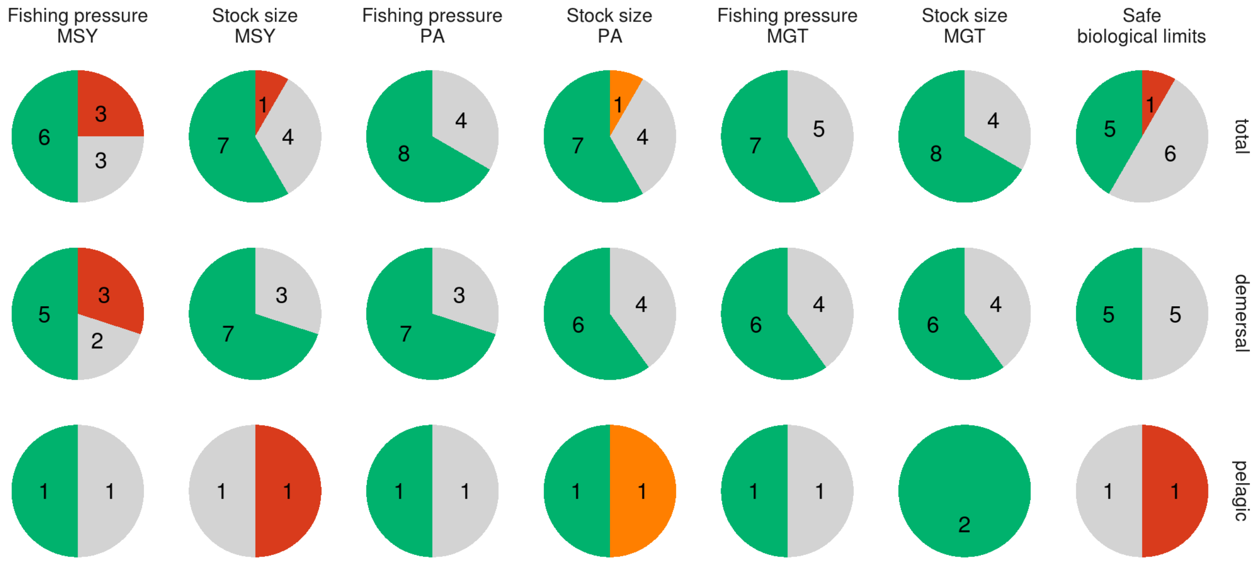


Figure 9 Status summary of Icelandic Waters ecoregion stocks, assessed by ICES, relative to the ICES maximum sustainable yield (MSY) approach and the precautionary approach (PA). Grey represents unknown reference points. For the MSY approach: green represents a stock that is fished at or below F_{MSY} or where the stock size is equal to or greater than MSY $B_{trigger}$; red represents a stock status that is fished above F_{MSY} or where the stock size is lower than MSY $B_{trigger}$. For the PA: green represents a stock that is fished at or below F_{pa} or where the stock size is equal to or greater than B_{pa}; orange represents a stock that is fished between F_{pa} and F_{lim} or has a stock size between B_{lim} and B_{pa}; red represents a stock that is fished above F_{lim} or has a stock size lower than B_{lim}. For MGT; green represents a stock that is fished at or below HR_{MSY} or where the stock size is equal to or greater than MSY $B_{trigger}$. Stocks having a fishing mortality below or at F_{pa} and a stock size at or above B_{pa} are defined as being inside safe biological limits. If this condition is not fulfilled, the stock is defined as being outside safe biological limits. For stock-specific information, see Table 1 in the Annex.

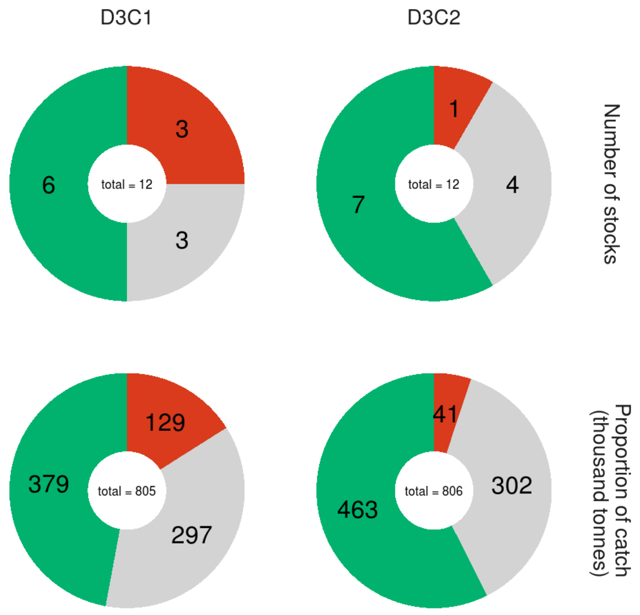


Figure 10 Status summary of Icelandic Waters ecoregion stocks, assessed by ICES in 2019, relative to the EU Marine Strategy Framework Directive (MSFD), good environmental status (GES), assessment criteria of fishing pressure (D3C1), and stock reproductive capacity (D3C2). Green represents either the proportion of stocks fished below F_{MSY} or where stock size is greater than MSY $B_{trigger}$, for criteria D3C1 and D3C2 respectively. Red represents either the proportion of stocks fished above F_{MSY} or where stock size is lower than MSY $B_{trigger}$, for criteria D3C1 and D3C2 respectively. Grey represents the proportion of stocks lacking MSY reference points. For stock-specific information, see Annex Table A1.

