Seafood Watch
Seafood Report

MONTEREY BAY AQUARIUM®

Atlantic cod
Gadus morhua

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About Seafood Watch® and the Seafood Reports

Monterey Bay Aquarium's Seafood Watch® program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch® defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch® makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from the Internet (seafoodwatch.org) or obtained from the Seafood Watch® program by emailing seafoodwatch@mbayaq.org. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Report. Each report synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices," "Good Alternatives," or "Avoid." The detailed evaluation methodology is available upon request. In producing the Seafood Reports, Seafood Watch® seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch® Fisheries Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch's sustainability recommendations and the underlying Seafood Reports will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling (831) 647-6873 or emailing seafoodwatch@mbayaq.org.

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Seafood Watch® strives to have all Seafood Reports reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science, and aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch® program or its recommendations on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

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I. Executive Summary

Atlantic cod (*Gadus morhua*) is found in the Northeast Atlantic along the coast of Europe from the Bay of Biscay to the Barents Sea, in the Northwest Atlantic on the east and west coast of Greenland, and from Cape Hatteras, North Carolina to Ungava Bay, Canada. Atlantic cod has exhibited dramatic declines on both sides of the Atlantic, with current biomass estimates at only 4% of historical levels in some locations. This report encompasses only cod caught in the Northeast Atlantic. For an analysis of U.S. and Canadian sources of Atlantic cod, see the Northeast Region Atlantic Cod Seafood Watch® report at: http://www.montereybayaquarium.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_AtlanticCodReport.pdf.

Atlantic cod exhibits life history characteristics that should make it inherently resilient to fishing pressure, such as a high intrinsic rate of increase and moderate age at maturity. Atlantic cod aggregates to spawn, and exhibits population variability in response to environmental conditions. Fourteen Atlantic cod stocks in the Northeast Atlantic, which are assessed on an individual basis, are encompassed in this report (the fishery on the Faroe Bank has been closed since January 2009 and so it is not evaluated). The two most commercially important cod stocks are the Northeast Arctic cod (Barents Sea cod) and Icelandic cod stocks. The Northeast Arctic stock is above precautionary biomass limits and being fished sustainably. The Icelandic stock appears to be rebuilding, short-term abundance is up and overfishing is no longer occurring. The stock is thus a moderate conservation concern. In the eastern Baltic, spawning stock biomass has increased since 2005 and is not currently considered to need a precautionary limit. Recent fishing mortality is also below F_{MSY}. All other stocks (except Rockall which supports a very small fishery) are considered to be in poor or critical condition due to being overfished and/or experiencing overfishing.

Bottom trawls account for the majority of Atlantic cod caught in most regions, but some countries have a more varied cod fishery. In Norway’s Barents Sea fishery, for example, trawls and bottom gillnets each account for 30% of the cod catch, while bottom longline (15%), Danish seine (15%) and handline (10%) account of the remainder. In Iceland, Atlantic cod is primarily caught with bottom trawls (43%), bottom longlines (22%), and bottom gillnets (19%). Catch from the Norwegian coastal stock has almost all been from the inshore fishery in recent years, which primarily uses pound nets and gillnets. In the Faroes, longlines (72%) and jigs (18%) account for the major part of the cod catch, although bottom trawls account for most (8%) of the remainder. The major bycatch problems in cold water seafloor fisheries using these gears are finfish (including juveniles) and invertebrates in the trawl and Danish seine fisheries, and seabirds and mammals in gillnet and longline fisheries. Jigs and handlines typically have low bycatch. Discard prohibition policies in Norway and Iceland likely reduce discards of species of commercial interest (reports suggest to levels below 10% of the catch), but little information is available on non-commercial species. Discarding is also thought to be of little concern in the Faroes, where fishermen are permitted to catch, land and sell anything they like. There is again little data on discards of species that have no commercial value, however. There is also little data on the quantity and trend of seabird and marine mammal bycatch in the gillnet and longline fisheries. Especially in areas where there is habitat-creating epifauna such as cold-water corals and sponge aggregations, bottom trawls may cause great damage to the seafloor. Bottom longlines, bottom gillnets and pound nets may also affect the bottom habitat, although to a lesser degree. Danish seining, which uses lighter ground gear than bottom trawling and is conducted only in habitats of high or moderate resilience, likely has a greater impact than set gears but a lesser impact than bottom trawling. Gears that do not contact the seafloor such as hook-and-line and jigs are deemed to have no habitat impacts.

Management of cod fisheries is only moderately effective in most cases. Effective data collection and utilization in robust stock assessments is fairly common for cod stocks, but these positive aspects are typically undermined by poor track records and a failure to follow scientific advice when setting TACs. Furthermore, most fisheries have only moderately effective enforcement, bycatch and habitat protection measures. One exception to this rule is Norwegian management, which would be amongst the best in the whole region if managers followed the advice of scientists when setting TACs (Barents Sea stock) and didn't have such a poor track record (Norwegian coastal stock). The only two management systems that are deemed highly effective are for Iceland and the Eastern Baltic, both of which follow scientific advice and have moderately good track records. Management is considered ineffective for the Greenland trawl fishery (failure to follow scientific advice when setting allowable catch, and a dearth of measures to reduce bycatch and habitat impacts), and the small fishery operating on the Rockall stock (very little information being collected, no stock assessment, and a poor track record).

Overall, the only Best Choice for Northeast Atlantic cod is hook-and-line-caught cod from the Northeast Arctic, Iceland or the eastern Baltic. Cod caught with other gears (including trawls) from these stocks is a Good Alternative, as is cod caught with bottom longline, bottom gillnet or hook and line from the Western Baltic, Celtic Sea, and the Faroe Plateau. All other sources are on the Avoid list, including Western Baltic, Celtic Sea, and Faroe Plateau; cod caught with bottom trawl or Danish seine, as well as all cod from the Norwegian Coastal, North Sea, Greenland, Kattegat, West of Scotland, and Rockall stock..

This report was first released in November 2005. Updates to catch statistics, stock status, discards (in the bycatch criterion) and management were made in April 2011. For more detail on the changes, please see Appendix A.

Four Atlantic cod fisheries have been certified as "sustainable" by the to the Marine Stewardship Council (MSC) standard: The Danish Fishermen's Producer Organization (DFPO) Eastern Baltic cod fishery using longlines and bottom trawls, the Domstein Longliner Partners Northeast Arctic cod fishery using longlines based in the Barents Sea (Norwegian and Russian waters), the Barents Sea Cod fishery using demersal trawl and based in the Barents Sea (Norwegian and Russian waters), and the Norway Northeast Arctic offshore cod fishery, based in Norway, using Danish seine, gillnet, hook and line, longline, and trawl. The MSC is an independent non-profit organization that has developed an environmental standard for sustainable and well-managed fisheries. It uses a product label to reward environmentally responsible fishery management and practices (http://www.msc.org/).

About the Overall Seafood Recommendation:

- A seafood product is ranked "**Avoid**" if two or more criteria are of High Conservation Concern (red) OR if one or more criteria are of Critical Conservation Concern (black) in the table above.
- A seafood product is ranked "**Good Alternative**" if the five criteria "average" to yellow (Moderate Conservation Concern) OR if the "Status of Stocks" and "Management Effectiveness" criteria are both of Moderate Conservation Concern.
- A seafood product is ranked "**Best Choice**" if three or more criteria are of Low Conservation Concern (green) and the remaining criteria are not of High or Critical Conservation Concern.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criterion	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks		√ (Northeast Arctic, Icelandic, East Baltic,)	√ (West Baltic, Faroe Plateau, Celtic	√ (Norwegian Coastal, North Sea, Greenland, Kattegat, West of Scotland)
Nature of Bycatch	√ (Hook and line)	√ (All other gears)		
Habitat Effects	√ (Hook and line)	√ (Bottom gillnet, bottom longline, pound net)	√ (Bottom trawl, Danish seine)	
Management Effectiveness	√ (Iceland, East Baltic)	√ (Northeast Arctic, Norwegian coastal, Greenland (other gears), North Sea, Irish Sea, Kattegat, West of Scotland, Celtic Sea, Faroe Plateau)	√ Greenland (trawl), Rockall)	

Overall Seafood Recommendation:

Northeast Arctic, Icelandic, East Baltic (hook and line):

[✓ **Best Choice** 🟩] Good Alternative 🟨 **Avoid** 🟥

Northeast Arctic, Icelandic, East Baltic (other gears); Faroe Plateau, Western Baltic, Celtic Sea (bottom gillnet, bottom longline, hook and line, pound net):

Best Choice 🟩 [✓ **Good Alternative** 🟨] Avoid 🟥

Western Baltic, Celtic Sea, Faroe Plateau (bottom trawl, Danish seine)
Norwegian Coastal, North Sea, Greenland, Kattegat, West of Scotland, Rockall (all gears):

Best Choice 🟩 Good Alternative 🟨 [✓ **Avoid** 🟥]

II. Introduction

Atlantic cod (*Gadus morhua*)[1] is distributed in the North Atlantic along the North American coast from Cape Hatteras, North Carolina, north to Ungava Bay, Canada (Froese and Pauly 2005). Cod is also found on the east and west coast of Greenland, around Iceland, and on the coasts of Europe from the Bay of Biscay to the Barents Sea (Froese and Pauly 2005). Cod occurs in many different habitats, including the open ocean, coastal banks, open fjords, and semi-enclosed bays (Berg and Albert 2003). Cod spawns once a year, and forms schools during the day (Froese and Pauly 2005). Age-0 cod consume copepods, krill, and fish (Bromley, Watson et al. 1997). In the North Sea, prey abundance, rather than prey size, is a primary factor in determining the diet of cod (Floeter and Temming 2003). As a demersal species, cod is commonly caught with gear such as bottom trawls, bottom longlines, and bottom gillnets. Hook-and-line gear and Danish seines are also used. There are 14 cod stocks in the Northeast Atlantic and European waters encompassed in this report (Table 1) (Figure 1). Assessment and management of the different cod stocks varies by stock and country, with the International Council for the Exploration of the Sea (ICES) providing scientific advice on stock status.

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[1] Throughout this report, Atlantic cod will be referred to as cod. Pacific cod occurs in the Pacific Ocean and is treated separately in another Seafood Watch® report.

Table 1. Cod stocks occurring in Northeast Atlantic and European waters (ICES 2010). * Does not include recreational/tourist catches, which are estimated to be about 35% of total catches in recent years.