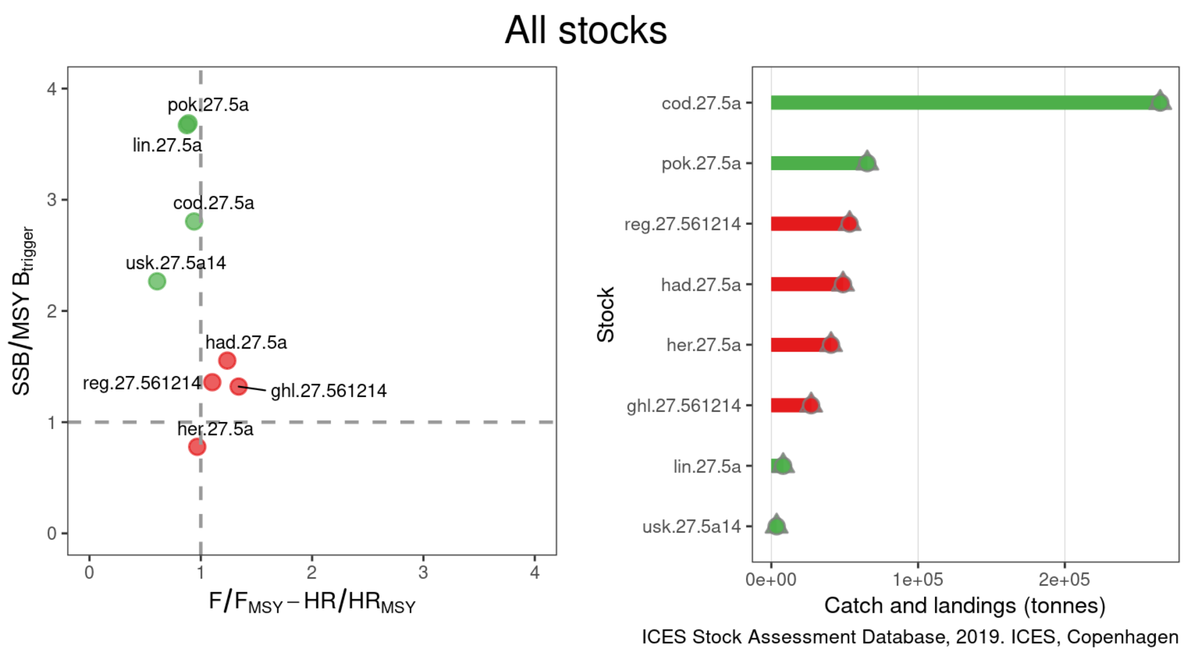
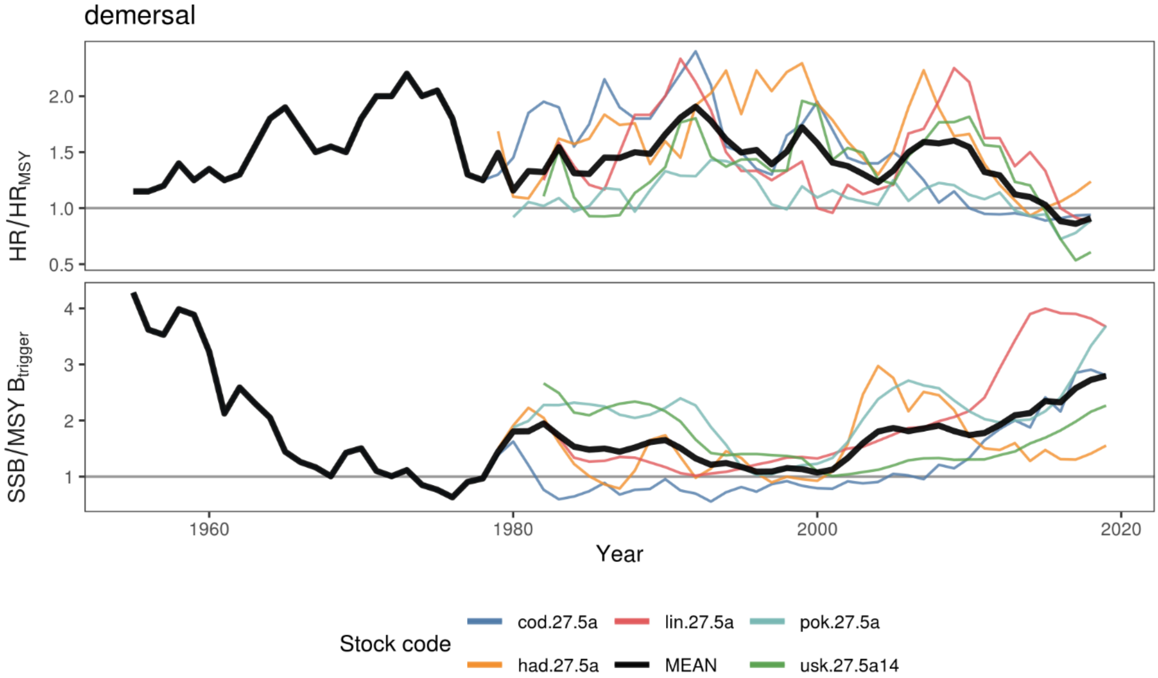
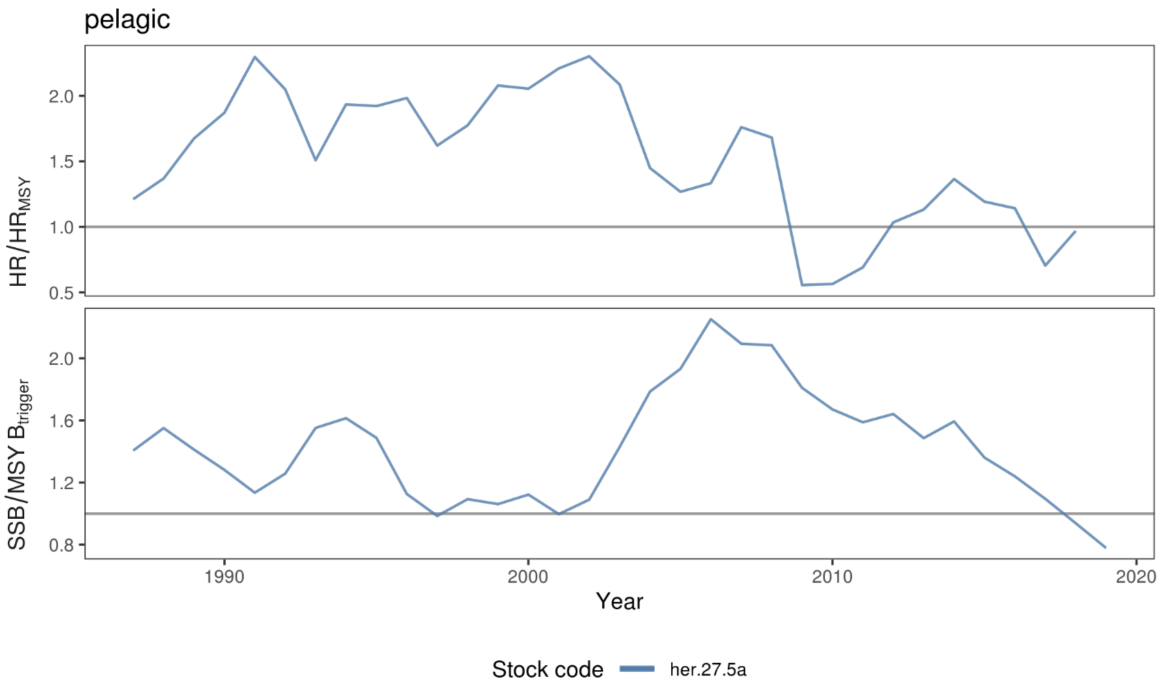


Figure 11 Status of Icelandic Waters Ecoregion stocks (category 1 stocks and assessed by ICES), relative to the joint distribution of exploitation (HR/HR_{MSY} and F/F_{MSY}) and stock size (SSB/MSY $B_{trigger}$) [left panel, by individual stocks] and catches (triangles) / landings (circles) from these stocks in 2018 [right panel]. The left panel only includes stocks for which MSY reference points have been defined (MSY where available). Stocks in green are exploited at or below HR_{MSY} and F_{MSY}, while the stock size is also at or above MSY $B_{trigger}$. Stocks in red are either exploited above HR_{MSY} and F_{MSY}, or the stock size is below MSY $B_{trigger}$, or both. For full stock names, see Table A1 in the Annex.


demersal
HR/HR$_{MSY}$
SSB/MSY B$_{trigger}$
Year
Stock code
cod.27.5a
lin.27.5a
pok.27.5a
had.27.5a
MEAN
usk.27.5a14


pelagic
HR/HR$_{MSY}$
SSB/MSY B$_{trigger}$
Year
Stock code
her.27.5a

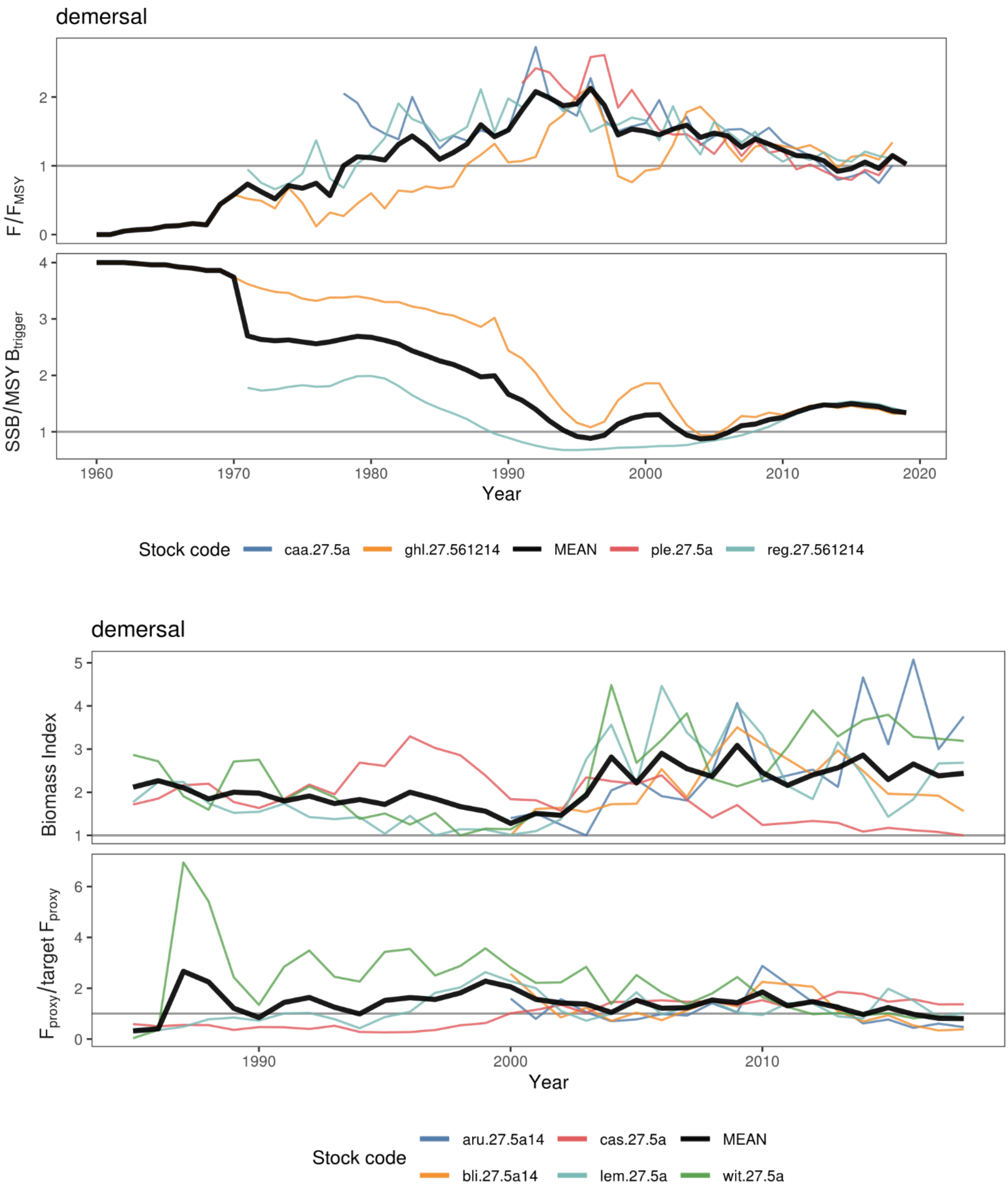


Figure 12 Temporal trends in HR/HR_{MSY}, F/F_{MSY}, and SSB/MSY $B_{trigger}$ for Icelandic Waters ecoregion demersal and pelagic fish stocks. Included are two stocks not accessed by ICES (plaice [ple.27.5a] and Atlantic wolffish [caa.27.5a]). Also shown is F_{proxy}/target F_{proxy}, and biomass indices for stocks that do not have analytical assessment. For full stock names, see Table A3 in Annex.