Stock	**Commercial landings (2008mt)**	**% of total landings (2008mt)**	**Countries with top landings (2008)**
Northeast Arctic	464,171	61	Norway, Russia
Icelandic	146,104	19	Iceland
Baltic (eastern)	42,235	6	Poland, Sweden, Denmark
North Sea, eastern Channel, & Skagerrak	26,800	4	U.K., Norway, Denmark, Netherlands
Norwegian coastal	26,000*	3	Norway
Greenland	2,997 (East) 22,000 (West)	3	Germany, Norway, Faroe Islands, U.K. (East) Greenland (West)
Baltic (western)	20,082	3	Denmark, Germany, Sweden
Faroe Plateau	7,465	1	Faroe Islands
Celtic Sea	3,961	1	France, Ireland
Irish Sea	662	<1	Ireland, U.K., Belgium
Kattegat	449	<1	Denmark, Sweden
West of Scotland	451	<1	U.K., France, Norway, Ireland
Faroe Bank	219	<1	Faroe Islands
Rockall	94.2	<1	U.K., Ireland

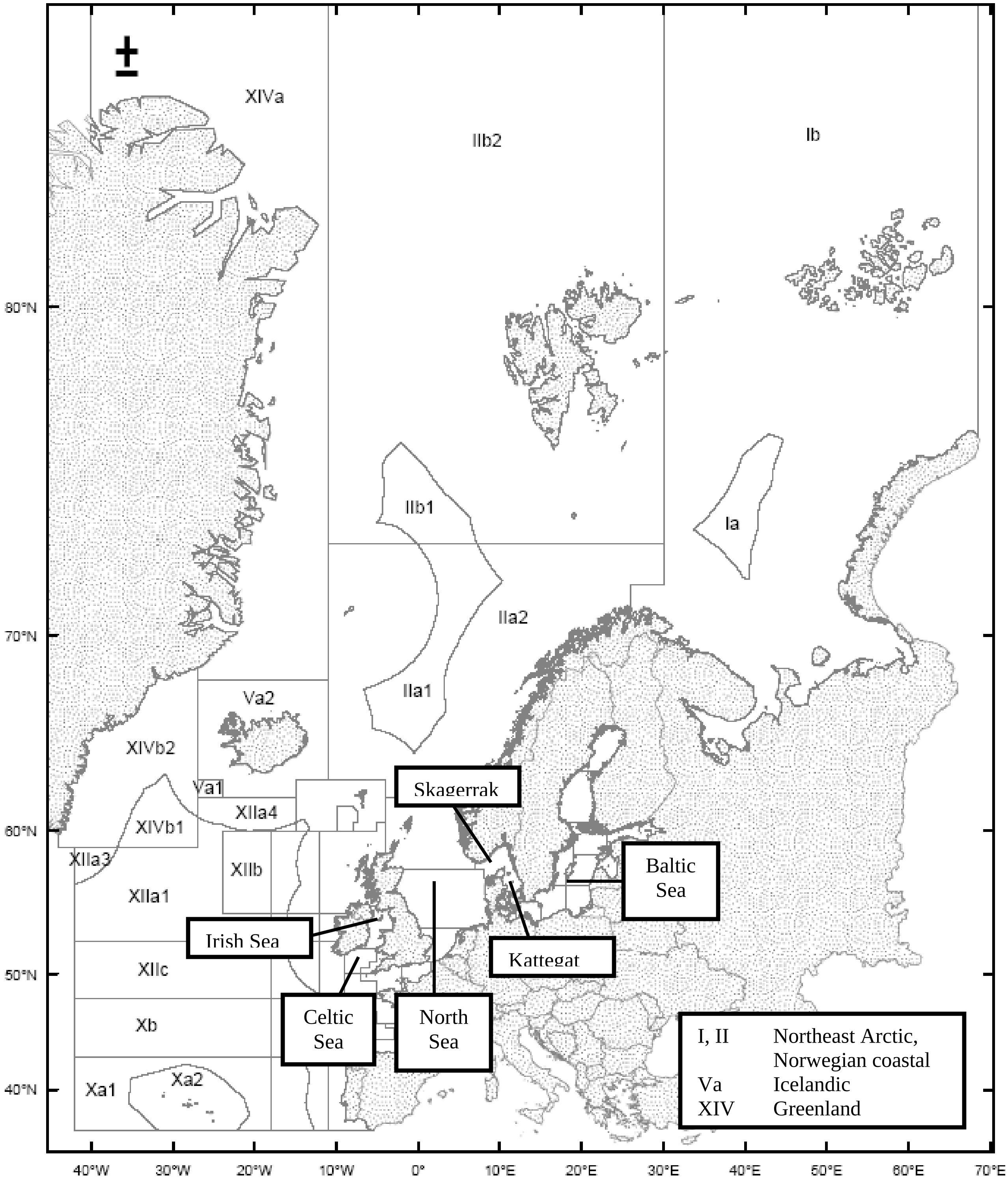

Figure 1. This map shows the majority of cod stocks assessed by ICES in the Northeast Atlantic (Map from ICES Overview of Areas, http://www.ices.dk/aboutus/icesareas.asp).

In terms of landings and imports to the U.S., the two most important stocks are the Northeast Arctic (Barents Sea) and Icelandic cod stocks (Froese and Pauly 2005). The Northeast Arctic cod fishery is the largest commercial cod fishery, with Norway and Russia each responsible for approximately half of total landings (Aanes and Pennington 2003). Norwegian and Russian fisheries often target immature cod that are found following spawning schools of capelin (Nakken 1998). In Iceland, cod landings increased from 1905 until 1980, and then declined from 1980 until 2002 (IMF 2003). Data available for every five years since 1905 give average landings per year as 221,095 mt; 2002 landings were 213,417 mt (IMF 2003). Catches since 2002 have been relatively stable, though lower in 2008 than at any time since the 1940s, and increasing again in 2009 (Figure 2) (IMF 2003).

In Iceland, fisheries are an integral component of the country's economy. In the 1990s, marine products accounted for some 80% of total Icelandic export value (products only, not services). That proportion has been steadily declining since then, but still accounted for 40% of total product export value in 2007 (IMF 2010). Cod is the most important fisheries resource in Icelandic waters, accounting for roughly 40% of total fisheries export value in 2007. The UK is the biggest export market for cod, with the USA fourth in 2007 behind Spain and the Netherlands (IMF 2010). Cod is the predominant fish targeted with bottom trawls, bottom gillnets, and bottom longlines in Icelandic waters (Valtysson 2001). The majority of the cod caught in Icelandic waters are from the domestic fishery, although there is also some fishing pressure from Norwegian and Faroese groundfish longliners (Valtysson 2001).

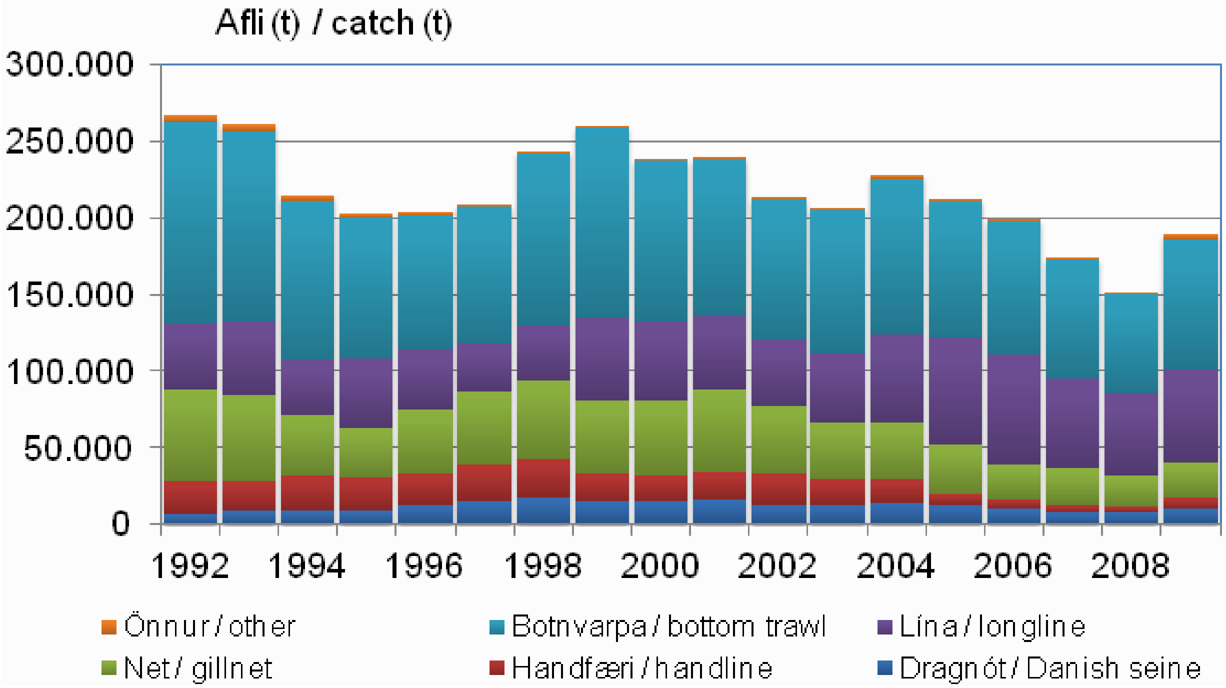

Figure 2. Cod landings in Iceland, by gear, 1992 – 2009.[2]

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[2] http://www.fisheries.is/main-species/cod/catch-and-fishing-methods/

Intense fishing pressure has resulted in a dramatic decline in the cod stocks in the Northwest Atlantic, and, even with a fishing moratorium, these stocks (i.e., Newfoundland and Labrador) have not recovered (Shelton, Sinclair et al. 2006; Stares, Rideout et al. 2007). Overall, the dramatic decline in cod stocks in this region has been attributed to mismanagement and fishing practices (Hutchings and Myers 1994; Nakken 1998; Kelly, Frank et al. 2009). One factor contributing to the overexploitation of cod in the Northwest Atlantic was the overestimation of stock size and fishing mortality rates above the targeted rates (Hutchings and Myers 1994). Similar concerns have been raised for several stocks in the Northeast Atlantic (ICES 2004). Cod on the Scotian Shelf has declined to 4% of the adult biomass that was present in 1852 and emphasizes the importance of ecosystem management as well as considering longer biomass goals when rebuilding fish stocks (Rosenberg, Bolster et al. 2005). There is also evidence that the population is skewed towards an earlier median age at maturity as a result of intense fishing pressure (Beacham 1983).

Atlantic cod is listed on the World Conservation Union (IUCN) Red List as vulnerable, which is defined as “facing a high risk of extinction in the wild in the medium-term future” (Sobel 1996). In addition, several cod stocks (North Sea, Skagerrak, Kattegat, west of Scotland, Irish Sea, Irish Channel, and Celtic Sea) are listed by the OSPAR Commission as threatened or declining (OSPAR 2004). The OSPAR Commission comprises government representatives from the contracting parties to the Convention for the Protection of the Marine Environment of the North-East Atlantic.

Scope of the analysis and the ensuing recommendation:
This report encompasses Atlantic cod imported from European and Northeast Atlantic waters, and focuses on Icelandic and Northeast Arctic cod stocks due to their prevalence in the U.S. market, relative to other Northeast Atlantic cod stocks. For an evaluation of cod caught in U.S. and Canadian waters, see the Atlantic Cod Seafood Watch® Report available on the Seafood Watch® website.

Availability of Science

Although there are stock status data available for the majority of cod stocks in the Northeast Atlantic, there are some stocks for which uncertainty is high due to unreported landings. In addition, there is little observer coverage to provide specific data on the bycatch and discards in some of these cod fisheries, while there has been adequate research and surveys done for other stocks.

Market Availability

Common and market names:
Atlantic cod is also known as cod. Cod imported from Iceland is often marketed as Icelandic cod.

Seasonal availability:
Cod is available year-round.

Product forms:
Cod is marketed whole, as fillets, salted, in brine, or smoked (FAO 2003). Additional products include cod liver oil and frozen roe (FAO 2003).

Import and export sources and statistics:
The National Marine Fisheries Service Foreign Trade Database does not distinguish between cod species for its import and export data; cod is either listed as “Atlantic” or “Not Specifically Provided For”. Of the total cod (“Atlantic” and “Not Specifically Provided For” or NSPF) imported into the U.S. in 2008, nearly three quarters (73.8%) was from China. The remaining quarter largely came from Canada (10%), Iceland (5%), Russia (4%), Thailand (3%), and Norway (2%) (NMFS 2010). For cod identified specifically as Atlantic cod, the primary imported sources were China (47%), Iceland (17%), Canada (16%), Russia (13%), and Norway (5%). Species identified as NSPF cod likely include several other groundfish species. For example, NSFP cod from China might be Atlantic cod, haddock, saithe (pollock), blue whiting, Pacific cod or Alaska pollock (Trondsen 2009). According to FAO catch statistics, China does not actually catch Atlantic cod (FAO 2010). Instead, the country acts as a global processing center for the species (and various other codfish species), receiving round frozen cod from producing countries such as Russia, the EU (which also imports from Russia), and Norway, and re-exporting after defrosting, filleting, and salting/refreezing (Trondsen 2009). Atlantic cod imports from China are thus twice frozen cod fillets, caught in Russian waters and the Barents Sea (Seafood Business 2004). China is also the top supplier to European markets such as the UK, Germany and France (O'Sullivan 2008).

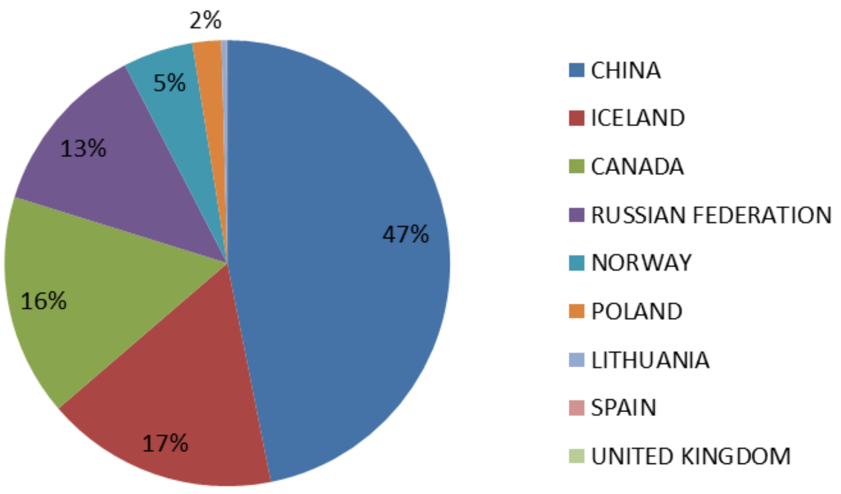

Figure 3. Imports of all cod (“Atlantic” and “Not Specifically Provided For”) into the U.S., 2008 (NMFS 2010).

III. Analysis of Seafood Watch® Sustainability Criteria for Wild-caught Species

CRITERION 1: INHERENT VULNERABILITY TO FISHING PRESSURE

The different cod stocks found in the North Atlantic differ in their life history characteristics (Table 2). Off the coast of Norway, for example, Norwegian coastal cod reached 50% maturity a year earlier than Northeast Arctic cod (Berg and Albert 2003). In general, inshore cod in the southern region of Norway have been found to reach maturity earlier than offshore cod (Berg and Albert 2003). In addition to their travel along the coast, Northeast Arctic cod migrate large distances between their feeding and spawning areas. (Bergstad, Jørgensen et al. 1987), while Norwegian coastal cod only perform short local migrations (Jakobsen 1987). Northeast Arctic cod are also larger than Norwegian coastal cod (Berg and Albert 2003). Norwegian coastal cod is likely composed of several sub-populations, based on varying life history characteristics (Vea Salvanes, Skjaeraasen et al. 2004). Cod in the Irish Sea have been shown to utilize greater depths than North Sea cod, and Irish Sea cod are also more active than North Sea cod throughout the year (Righton and Metcalfe 2002). During their migration between feeding and spawning grounds, North Sea cod are highly active and utilize a large vertical range compared to their activity on summer feeding grounds (Turner, Righton et al. 2002).

Growth rate and age at maturity

There is extreme variability in age at maturity and intrinsic rate of increase among the different cod stocks; age at maturity ranges from 2.5 to 7.5 years, while intrinsic rate of increase ranges from 0.24 to 1.03 (Table 2) (Denney, Jennings et al. 2002; Myers, Mertz et al. 1997). The estimates for Icelandic cod age at maturity and intrinsic rate of increase are 7 years and 0.24, respectively. Some male cod off of Norway have been shown to reach maturity by age-2, while by age-10 almost all cod are mature (Berg and Albert 2003). The average 50% maturity for Northeast Arctic and Norwegian coastal cod is 6.9 and 5.7 years, respectively (Berg and Albert 2003). Cod off the northern coast of Iceland have been shown to reach maturity at different ages and sizes than cod in the southern waters of Iceland, but overall, 50% of female cod are mature at 6.6 years while 50% of male cod are mature at 5.8 years (Marteinsdottir and Begg 2002). Organisms with growth coefficients (k) less than 0.10 are particularly vulnerable to excessive mortality (Musick 1999). The median growth coefficient for Atlantic cod is 0.10 (Froese and Pauly 2005).

Cod can reach 200 cm total length (TL), 96.0 kg in weight, and 25 years of age (Froese and Pauly 2005). Due to overexploitation in the North and Celtic Seas, the maximum observed sizes of many fish species have declined in recent years (Jennings, Pinnegar et al. 2001). In the North Sea, the current maximum recorded length of cod is 123 cm, and the current maximum recorded weight is 17.65 kg (Jennings, Pinnegar et al. 2001). Slower growth rates in the waters off northern Iceland may be reflective of cooler water temperatures, and cod in these waters are mature at a later age (Begg and Marteinsdottir 2002).

Spawning and fecundity

In the Baltic Sea, spawning occurs in the central region known as the Bornholm Basin; from there, larval cod then drift to nursery areas (Hinrichsen, Mollmann et al. 2002). Spawning occurs in the warmer waters where there is a larger larval food supply (Godø 2003). Regional spawning areas off of Iceland include the southwest, southeast, and north coasts (Marteinsdottir, Gudmundsdottir et al. 2000; Begg and Marteinsdottir 2002), with the main spawning grounds occurring on the south coast (Marteinsdottir, Gudmundsdottir et al. 2000). The main spawning period in Icelandic waters is from March to May (Marteinsdottir and Bjornsson 1999; Begg and Marteinsdottir 2002). Spawning cod are most often found in depths down to 300 m and water temperatures above 2°C, as well as in inshore waters (Begg and Marteinsdottir 2002). Begg and Marteinsdottir (2002) also found fewer older and larger fish present in the stock, with most spawners ranging from 60- –100 cm in length and 8–10 years of age. Larger and faster-growing cod spawn closer to the coast, while the smallest and youngest cod spawn along the continental edge (Marteinsdottir, Gudmundsdottir et al. 2000). Within the spawning area, there is a shallow-water and deep-water component of Icelandic cod, with the deep-water cod migrating to deeper and cooler waters, and conducting more vertical migrations than the shallow-water component when it is not the spawning season (Pálsson and Thorsteinsson 2003).

Cod is highly fecund, with an average production of 1 million eggs per female annually (FAO 2003). Length/fecundity relationships show that a 75 cm female can produce 1.5–2.9 million eggs while a 100 cm female can produce 3.9–8.7 million eggs (Heessen, H., unpublished data). Egg production varies according to the size structure of the stock (Marteinsdottir, Gudmundsdottir et al. 2000) and there is spatial variation in the size and age of spawners within the main spawning grounds (Marteinsdottir, Gudmundsdottir et al. 2000). Spawning aggregations may be patchy, with fish aggregating over a particular habitat-type or structure (Marteinsdottir, Gudmundsdottir et al. 2000). On average, larger females have been shown to produce more eggs (Marteinsdottir and Thorarinsson 1998), and it has been shown for other species that removing these larger females from the population can have detrimental population effects (Berkeley et al. 2004). Icelandic cod appear to have higher fecundity than Arcto-Norwegian, Northwest Atlantic, and Baltic and North Sea cod (Marteinsdottir and Begg 2002). Retention and dispersal are essential factors affecting the survivability of larval cod (Hinrichsen, Mollmann et al. 2002).

Population dynamics are affected by environmental conditions; in transition periods between high and low productivity, cod may be more vulnerable to intense fishing pressure (Godø 2003). In addition, yearly variability in life history characteristics such as fecundity and growth rates may not be captured by biomass models (Jonzen, Cardinale et al. 2002).