Mixed fisheries

ICES has not been requested to provide mixed fisheries scenarios for this ecoregion. This section gives a brief overview of the mixed fisheries and important bycatch.

Fishing operations typically catch more than one species at a time (mixed fisheries), although some are more species selective than others. For example, pelagic trawling and purse-seining typically catch only one species with bycatch of small proportions; demersal trawling, bottom-seining, and longlining normally catch several species simultaneously. These operations are reported to MFRI via logbooks, where catches of every species landed from each haul are reported.

The average catches for 2017–2019 are aggregated to the following key description of fishing activity (hereafter called métier, see Table A4 in the Annex for métier definitions): gear and target assemblage.

Sixteen demersal TAC species dominate the landings (mean annual landings > 1000 tonnes; Figure 13b), using nine métiers (Figure 13a). Cod, for example, is the main species landed by the demersal fisheries and is caught in most métiers to a varying extent, except in the gillnet fishery for Greenland halibut (Figure 13b). As another example, Northern shrimp is only caught in the otter trawl fishery directed at that species.

Figure 14 demonstrates the catch composition of the six most important demersal target species caught in the otter trawl fisheries. As an example, haddock, saithe, and golden redfish are often taken as bycatch in the otter trawl fishery for cod. There are mixed saithe and golden redfish fisheries, where proportions of the two species depend on the spatio-temporal operation of each of the fisheries. This leads to two different métiers, as shown in Figure 14 (OTB-DEF-POK and OTB-DEF-REG).

Figure 15 illustrates species composition by individual hauls. Most of the cod is caught in hauls where it constituted over 50% of the total catch. As another example, haddock is more frequently caught in fisheries directed at other species like cod. Several species that are subjected to TAC are mainly taken as bycatch, meaning that most of their annual catch is taken in fishing operations where they form less than 50% of the haul catch. These species include spotted wolffish, Atlantic halibut, Norway redfish, whiting, blue ling, ling, tusk, witch, dab, anglerfish, and blue skate. Species where mean annual catch is less than 50 tonnes are exclusively taken as bycatch (not shown).

Mixed fisheries in pelagic fisheries, targeting capelin, herring, mackerel, and blue whiting are relatively low. There is no bycatch reported in the fishery targeting capelin. In the mackerel fishery, herring (Icelandic summer-spawning and Norwegian spring-spawning herring combined) bycatch has varied between 5% and 14% during the last 10 years (2009–2018). Mackerel bycatch during this period in the Norwegian spring-spawning herring fishery varied between 1% and 12%. In the blue whiting and Icelandic summer-spawning herring fisheries, little bycatch (< 2%) was recorded.

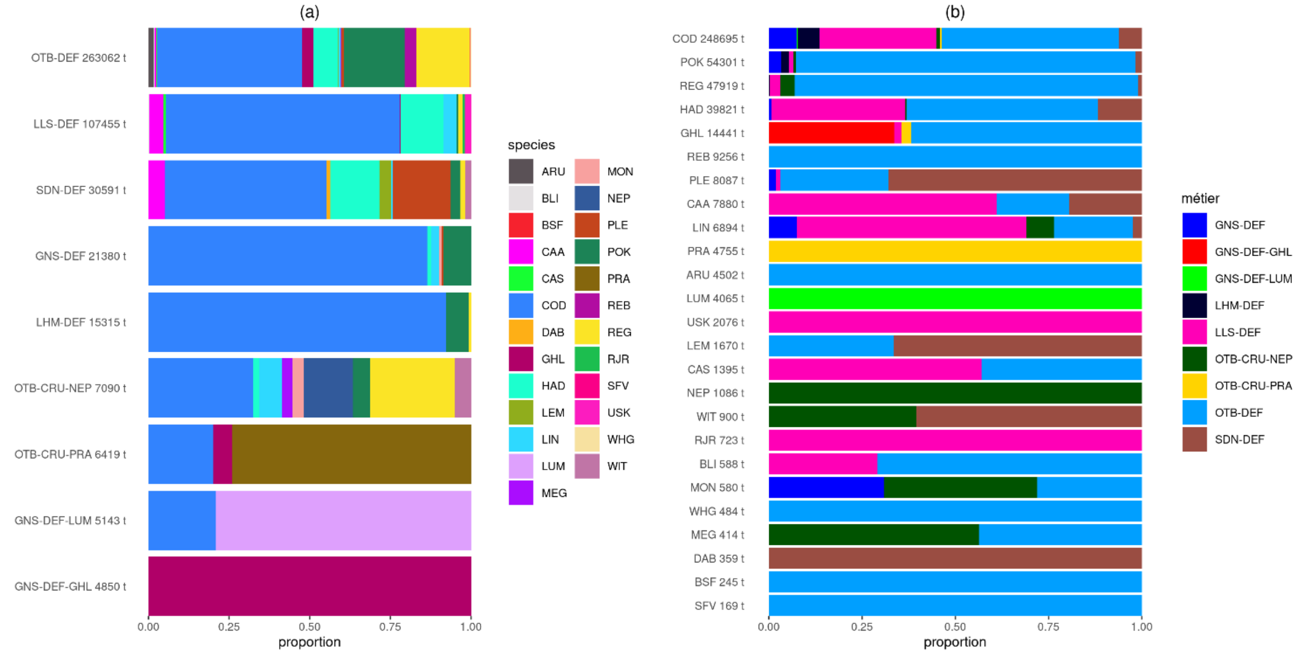


Figure 13 Description of technical interactions of demersal TAC species in the Icelandic Waters ecoregion. The left panel (a) shows the species composition of the main demersal métiers (catch > 99 tonnes) of the Icelandic fleet operating in Icelandic waters. The label incorporates métier and mean annual (2016–2018) catch in tonnes. The right panel (b) shows the proportion of the catch of each species accounted for by the different demersal métiers. The label includes the mean annual landings (2016–2018). See Table A3 in the Annex for species definitions, and Table A4 for métier definitions. Data obtained from logbooks of the Icelandic fleet.