The collapse of the Northwest Atlantic cod stocks was preceded by a shift towards an earlier age at maturity and size at maturity (Olsen, Heino et al. 2004). Such life history changes are a result of intense fishing pressure (Olsen, Heino et al. 2004). Intense fishing pressure affects the adult cod population, and therefore recruitment (Fogarty, Myers et al. 2001). Recruitment variability has been shown to be particularly high for cod in the Barents Sea and the Faroe Plateau, although the high variability seen in the Barents Sea stock may be due to the fact that this is the northern range of the species (Fogarty, Myers et al. 2001).

Observations show a clear trend toward earlier maturation of Northeast Arctic cod, with a decrease of about three years in the mean age at first spawning from the 1940s until today. Because age at first spawning is a heritable characteristic, the data seem to support the hypothesis that the Northeast Arctic cod has responded evolutionarily to the altered exploitation regime (Heino, Dieckmann et al. 2000). Such phenotypic variation could also be due to changes in density or the environment, however.

Table 2. Some life history characteristics of Northeast Atlantic cod. Main reference is Denney, Jennings et al. (2002). Other references (italicized) are Myers, Mertz et al. (1997) for intrinsic rate of increase, Berg and Albert (2003) for the lower (6.9) and higher (5.7) values for age at 50% maturity for Northeast Arctic and Norwegian coastal cod, respectively, Marteinsdottir and Begg (2002) for gender-specific values of age at 50% maturity for Icelandic cod, and Froese and Pauly (2010) for maximum reported age. Blank cells indicate values that were not easily obtainable in the literature.

Stock	Intrinsic Rate of Increase (r)	Age at Maturity (50% of individuals)	Growth Rate (k)	Max Age (yrs)	Max Size (cm)	Fecundity (1000s of eggs)	Species Range	Special Behaviors
northeast Arctic	*0.36*	*6.9*–7.12	0.1	*25*	136.9	3660	Northeast Atlantic from the Bay of Biscay to the Barents Sea; east and west coasts of Greenland; around Iceland; Northwest Atlantic	Aggregate to spawn and experience population variability due to environmental conditions
eastern Baltic	*0.85 (SE Baltic)*	3.5			85.7			
western Baltic	*0.58 (central Baltic)*	4.15			86.2			
Celtic	*0.72*	2.11	0.22		113.9			
Faroe	*0.52 (Plateau)*	2.75			108.6			
Icelandic	*0.24–0.34*	5.93 *(males 5.8; females 6.6)*	*0.1*		135.5	2418		
Irish Sea	*1.15*	3.09			122	1081		
Kattegat	*0.64*	2.46	0.13		105			
North Sea	*0.68*	3.79	0.16		131.8	1642		
Norway Coastal		4.94–*5.7*	0.11		122.8			
west Scotland	*0.9*	1.95	0.16		104.8			

Synthesis

Cod has a high intrinsic rate of increase, a moderate age at sexual maturity, a moderate growth coefficient, and is moderately long-lived. The Icelandic and Barents Sea (Northeast Arctic) stocks are less productive than more southerly stocks. Cod also exhibits several characteristics that increase its vulnerability to fishing pressure. These include the formation of spawning aggregations and population variability in response to environmental conditions. Based on the depletion of the Northwest Atlantic cod stock, changes in life history characteristics may be an indication of the present severely declining population, and caution is warranted in the Northeast Atlantic. However, based on a high intrinsic rate of increase, cod is considered inherently resilient to fishing pressure.

Inherent Vulnerability Rank:

Resilient 🟩 Moderate 🟨 Vulnerable 🟥

CRITERION 2: STATUS OF WILD STOCKS

The International Council for the Exploration of the Sea (ICES) is the main institution charged with assessing Northeast Atlantic cod stocks, though some countries (e.g. Iceland) conduct their own assessments. ICES does not yet use an MSY-based approach, though plans to do so by 2015 (ICES 2010). As part of this transition, some stocks do currently have MSY-based reference points defined. Most, however, are currently assessed using ICES Precautionary Approach (PA). The PA is based on three criteria: 1) spawning biomass in relation to precautionary limits; 2) fishing mortality in relation to precautionary limits; and 3) fishing mortality in relation to highest yield (Table 3). The precautionary limits are referred to as B_{pa} (for spawning stock biomass or SSB) and F_{pa} (for fishing mortality). ICES stresses that these are limits, not targets, and the goal of management should be to keep SSB well above B_{pa} and fishing mortality well below F_{pa}. ICES also uses biomass and fishing mortality limit reference points. B_{lim} is the minimum biomass limit, below which recruitment is expected to be impaired or the stock dynamics unknown (the latter in the case where B_{lim} is the lowest observed). F_{lim} is the fishing mortality rate expected to result in stock collapse if maintained over the long term.

The first criterion is a measure of the biomass of adult fish in a stock and whether the biomass estimate is above or below the minimum level recommended by ICES (ICES undated; ICES 2005). There are three categories:

- If $SSB>B_{pa}$, the fish stock status is considered as '**having full reproductive capacity**.' It is considered healthy and above the minimum level recommended by ICES.
- If $B_{lim}<SSB<B_{pa}$, the fish stock is considered below the minimum level recommended by ICES and '**at risk of reduced reproductive capacity.'**
- If $SSB<B_{lim}$, the stock is considered to be depleted and suffering '**reduced reproductive capacity**,' and current fishing pressure should be reduced to allow rebuilding.

The second criterion is a measure of the fishing pressure on a fish stock and whether it is above or below the maximum level recommended by ICES (ICES undated; ICES 2005). There are three categories:

- If $SSB>B_{pa}$, the stock is being '**harvested sustainably**' and fishing pressure is below the maximum level recommended by ICES.
- If $F_{lim}>F>F_{pa}$, there is a "**risk of being harvested unsustainably,**' fishing pressure is above the maximum level recommended by ICES and could result in depletion of the stock in the future if it is not reduced.
- If $F>F_{lim}$, fishing pressure is well above the maximum level recommended by ICES and the stock is being '**harvested unsustainably**.'

The third criterion is a measure of the level of fishing pressure on a stock that will, on average, result in a long-term high yield. The three categories for the third criterion are "**below target**" (increased fishing pressure on the stock would result in a higher yield in the long term), "**appropriate**" (fishing pressure is at the right level to get the most fish from the stock in the long term), and "**overfished**" (fishing pressure is too high and more fish could be taken from the stock in the future if current fishing pressure is reduced) (ICES undated).

The ICES reference points F_{pa}, F_{lim}, B_{pa} and B_{lim} are not equivalent to MSY-based reference points, and comparisons have demonstrated that F_{pa} is typically above F_{MSY} and B_{pa} is typically below B_{MSY}, such that MSY-based reference points are generally more conservative (ICES 2010); in many cases, B_{pa} is well below B_{MSY} and even below $1/2B_{MSY}$ (Kell, Pastoors et al. 2005).

The status of each stock is discussed in detail below, and a summary is provided at the end of this section (Table 3).

Northeast Arctic

According to ICES, the Northeast Arctic cod stock was being fished at above F_{pa} from the early 1950s to the late 1980s, including many years of being fished at above F_{lim} (ICES 2010). During this time, spawning biomass was below B_{pa} and often below B_{lim}. Fishing mortality was then sharply curtailed in the late 1980s, and spawning biomass increased to levels above B_{pa} by the early 1990s. Fishing mortality sharply increased again in the mid- to late-1990s, and biomass subsequently declined to below B_{pa}.

Northeast Arctic cod have exhibited large fluctuations in biomass related to temperature and lunar cycles (Yndestad 2003). Godø (2003), however, suggests that overexploitation caused the dramatic decline in stock abundance in the 1980s. Historically, the Northeast Arctic cod stock was plagued with problems such as quotas exceeding the recommended level, actual catches higher than the total allowable catch (TAC), and discarding of small fish (Nakken 1998). These issues were exacerbated by poor recruitment (Godø 2003). Skewed sex ratios have also been reported for cod in the Northeast Arctic (Nordeide 1998; Heino, Dieckmann et al. 2000). Despite these concerns and the historical overfishing, however, in recent years fishing pressure has been dramatically reduced (Figure 5) and spawning stock biomass is now increasing (Figure 4) (ICES 2010). Fishing mortality was then reduced from well above F_{lim} in 1999 to below F_{pa} in 2007 (Figure 5). In 2010, F was estimated to be 0.28, which remains below the target F_{pa} (0.40) (ICES 2010). Spawning biomass was 1,145,460t in 2010, and has been above B_{pa} (460,000t) since 2002 (Figure 4) (ICES 2009; ICES 2010).

Northeast Arctic cod also occur in the Svalbard area, and are caught as they migrate to the coastal waters of Norway (Bergstad, Jørgensen et al. 1987). The two Norwegian fisheries for Northeast Arctic cod are the winter spawning fishery on the coastal banks, and the spring fishery for large immature fish off the coast of northern Norway (Godø 2003). Norway and Russia are the predominant countries landing Northeast Arctic cod (ICES 2004).

Northeast Arctic cod have shown a drastic reduction in age at maturation from 10–11 years in the 1930s to approximately 7 years in the late 1990s (Heino, Dieckmann et al. 2002). This is likely a fisheries-induced adaptive genetic change (Heino, Dieckmann et al. 2002). Tretyak (2002) reports that Northeast Atlantic cod spawn in at least two groups, early spawners at 3–8 years and late spawners at 9 years and older. Abundance of the latter declined markedly from 1949 to 1997, while abundance of the former has been increasing steadily since the 1960s. This change in the structure of the spawning stock is related to long-term overfishing (Tretyak 2002). Long term environmental changes in the region may also have played a role in these trends.

Sources of uncertainty include unreported catches. From 2002–2006, it was estimated that up to 90,000-166,000t of cod catch was unreported (ICES 2010). According to the Norwegian authorities, Russian catches accounted for most (if not all) of the unreported catch.[3] More recently, the efforts of Norwegian and Russian authorities to curb IUU fishing[4] are estimated to have decreased unreported catch from 8,757-41,087t in 2007 to 0-15,000t in 2008 to 0t (provisional estimate in 2009) (ICES 2010). Estimates of unreported catch are taken into account in the overall fishing mortality when ICES calculates the proposed quotas.

The stock status of Northeast Arctic cod is a moderate conservation concern according to Seafood Watch® due to biomass relative to B_{MSY} being unknown but well above the management reference point and increasing in the short-term (Figure 4), fishing mortality being substantially below the management reference point, and spawning distribution parameters being skewed.

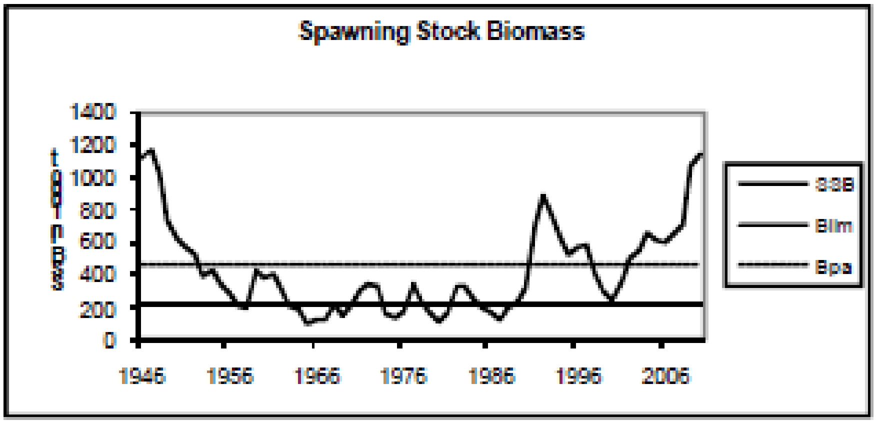

Figure 4. Spawning stock biomass of Northeast Arctic cod, 1946–present (Figure from ICES 2010).

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[3] http://www.fiskeridir.no/english/fisheries/reports/russian-cod-fishing-transhipment-at-sea

[4] http://www.fisheries.no/resource_management/control_monitoring_surveillance/No_IUU_fishing_of_cod_in_the_Barents_Sea/

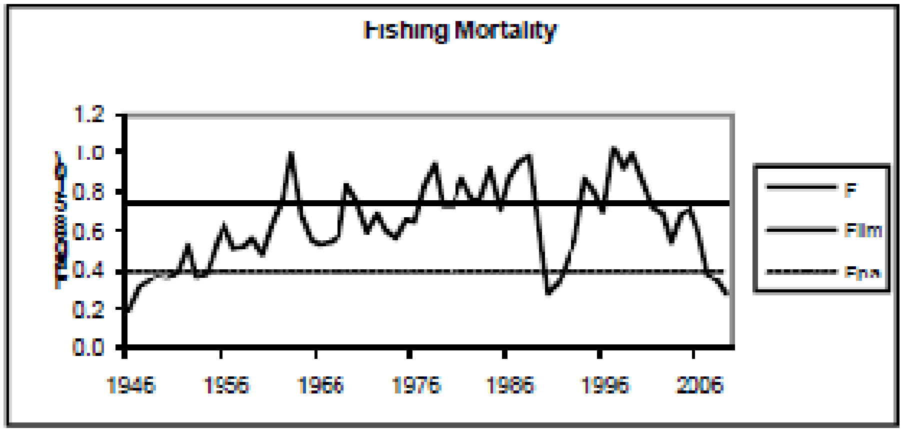

Figure 5. Fishing mortality for Northeast Arctic cod, 1946–present (Figure from ICES 2010).

Icelandic

Spawning stock biomass exhibited a dramatic declining trend from 1955 until the mid-1980s; since then SSB has remained relatively stable at low levels with a gradual increase since the mid-2000s (ICES 2010). In the waters off Iceland, the cod stock has been depleted since the mid-1980s, with both a low spawning stock biomass and poor recruitment (Schopka 1994; Marteinsdottir and Thorarinsson 1998; ICES 2010). Continued low recruitment combined with a historical low weight-at-age means the productivity of the stock is currently very low (ICES 2010). The continuous decline observed in the Icelandic cod stock until the early 1990s was due to a combination of fishing pressure and environmental factors (Schopka 1994).

Prior to 2010, biological reference points had not been defined for the Icelandic cod stock. ICES therefore evaluated the stock only in relation to the highest yield, and found it to be overfished/overexploited from 2004 (the earliest stock status report available on the internet) to 2008 (ICES 2009). In 2010, ICES evaluated the stock based on the Icelandic government's new rebuilding plan and harvest control rule (HCR), adopted in spring 2009 for the 2009/2010 fishing season (ICES 2010). The new HCR does define a trigger point for spawning stock biomass ($SSB_{trigger}$=220,000t) below which fishing mortality must be reduced, a minimum biomass limit (B_{lim}=125,000t), and a harvest rate (F=0.2 when SSB is above $SSB_{trigger}$). Fishing mortality reference points remain undefined, however. The goal of the plan is to maintain fishing mortality at a rate that generates MSY over the long term, and to ensure that SSB remains over 220,000 t in the medium-term (2015). ICES found the plan and HCR to be consistent with their precautionary approach and MSY framework, and found that the plan will have a very high probability of meeting the medium-term goal. Estimated SSB in 2010 is 300,488t, which is above $SSB_{trigger}$ and B_{lim} (ICES 2010). According to ICES, biomass is expected to remain above 220,000t in the medium-term (2015).

The medium-term SSB goal (220,000 t) is very low compared with the estimated SSB prior to the 1960s, however, less than 24% of the peak in the time series (938,351t in 1955, the earliest year presented in ICES' stock evaluations) (Figure 6). Furthermore, estimated SSB from the late 1920s and early 1930s suggests the stock had already declined by 1955, perhaps by 20% or so

(Schopka 1994; Astthorsson, Gislason et al. 2007).[5] Estimated SSB increased to 300,488 t in 2010, approximately 32% of that in 1955 (ICES 2010).

The fishing mortality rate has exhibited a general increase since 1955, although it has been relatively stable at a high level over the last 20 years (ICES 2004). Fishing mortality has been as high as F=0.7–0.9 on ages 5–10 during some periods, most recently in the early 2000s. Since then, fishing mortality has declined and is now the lowest it has been in 40 years (Figure 7) (ICES 2010). Prior to 2010, the HCR assumed a fishing mortality rate of F=0.4. F (ages 5–10) was above 0.4 from 1963 to 2007, and just under (F=0.38) in 2008 and 2009 (ICES 2010). The new harvest control rule adopts a target fishing mortality rate of F=0.2 on ages 4+ when SSB>220,000 t (and decreases fishing mortality when below 220,000 t). F=0.2 is lower than estimated fishing mortality for any year in the entire time series (1955–2009), though recently by a relatively small margin (F_{2008}=0.21 and F_{2009}=0.23) (ICES 2010). Although fishing mortality in 2008 and 2009 was above F=0.2, it was well below the target at the time of F=0.4, and the current target F is now set at a much more sustainable level of F=0.2 (ICES 2010). Thus, the target fishing mortality has been reduced and is more likely to be sustainable now. However, it is unknown whether overfishing is occurring as of 2010.

According to ICES (2004), the age composition of the Icelandic cod stock is highly skewed, with spawners age-8 and younger constituting approximately 94% of the spawning stock biomass in 2005. The age composition of the Icelandic cod stock has changed over time, with fewer fish surviving beyond age-7 or age-8 (Marteinsdottir and Thorarinsson 1998). Increased fishing pressure has resulted in smaller spawning size peaks (Marteinsdottir and Thorarinsson 1998). Pardoe, Vainikka et al. 2009(2009) find that age and size at maturation has decreased over time, a phenomenon at least partially due to genetic change. Skewed sex ratios have been reported for Icelandic cod spawning aggregations (Jónsdóttir, Daníelsdóttir et al. 2001); however, these sex ratios were obtained from spawning fish and therefore may not be a good indication of the actual sex ratio for the stock.

Biomass of Icelandic cod has increased over the last several years and is above $SSB_{trigger}$ and B_{lim}; however, the stock relative to B_{MSY} is unknown. Fishing mortality is now as low as it has been in the last four decades, and fell below the target F=0.4 for the first time in 2008. As the Icelandic stock appears to be rebuilding, short-term abundance is up and overfishing is no longer occurring, and stock uncertainty is low, Seafood Watch deems it a moderate conservation concern.

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[5] Schopka (1994) and Astthorrson, Gislason, et al. (2007) indicate that SSB was 300,000 t in the early 1990s, which is approximately 16% of its peak of some 1.9 million t around 1930. However, the data presented in these studies suggests SSB was about double that estimated by ICES in recent (2005–2010) stock assessments (e.g. 124,316 t in 1993; ICES 2010). Thus, while it appears that SSB was considerably higher in 1930 than in 1955, actual quantifiable estimates are difficult.

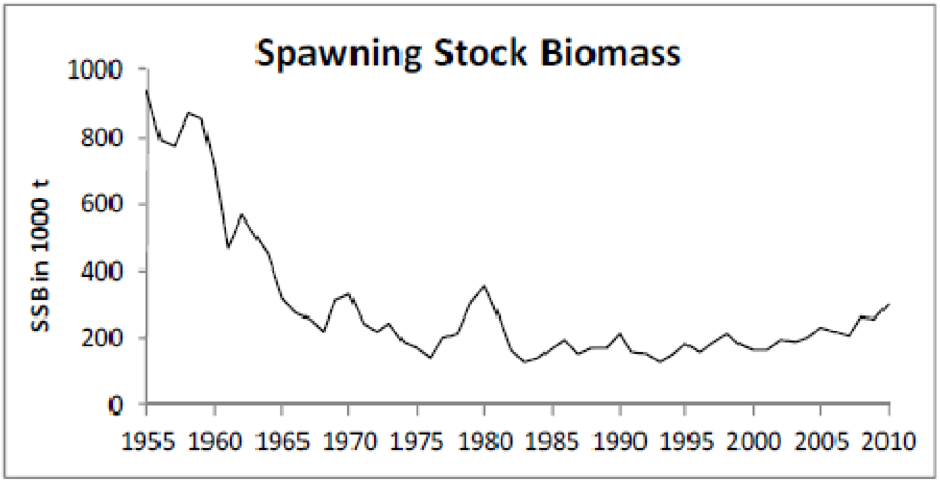

Figure 6. Spawning stock biomass of Icelandic cod, 1955–present (Figure from ICES 2010).