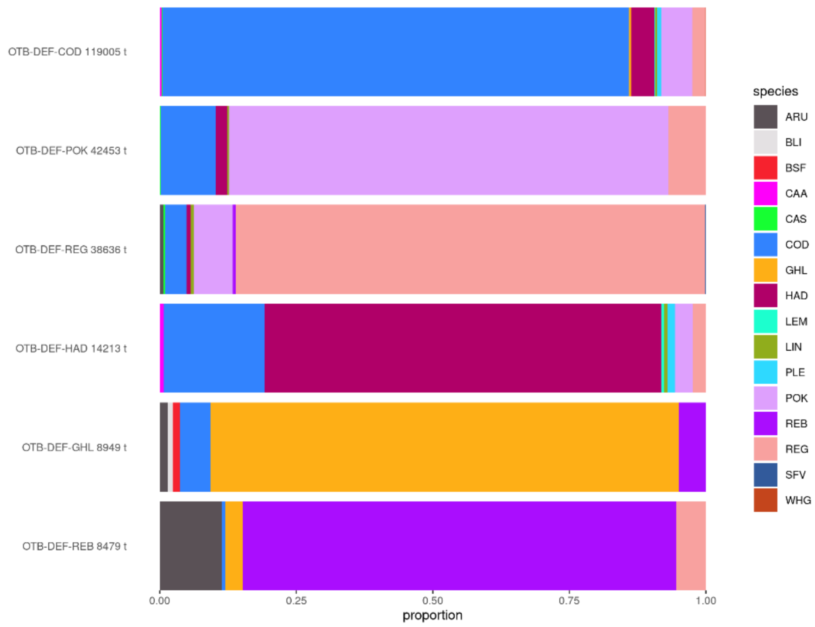


Figure 14 Description of technical interactions of demersal TAC species in the Icelandic Waters ecoregion of the Icelandic otter trawl fleet operating in Icelandic waters. The panel shows the species composition of catches by demersal métiers (landings > 99 tonnes). The criteria for the division into métiers is that a given species was more than 50% of the total catch in a single haul (data obtained from logbooks). The label incorporates métier and mean annual (2016–2018) landings in tonnes. See Table A3 in the Annex for species definitions and Table A4 for métier definitions.

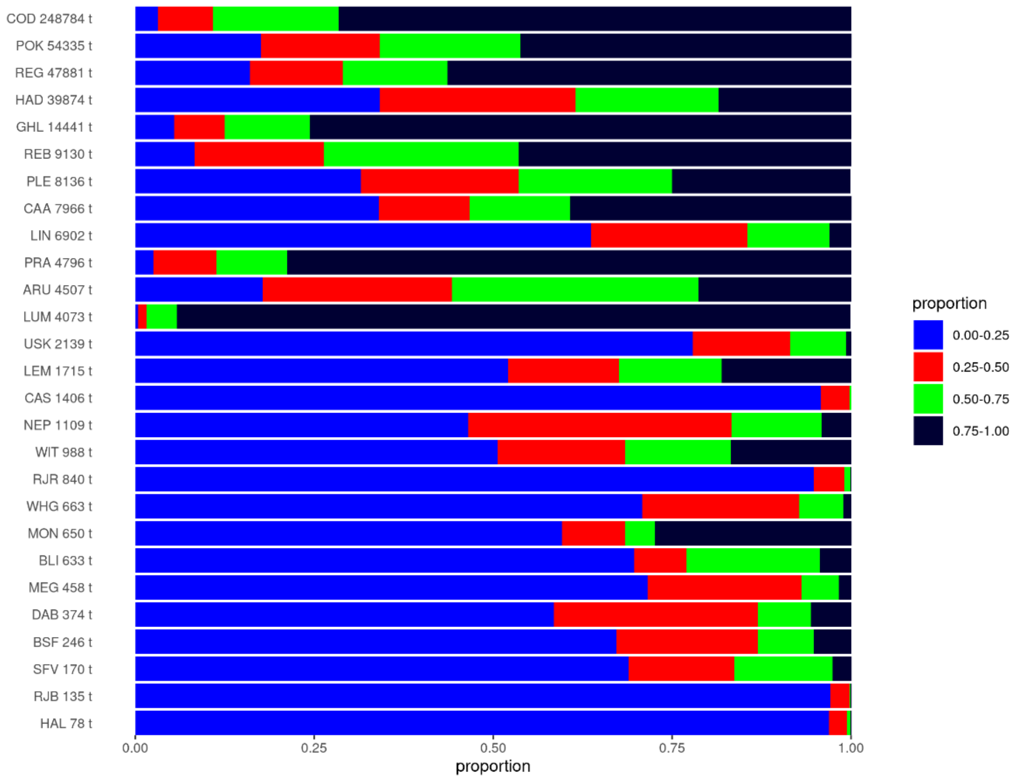


Figure 15 Description of technical interactions of demersal species in the Icelandic Waters ecoregion caught with bottom trawls, demersal seines, and static gears (all gears combined). The panel shows the proportion of a species out of the total catch in a single haul or set (0–0.25 = 25% and less of a catch of a species; 0.25–0.50 = 25–50% of the total catch of a species; 0.50–0.75 = 50–75% of the total catch of a species, 0.75–1.00 = 75% or more of the total catch of a species). The label includes the mean annual catch (2016–2018). See Table A3 in the Annex for species definitions.