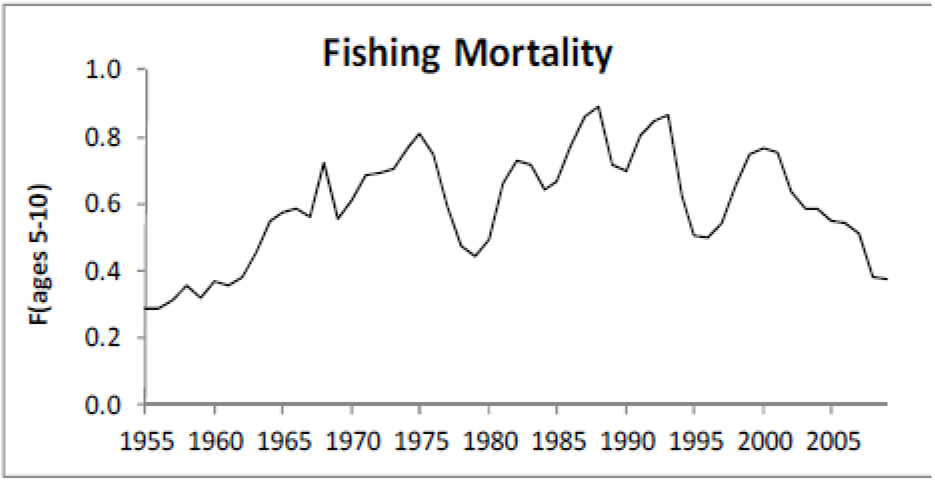

Figure 7. Fishing mortality on Icelandic cod, 1955–present (Figure from ICES 2010).

Baltic Sea

In the Baltic Sea, there are two cod stocks, one in the eastern region (25–32), and one in the western region (22–24); more than twice as much cod is landed in the eastern region than in the western region (ICES 2010). The most common gears used to catch cod in both areas are trawls (70%) and gillnets (ICES 2010).

Eastern Baltic Sea

Biomass reference points have not been defined for the eastern stock, but F_{MSY}, F_{lim}, F_{pa} and F_{target} have all been defined (ICES 2010). In the early- to mid-2000s, the eastern stock was five times lower than it was in the 1980s due to a combination of poor recruitment and fishing pressure (Figure 9) (Radtke 2003). The stock was considered to be at reduced reproductive capacity, harvested unsustainably, and overexploited (ICES 2005). From 1980 to 1998, a fishing mortality rate of F=0.9 was higher than the level recommended by ICES, and there were fears that a fishing mortality rate this high may reduce the eastern Baltic cod stock to less than 1,000 mt within the next 10 years (Jonzen, Cardinale et al. 2002). In addition, size at maturity has decreased since the late 1980s (Cardinale and Modin 1999). SSB was at the lowest point in the time series (1966–2010) in 2005 at 66,236t, approximately 10% of the biomass at the peak (696,743t in 1980) (Figure 9). Since then, recruitment has improved (the 2006 and 2007 years classes are the strongest since 1987), and SSB increased rapidly to 294,000t in 2010. Biomass reference points have not been defined, but ICES considers the present SSB to be above any candidate for precautionary biomass reference points (ICES 2010). Fishing mortality reached a peak in 2004 at F=1.52, and then declined sharply, reaching a time series-low of F=0.23 in 2009 with the adoption of a new EU management plan defining F_{MSY}=0.3 (Figure 10) (ICES 2010).

There is moderate uncertainty associated with the eastern stock due to poor data quality, and there is no absolute estimate of stock biomass. It is estimated that total catches were 32%–45% higher than reported catches due to extensive misreporting, and these estimates are included in the assessment (ICES 2010).

The previous version of this report (November 2005) deemed Baltic Sea cod a critical conservation concern, as ICES listed the stock as being at reduced reproductive capacity and harvested unsustainably; and considered it overexploited. Since then, managers appear to have brought fishing mortality under control (below F_{MSY}) in the eastern Baltic and biomass has increased sharply to a level above any candidate for precautionary biomass reference points. However, biomass relative to B_{MSY} or a similar reference point is not known. Seafood Watch thus deems the eastern Baltic stock as moderate conservation concern, but will continue to monitor the stock to ensure the positive trends continue.

Western Baltic Sea

Spawning stock biomass of western Baltic Sea cod declined from a peak of around 50,000 t in 1980 to under 10,000 t in 1992 and then sharply increased to some 42,000 t in 1994. Since the late 1990s, SSB has been fluctuating around the B_{pa} of 23,000 t (all values are means) (Figure 9) (ICES 2010). In 2010, SSB was estimated at just over B_{pa}, at nearly 24,000 t. However, there is moderate uncertainty in this estimate, with a range from 16,200 t to 35,427 t (ICES 2010). Fishing mortality was relatively stable from 1970 to the late 1990s (ICES 2004), but has since been decreasing and has been around 0.7 in recent years. The current management plan (agreed by the EC in 2007) aims for a 10% reduction in F each year. The current estimate of F is still much above F_{MSY}=0.24, however ($F_{2009(ages3\text{-}6)}$=0.72) (Figure 10) (ICES 2010). Like the estimates of SSB, there is moderate uncertainty over current F as evidenced by large confidence intervals in Figure 10. Sources of uncertainty include poor recruitment data, not all removals are considered, and discarding may be significant in some years (ICES 2010).

In the western Baltic, current SSB is uncertain but is probably around B_{pa}. Fishing mortality has been decreasing over the last few years, but remains higher than F_{MSY}. The western stock is thus deemed a high conservation concern.

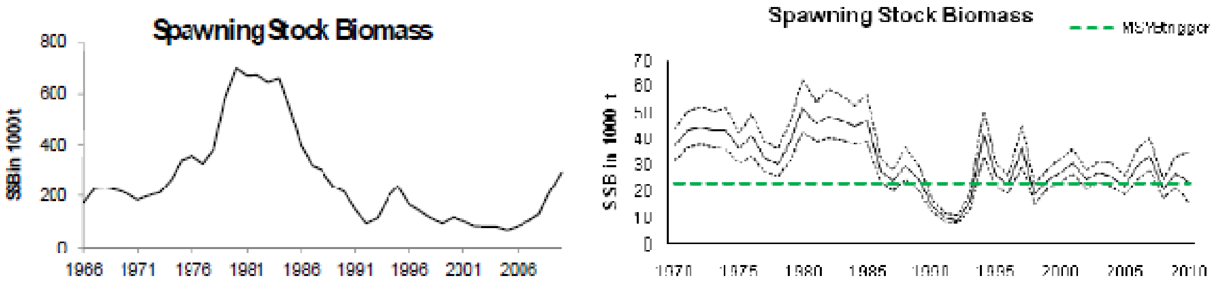

Figure 9. Spawning stock biomass of eastern (left graphic) and western (right) Baltic Sea cod (Figures from ICES 2010).

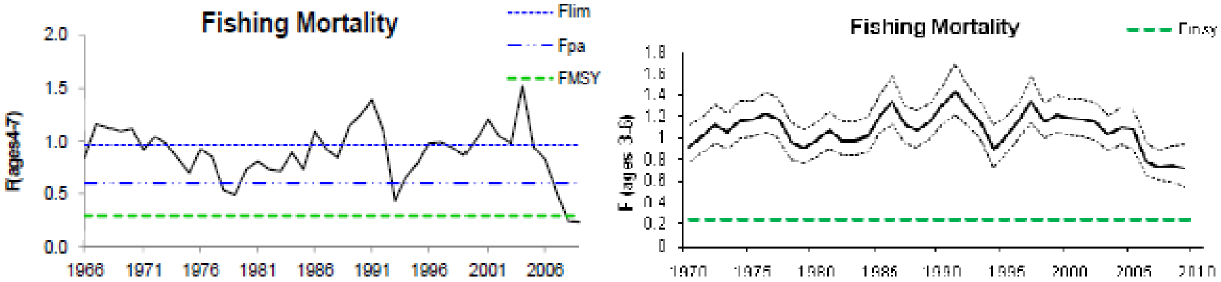

Figure 10. Fishing mortality on eastern (left graphic) and western (right graphic) Baltic Sea cod, (Figures from ICES 2010 Book 8).

Celtic Sea

The state of the cod stock in the Celtic Sea is uncertain (ICES 2010). No estimate of SSB is available. Although precautionary reference points have been defined for the stock (B_{pa}=8800 t, B_{lim}=6300 t, F_{pa}=0.68, F_{lim}=0.90), F_{MSY} and $B_{MSY\text{-}trigger}$ have not, and no estimate of SSB is available. More than 80% of landings from 1971 from 2009 are from the 1–3 yr age groups, and total mortality (fishing and natural) appears to be very high. There are no specific management objectives, though a plan is under development. Landings have declined since the late 1990s. Although F_{MSY} has not been defined, ICES consider it likely that current F is above F_{MSY} (ICES 2010). Uncertainty is high. The most recent evaluation used survey indices but no commercial indices (landings and effort data from France were not available in time for the evaluation) and no estimates of discarding and misreporting (both of which have likely been exacerbated since 2003, when quotas became more restrictive) (ICES 2010). The stock status of Celtic Sea cod is considered a high conservation concern as overfishing is likely occurring, there is no estimate of SSB, and there is high uncertainty in the status of the stock.

Norwegian coastal

According to ICES, SSB of Norwegian coastal cod is at historically low levels. Recruitment has declined over the period 1984–2002, has remained low since, and is "clearly impaired at present SSB" (Figure 11) (ICES 2010). In 2004 ICES advised that no catch should be taken from this stock (for the 2005 fishing season), and that a rebuilding plan be developed and implemented.[6] Nonetheless, the annual catch was around 22–26,000 t for 2005-2009, the harvest rate had not

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[6] ICES Advice reports are available online at http://www.ices.dk/advice/icesadvice.asp

decreased appreciably (Figure 12) (ICES 2010), and a rebuilding plan is still in development (proposed by the Norwegian government and is currently being evaluated by ICES) (ICES 2010). Some 35% of the catch is estimated to be from the recreational fishery, for which annual landings data are not available. The stock status of Norwegian coastal cod is considered a critical conservation concern as it is at reduced reproductive capacity and fishing mortality is high.

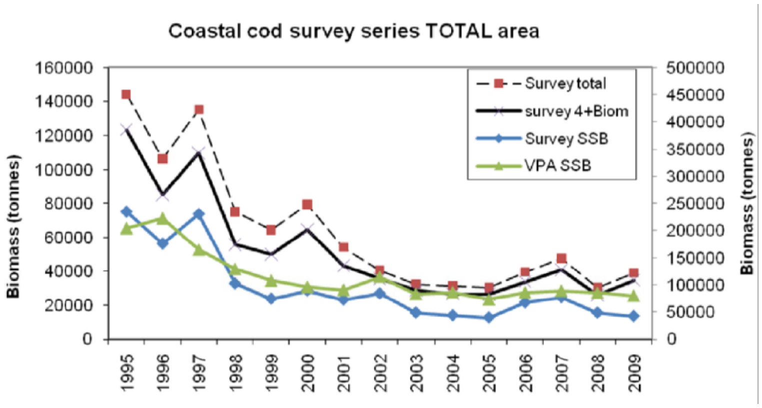

Figure 11. Spawning stock biomass of Norwegian coastal cod, 1984–2005 (Figure from ICES 2010).