Species interaction

The fish species of commercial value in the Icelandic Waters ecoregion are clearly a significant part of the marine foodweb; they interact in various ways, including through predation and food competition. Generally, even if the pathways of the foodweb in the ecoregion are to some degree known, they are still poorly quantified. Consumption of fish by some predators has been estimated, but predation mortality has not been quantified; it is not, therefore, directly included in the assessments of fish stocks in Icelandic waters.

With more emphasis on sustainability, the precautionary approach, and rebuilding of fish stocks, fishing mortality has been reduced for many stocks in the ecoregion. This can alter the ratio between natural and fishing mortality. Natural mortality from predation can occur from other fish, seabirds, and marine mammals. The abundance of some cetacean species has been increasing in the ecoregion whereas the abundance of two pinniped species, harbour seal and grey seal, has decreased to their lowest observed levels since 1980. The population size of many seabird species has also declined substantially.

Capelin is a key forage species in the ecoregion, and promotes an important energy transfer into the ecosystem. Capelin feeds mainly on copepods and euphausiids, and it is one of the most important prey for several predators, e.g. cod, haddock, saithe, Greenland halibut, seabirds, and marine mammals. Other prey species of lesser importance are shrimp and sandeel.

Effects of fisheries on the ecosystem

There are multiple effects on the fisheries ecosystems; two different effects of fisheries on the ecosystem are described in this section: (1) Physical disturbance of benthic habitats by mobile bottom-contacting fishing gear; and (2) fisheries bycatch of protected, endangered, and threatened species.

Physical disturbance of benthic habitats by mobile bottom-contacting fishing gear

The main abrasive impact in the Icelandic Waters ecoregion is caused by mobile bottom-contacting fishing gears, mainly otter trawl, targeting demersal fish, shrimp, and *Nephrops*. Other mobile bottom-contacting fishing gears are demersal-seines and dredges. Abrasion may affect the surface (top 2 cm of sediments) or the subsurface (> 2 cm), and affect fragile three-dimensional biogenic habitats in particular (e.g. sponge aggregations, coral gardens, and coral reefs). Most effects occur between 200 and 500 m depth ranges, while the effects on soft substrata in shallow waters have been shown to be minor. Other effects involve overturning boulders, scouring the seabed, and the direct removal of and/or damage to epifaunal organisms. The extent, magnitude, and effects of mobile bottom-contacting fishing gear on the seabed and benthic habitats varies geographically across the ecoregion (Figure 16).

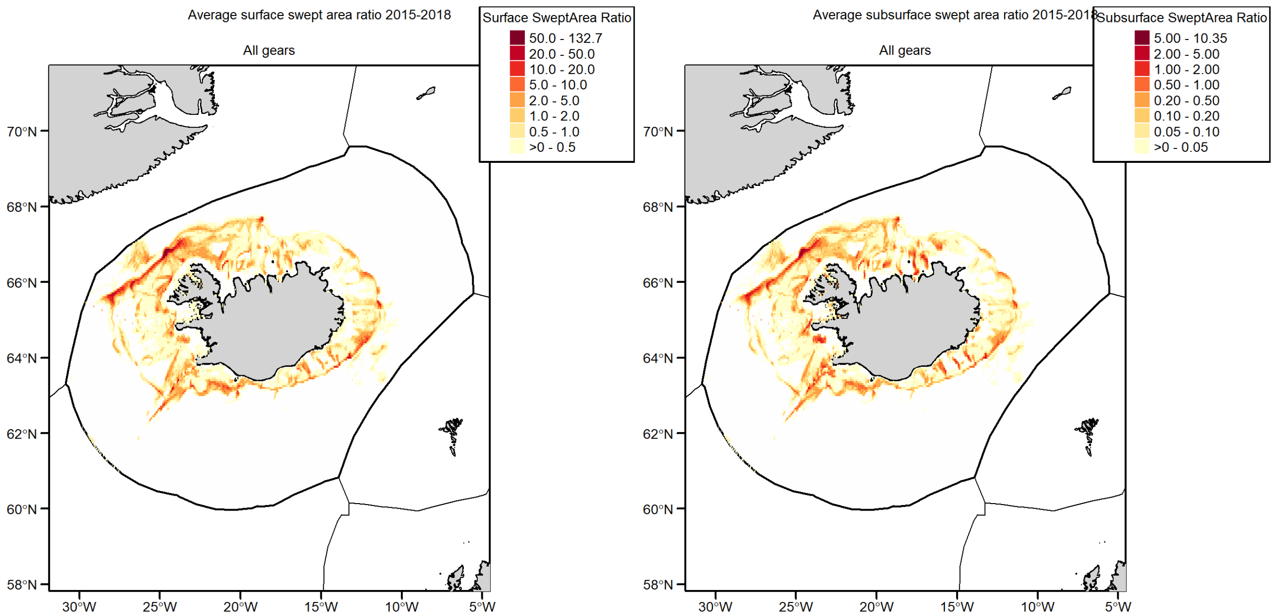


Figure 16 Average annual surface (left) and subsurface (right) disturbance by mobile bottom-contacting fishing gear (bottom otter trawls, demersal seines, beam trawls) in the Icelandic Waters ecoregion between 2015 and 2018, expressed as average swept-area ratios (SAR).

Bycatch of protected, endangered, and threatened species

All fisheries risk catching protected, endangered, or threatened species (e.g. fish, seabirds, and marine mammals) as non-targeted bycatch. Recording of the bycatch of seabirds and mammals has been undertaken in some Icelandic Waters fisheries by MFRI, usually where there is perceived risk of such bycatch. Seabirds can become entangled in gillnets or hooked on longlines, and consequently drown. Seals and harbour porpoises can become entangled in gillnets, leading to the deaths of these animals.

Cetaceans

Harbour porpoise is the most common marine mammal bycatch. The annual estimate of bycatch of harbour porpoise has decreased from 7300 animals in 2003, to 2000 in 2018. The estimated incidental captures of harbour porpoise in 2009–2017 ranged between 0.5–6.0% per year of the estimated abundance of the species, which is based on estimates from the most recent aerial survey of Icelandic coastal waters in 2007. The incidental captures have decreased with decreased gillnet fishing for cod.