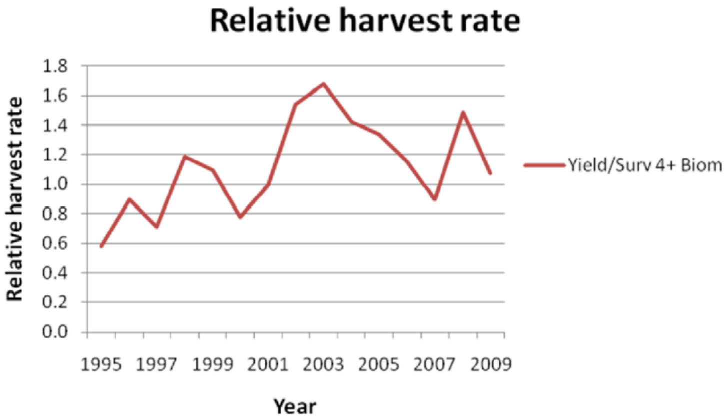

Figure 12. Relative harvest rate on Norwegian coastal cod (ages 4+), 1995–2009 (Figure from ICES 2010).

North Sea (including the Eastern Channel and Skagerrak)

In the North Sea, the cod stock has been subject to intense fishing pressure and rising sea temperatures and is currently considered depleted (Hislop 1996; Serchuk, Kirkegaard et al. 1996; Cook, Sinclair et al. 1997). In the fishery, most cod are fully exploited by age-2, and do not have a chance to reproduce (Cook, Kunzlik et al. 1991). Long-term changes in the abundance of plankton, due to rising sea temperature, have resulted in concomitant changes in North Sea cod recruitment due to larval survival (Beaugrand, Brander et al. 2003). Recruitment since 2000 has been poor (ICES 2010). Over the period of decline of the North Sea cod stock, genetic changes also occurred in the population (Hutchinson, Oosterhout et al. 2003). The combination of a high fishing mortality rate, low recruitment, and low spawning stock biomass is considered unsustainable (Bannister 2004).

SSB reached a historical low in 2006, at just below 35,000 t, approximately 13% of the peak biomass in 1971 (264,800 t) (Figure 13) (ICES 2010). It increased to 68,560 t in 2009, but is still below B_{lim} (70,000t) and far below $B_{pa}/B_{MSY\text{-}trigger}$ (150,000t). Fishing mortality increased from 1963 to the early 1980s, at which point it was substantially over F_{lim}. F largely remained above F_{lim} through the late 1990s, reaching a peak of nearly F=1.2 in 1999 and subsequently decreased to below F_{pa} by 2007 (Figure 14). However, F increased again to F_{lim} in 2009 (ICES 2010). Moderate uncertainty is introduced through unreported landings and estimates of discards of 30%–50% of the total catch (in 2007–2009) (ICES 2010).

North Sea stocks mature earlier and at a smaller size than they did 20–30 years ago (Rochet and Munch 2002; Yoneda and Wright 2004). Inshore cod are now (2002–2003) more fecund than when spawning stock size was high (1969–1970), a change consistent with modeled effects of intense size-selection pressures (such as under high overexploitation) (Yoneda and Wright 2004). These cod also now have a higher fecundity-at-age/size than offshore and West of Scotland stocks, a spatial pattern that did not exist in 1970 (Yoneda and Wright 2004). Rowell (1993) (in Law 2002) found that under the very high fishing mortalities in the 1980s, there was a strong advantage to early maturation because older maturers would likely perish before spawning.

The stock status of cod in the North Sea (including the Eastern Channel and Skagerrak) is considered a critical conservation concern, as the stock is at reduced reproductive capacity and is overexploited, fishing mortality is high, and spawning parameters are skewed.

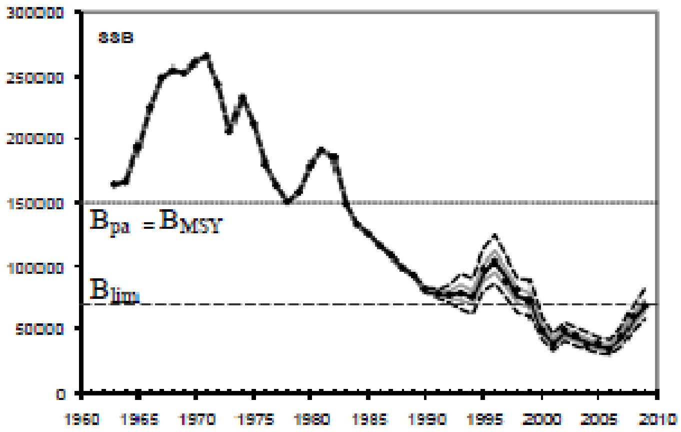

Figure 13. Spawning stock biomass of North Sea cod with percentiles (5,25,75,95), 1963 – 2009 (Figure from ICES 2010).

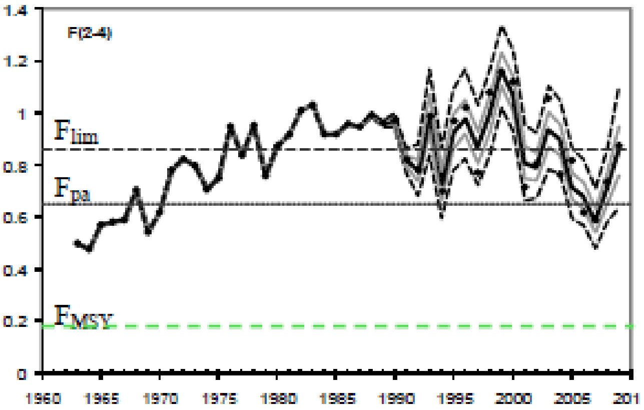

Figure 14. Fishing mortality of North Sea cod with percentiles (5,25,75,95), 1963–2009 (Figure from ICES 2010).

Faroe Plateau

MSY-based reference points have not been defined for Faroe Plateau cod, but reference points based on the precautionary approach were defined in 1998. SSB has been highly variable but above B_{pa} (40,000 t) for the majority of the time series (1961–2009) (Figure 15). It has been below B_{pa} twice, in the early 1990s and in recent years. SSB in 2007 was the lowest observed in the time series, below B_{lim} (21,000 t) which was set at the previous lowest point (1992). SSB increased in 2008 and 2009, and is now between B_{pa} and B_{lim}. Fishing mortality has likewise been very variable since 1961, and has been above F_{lim} on five occasions, most recently in the early 2000s (Figure 16). Since then, F has decreased, and in 2009 was between F_{lim} and F_{pa}. As F_{pa} is typically above F_{MSY} (see introduction to Stock Status Section), $F_{current}$ must be above F_{MSY}; overfishing is therefore occurring according to Seafood Watch® criteria. Uncertainty in stock status is low as landings data and two fishery-independent indices are considered accurate and unreported landings are likely low. While fishing mortality has decreased, short-term biomass has increased and there is low uncertainty in the recent stock assessment, the stock is still being overfished and is thus deemed a high conservation concern.

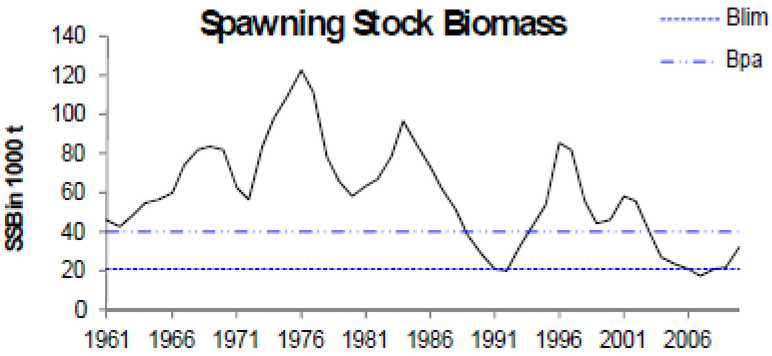

Figure 15. Spawning stock biomass of Faroe Plateau cod, 1961–2009 (Figure from ICES 2010).

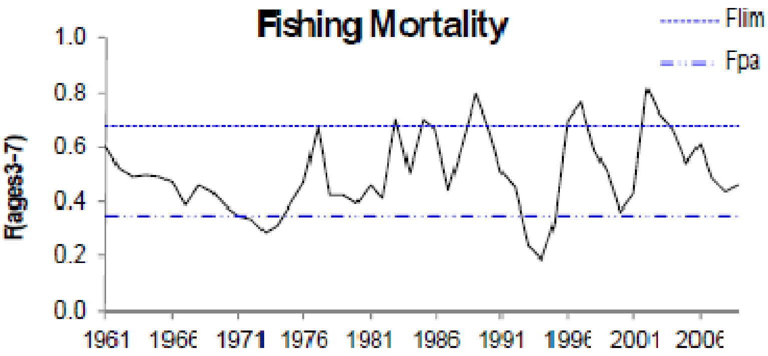

Figure 16. Fishing mortality of Faroe Plateau cod, 1961–2009 (Figure from ICES 2010).

Greenland

No reference points have been defined for Greenland cod (ICES 2010). The stock derives from three stock components, labeled by their spawning area. The offshore Greenland spawning stock has been severely depleted since 1990, the result of both environmental factors and high fishing mortality (ICES 2010). Recruitment of Greenland cod exhibited a steady declining trend from 1950 to 2000 (Stein and Borovkov 2004). An improvement in conditions (high temperature and large shrimp stocks) has facilitated recolonization of the offshore areas, and SSB has increased since 2005 (ICES 2010). ICES has recommended no fishing for this component since 1993, including 2009–2011. There has been no directed fishery since 1992, but one began in 2005 with annual catches of up to 22,000 t (in 2009). Surveys indicate generally poor recruitment, except for 1985 and 2003. Catches from the inshore component, for which spawning occurs in the fjords, have increased ten-fold in the last decade. Inshore recruitment may have improved since 2000. The third component is Icelandic spawned cod that drift to Greenland (ICES 2010). Due to low commercial landings for many years, the stock is assessed using only research surveys so there is moderate uncertainty in the stock assessment. As the stock is depleted and likely undergoing overfishing, and there is a fishery despite ICES' recommendation of no fishing, it is deemed a critical conservation concern.