Seals

Harbour seal is mainly caught as bycatch in the lumpfish and cod gillnet fisheries. It is estimated that the annual bycatch of harbour seal in recent years has been 900–1800 animals, which represents approximately 9–19% of the current abundance estimates of the species in Icelandic waters. The bycatch of harbour seals is largely dependent on the fishing effort for lumpfish.

Grey seal is mainly caught as bycatch in the lumpfish gillnet fishery. It is estimated that the annual bycatch of grey seal in recent years has been 500–1500 animals, which represents approximately 8–24% of the current abundance estimates of the species in Icelandic waters.

Harp seals, ringed seals, and bearded seals are also caught as bycatch in the lumpfish fishery, but to a much lesser extent than harbour and grey seals. Bycatch of harp seal is estimated at around 240 seals annually, while it is estimated that 50 ringed seals and 30 bearded seals are caught annually.

Seabirds

The main seabird bycatch are the northern fulmar, common murre, northern gannet, black guillemot, common eider, great cormorant, and European shag, all of which are caught in gillnets and longlines. The combined stock size of the two cormorant species (great cormorant and European shag) in Icelandic waters is estimated at around 16 000 birds per year, and annual bycatch in the lumpfish fishery was estimated at 900 birds or 6% of the estimated stock size. The stock size of black guillemot in Icelandic waters is estimated to be between 20 000 and 40 000 birds. The annual bycatch of black guillemot in the lumpfish fishery in 2014–2018 was estimated at 1653 birds, or between 4–8% of estimated stock size.

Fish species

Several of the species listed on the OSPAR list of threatened and declining species are known bycatch species in the Icelandic fishery. These species are leafscale gulper shark, basking shark, porbeagle, spiny dogfish, and common skate [1]. Landings of these species are small or incidental.

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[1] Taxonomic confusion with common skate has recently been resolved (Iglésias *et al.*, 2010) and it is likely that the smaller type *D. cf. flossada* (blue skate) is the species found in Icelandic waters (Pálsson and Jakobsdóttir, 2018). Annual landings of blue skate are ~ 150 tonnes (10 years average).

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Annex

Table A1 Status summary of ten Icelandic Waters ecoregion stocks accessed by ICES in 2019 relative to maximum sustainable yield (MSY) and the ICES precautionary approach (PA). Grey represents unknown reference points. For MSY: green represents a stock that is fished below F_{MSY} or the stock size is above MSY $B_{trigger}$; red represents a stock that is fished above F_{MSY} or the stock size is lower than MSY $B_{trigger}$. For PA: green represents a stock that is fished below F_{pa} or the stock size is above B_{pa}; yellow represents a stock that is fished between F_{pa} and F_{lim} or the stock size is between B_{lim} and B_{pa}; red represents a stock that is fished above F_{lim} or the stock size is below B_{lim}. Stocks having a fishing mortality rate at or below F_{pa} and a stock size above B_{pa} are defined as being inside safe biological limits. Grey represents stocks for which reference points are unknown. SBL = safe biological limits; MSFD = Marine Strategy Framework Directive; D3C1 = MSFD indicator for fishing mortality; D3C2 = MSFD indicator for spawning-stock biomass; GES = good environmental status.

Stock	Stock description	Data category	Fisheries guild	Assessment year	Advice category	Reference points	SBL	Fishing pressure	Stock size	D3C1	D3C2	GES
aru.27.5a14	Greater silver smelt in Subarea 14 and Division 5.a	3.3	Demersal	2019	PA	MSY	?	✔	?	✔	?	?
						PA	?	✔	?	✔	?	?
cap.27.2a514	Capelin in subareas 5 and 14 and Division 2.a west of 5°W	1.8	Pelagic	2018	MP	MSY	?	?	?	?	?	?
						PA	?	?	✔	?	✔	?
cod.27.5a	Cod in Division 5.a	1	Demersal	2019	MP	MSY	✔	✔	✔	✔	✔	✔
						PA	✔	✔	✔	✔	✔	✔
ghl.27.561214	Greenland halibut in subareas 5, 6, 12, and 14	1	Benthic	2019	MSY	MSY	?	✖	✔	✖	✔	✖
						PA	?	?	✔	?	✔	?
had.27.5a	Haddock in Division 5.a	1	Demersal	2019	MP	MSY	✔	✖	✔	✖	✔	✖
						PA	✔	✔	✔	✔	✔	✔
her.27.5a	Herring in Division 5.a, summer-spawning herring	1	Pelagic	2019	MSY	MSY	✖	✔	✖	✔	✖	✖
						PA	✖	✔	o	✔	o	?
lin.27.5a	Ling in Division 5.a	1	Demersal	2019	MP	MSY	✔	✔	✔	✔	✔	✔
						PA	✔	✔	✔	✔	✔	✔
pok.27.5a	Saithe in Division 5.a	1	Demersal	2019	MP	MSY	✔	✔	✔	✔	✔	✔
						PA	✔	✔	✔	✔	✔	✔

Stock	Stock description	Data category	Fisheries guild	Assessment year	Advice category	Reference points	SBL	Fishing pressure	Stock size	D3C1	D3C2	GES
reg.27.561214	Golden redfish in subareas 5, 6, 12, and 14	1	Demersal	2019	MP	MSY	✓	✗	✓	✗	✓	✗
						PA	✓	✓	✓	✓	✓	✓
usk.27.5a14	Tusk in Subarea 14 and Division 5.a	1	Demersal	2019	MP	MSY	✓	✓	✓	✓	✓	✓
						PA	✓	✓	✓	✓	✓	✓

Table A2 List of those stocks in the Icelandic Waters ecoregion in 2019 that do not have a full set of reference points.

Stock code	Stock name	Fish category	Data category	Year of assessment	Advice category
bli.27.5a14	Blue ling in Subarea 14 and Division 5.a	Demersal	3.3	2019	PA
reb.27.5a14	Beaked redfish in Subarea 14 and Division 5.a, Icelandic slope stock	Demersal	3.2	2019	PA

Table A3 Scientific names of species.

Common name	Scientific name	Species code	Assemblage	Assemblage code
Anglerfish	*Lophius piscatorius*	MON	Demersal fish	DEF
Atlantic cod	*Gadus morhua*	COD	Demersal fish	DEF
Atlantic halibut	*Hippoglossus hippoglossus*	HAL	Benthic	BEN
Atlantic wolffish	*Anarhichas lupus*	CAA	Demersal fish	DEF
Baird's slickhead	*Alepocephalus bairdii*	ALC	Demersal fish	DEF
Basking shark	*Cetorhinus maximus*	BSK	Elasmobranch	
Beaked redfish	*Sebastes mentella*	REB	Demersal fish	DEF
Bearded seal	*Erignathus barbatus*			
Black guillemot	*Cepphus grylle*			
Black scabbard fish	*Aphanopus carbo*	BSF	Demersal fish	DEF
Blue ling	*Molva dypterygia*	BLI	Demersal fish	DEF
Blue whiting	*Micromesistius poutassou*	WHB	Small pelagic fish	SPF
Capelin	*Mallotus villosus*	CAP	Small pelagic fish	SPF
Common eider	*Somateria mollissima*			
Common murre	*Uria aalge*			
Common skate	*Dipturus batis*	RJB	Elasmobranch	
Common whelk	*Buccinum undatum*	UHE	Molluscs and invertebrates	MOL
Dab	*Limanda limanda*	DAB	Benthic	BEN
European shag	*Phalacrocorax aristotelis*			
Fin whale	*Balaenoptera physalus*		Whaling	
Golden redfish	*Sebastes norvegicus*	REG	Demersal fish	DEF
Great cormorant	*Phalacrocorax carbo*			
Greater silver smelt	*Argentina silus*	ARU	Demersal fish	DEF
Greenland halibut	*Reinhardtius hippoglossoides*	GHL	Demersal fish	DEF
Greenland shark	*Somniosus microcephalus*	GSK	Elasmobranch	
Grey seal	*Halichoerus grypus*			
Haddock	*Melanogrammus aeglefinus*	HAD	Demersal fish	DEF
Harbour porpoise	*Phocoena phocoena*			
Harbour seal	*Phoca vitulina*			
Harp seal	*Pagophilus groenlandicus*			
Herring	*Clupea harengus*	HER	Small pelagic fish	SPF
Iceland scallop	*Chlamys islandica*	ISC	Molluscs and invertebrates	MOL
Leafscale gulper shark	*Centrophorus squamosus*	GUQ	Elasmobranch	
Lemon sole	*Microstomus kitt*	LEM	Benthic	BEN
Ling	*Molva molva*	LIN	Demersal fish	DEF
Long rough dab	*Hippoglossoides platessoides*	PLA	Benthic	BEN
Lumpfish	*Cyclopterus lumpus*	LUM	Demersal fish	DEF
Mackerel	*Scomber scombrus*	MAC	Small pelagic fish	SPF
Megrim	*Lepidorhombus whiffiagonis*	MEG	Benthic	BEN
Minke whale	*Balaenoptera acutorostrata*		Whaling	
Northern fulmar	*Fulmarus glacialis*			
Northern gannet	*Morus bassanus*			
Northern wolffish	*Anarhichas denticulatus*	CAB	Demersal fish	DEF
Northern shrimp	*Pandalus borealis*	PRA	Crustaceans	CRU
Norway lobster	*Nephrops norvegicus*	NEP	Crustaceans	CRU
Norway redfish	*Sebastes viviparus*	SFV	Demersal fish	DEF

Common name	Scientific name	Species code	Assemblage	Assemblage code
Ocean quahog	*Arctica islandica*	CLQ	Molluscs and invertebrates	MOL
Orange roughy	*Hoplostethus atlanticus*	ORY	Demersal fish	DEF
Plaice	*Pleuronectes platessa*	PLE	Benthic	BEN
Porbeagle	*Lamna nasus*	POR	Elasmobranch	
Ringed seal	*Pusa hispida*			
Roughhead grenadier	*Macrourus berglax*	RHG	Demersal fish	DEF
Roundnose grenadier	*Coryphaenoides rupestris*	RNG	Demersal fish	DEF
Saithe	*Pollachius virens*	POK	Demersal fish	DEF
Sea cucumber	*Cucumaria frondosa*	KHG	Molluscs and invertebrates	MOL
Sea urchin	*Strongylocentrotus droebachiensis*	UYD	Molluscs and invertebrates	MOL
Spiny dogfish	*Squalus acanthias*	DGS	Elasmobranch	DEF
Spotted wolffish	*Anarhichas minor*	CAS	Demersal fish	DEF
Thorny ray	*Amblyraja radiata*	RJR	Elasmobranch	
Tusk	*Brosme brosme*	USK	Demersal fish	DEF
Witch flounder	*Glyptocephalus cynoglossus*	WIT	Benthic	BEN
Whiting	*Merlangius merlangus*	WHG	Demersal fish	DEF

Table A4 Métier definitions.

Gear type	Target assemblage	Métier label
Dredges	Mollusks and invertebrates other than Norway shrimp and *Nephrops*	DBR_MOL
Gillnets	Demersal fish, other than Greenland halibut and lumpfish	GNS_DEF
	Greenland halibut	GNS_DEF_GHL
	Lumpfish	GNS_DEF_LUM
Handlines	Demersal fish	LHM_DEF
Longlines	Demersal fish	LLS_DEF
Otter trawls	Crustaceans – Northern shrimp	OTB_CRU_PRA
	Crustaceans – *Nephrops*	OTB_CRU_NEP
	Demersal fish	OTB_DEF
Pelagic trawls	Small pelagic fish	OTM_SPF
Purse-seines	Small pelagic fish	PS_SPF
Demersal seines	Demersal fish	SDN_DEF