Kattegat

The Skagerrak-Kattegat area is a region that joins the North Sea and the Baltic Sea, although cod from the Skagerrak is assessed with the North Sea and Eastern Channel cod stocks while the Kattegat stock is assessed separately. Over the past 20 to 40 years, the abundance of cod off the west coast of Sweden has become greatly depleted (Svedäng and Bardon 2003). In particular, there has been a decline in large adult cod in both the Kattegat (Hagstrom, Larsson et al. 1990) and Skagerrak (Fromentin, Stenseth et al. 1998). Logbook data indicate that the CPUE of cod has declined in offshore (by more than 90% between 1982 and 1999) and inshore waters, although the decline in inshore waters occurred 5–10 years prior to the decline in offshore waters (Svedäng and Bardon 2003). Spawning stock biomass was at its historically lowest level in 2000, and has continued to decline since then. B_{lim} has been set at the lowest observed SSB before the late 1990s (6,400t); current SSB is approximately 750–1800 t or 12%–28% of B_{lim} (Figure 17) (ICES 2010).

Fishing mortality has been the major driver of the long term dynamics of the stock (ICES 2010). ICES has recommended a reduction in F every year through 2001 (and to minimize bycatch in 2011). Officially reported landings have declined from over 20,000 t in 1974 to less than 200 t in 2009. However, unreported catches have been estimated at up to 400% greater than official landings in recent years, making estimates of F very uncertain (Figure 18) (ICES 2010). The stock status of Kattegat cod is considered a critical conservation concern, as the stock has reduced reproductive capacity and has declined in the short term, and is currently experiencing high fishing pressure as a result of illegal fishing.

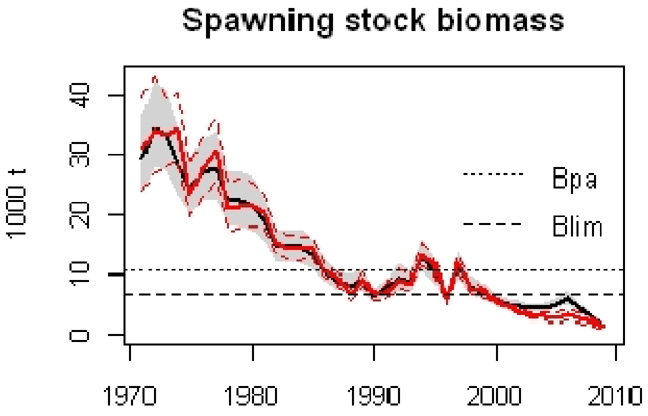

Figure 17. Spawning stock biomass of Kattegat cod, 1970–2009, represented by two runs with (black line) and without (red line) estimating unallocated removals. Shading represents 95% confidence intervals (Figure from ICES 2010).

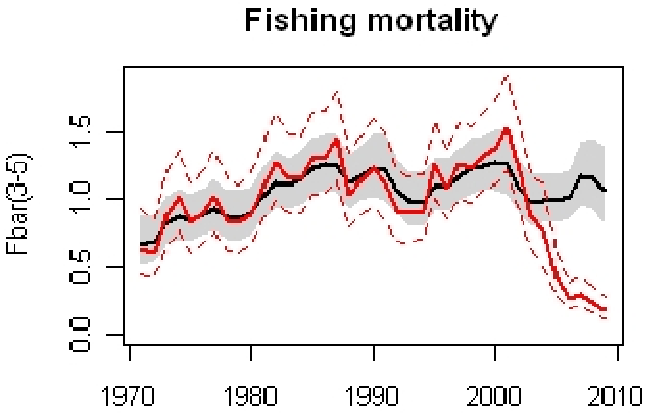

Figure 18. Fishing mortality of Kattegat cod, 1970–2009, represented by two runs with (black line) and without (red line) estimating unallocated removals. Shading represents 95% confidence intervals (Figure from ICES 2010).

Irish Sea

Spawning stock biomass of Irish Sea cod has declined ten-fold since the 1980s, and has been below B_{lim} (6,000 t) since 1995 (Figure 19). In 2009, SSB was at its historical low (1,192 t), some 20% of B_{lim}. Recruitment has been consistently low, with the second and third lowest year classes occurring in 2002 and 2003 (ICES 2004). The 2009 year class estimated to be more abundant, the largest since 2001 (ICES 2010). Fishing mortality fluctuated around F_{pa} in the 1970s, but has since been above F_{lim} every single year (Figure 20). Recent F is uncertain due to unreported removals, which may be double the official landings, but all estimates indicate it remains much above F_{lim} (ICES 2010). ICES has recommended major reductions in F since the early 1990s, including a closure of all cod fisheries in 2003 and a zero catch since then (ICES 2010). The stock status of Irish Sea cod is considered a critical conservation concern, as the stock is at reduced reproductive capacity and fishing pressure is high.

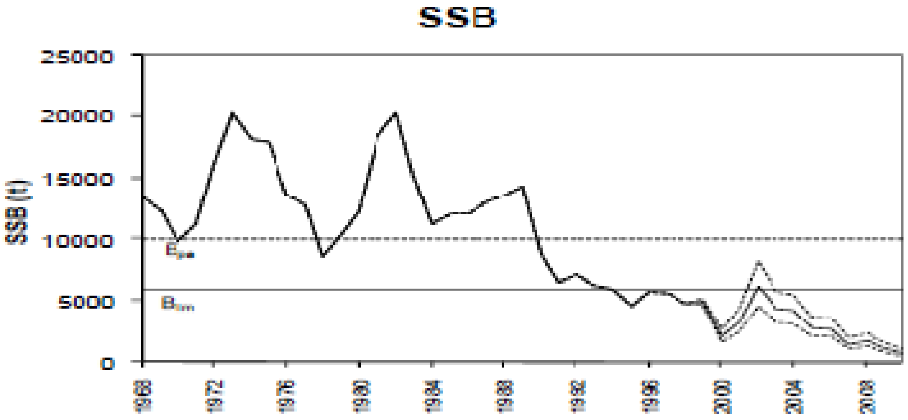

Figure 19. Spawning stock biomass of Irish Sea cod, 1968–2009. Dotted lines are 95% confidence intervals (Figure from ICES 2010).

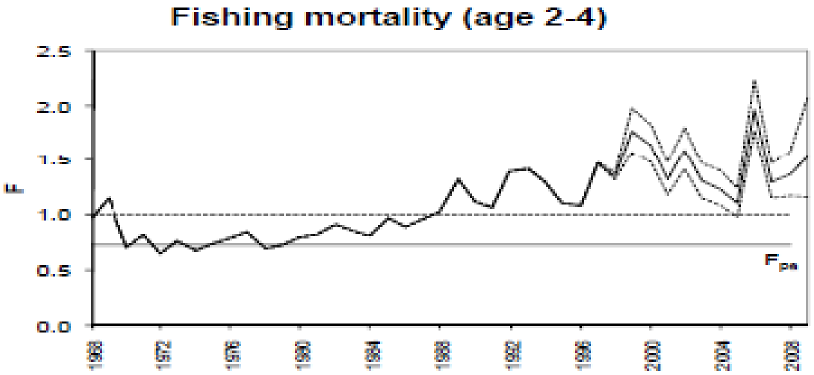

Figure 20. Fishing mortality of Irish Sea cod, 1968–2009. Dotted lines are 95% confidence intervals (Figure from ICES 2010).

West of Scotland

The West of Scotland cod stock spawning stock biomass has been declining since the early 1980s, has been below B_{pa} (22,000 t) since the late 1980s, and below B_{lim} (14,000 t) since the late 1990s (Figure 21) (ICES 2010). It reached a historical low in 2006 of 3,573 t—roughly 26% of B_{lim}. Since then it has increased, but remains well below B_{lim}. Fishing mortality has generally been above F_{lim} since the early 1980s (and above F_{pa} for the entire time series) (Figure 22) (ICES 2010). Recent estimates of F have become more uncertain due to estimates of discards; in 2009, discards were six times the reported landings. Nonetheless, F is most likely still well above F_{lim}, and certainly well above F_{pa} (ICES 2010). The status of this stock is considered a critical conservation concern.

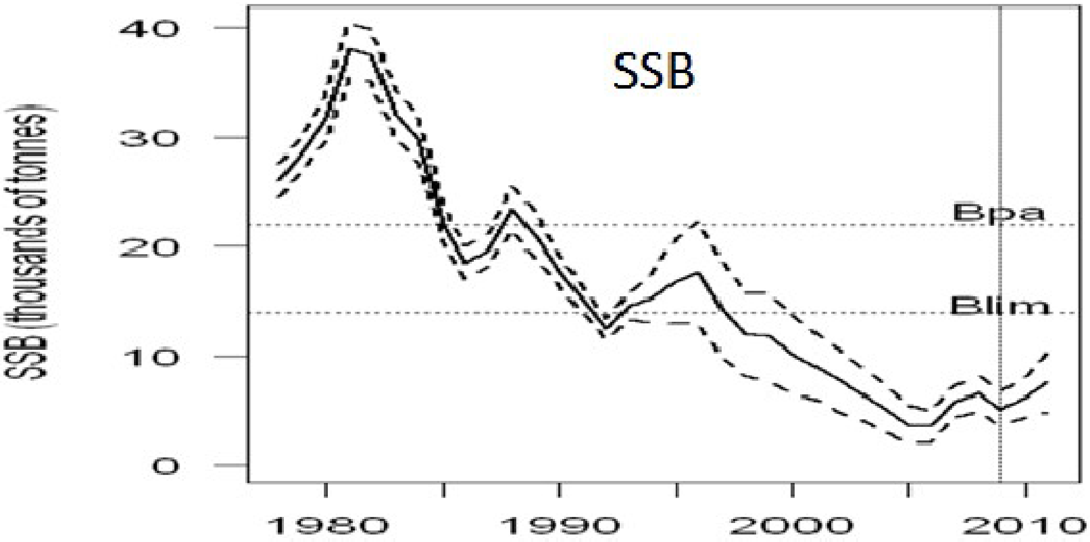

Figure 21. Spawning stock biomass of West of Scotland cod, 1978–2010. Dotted lines are 95% confidence intervals. Values after 2009 are forecasts (Figure from ICES 2010).

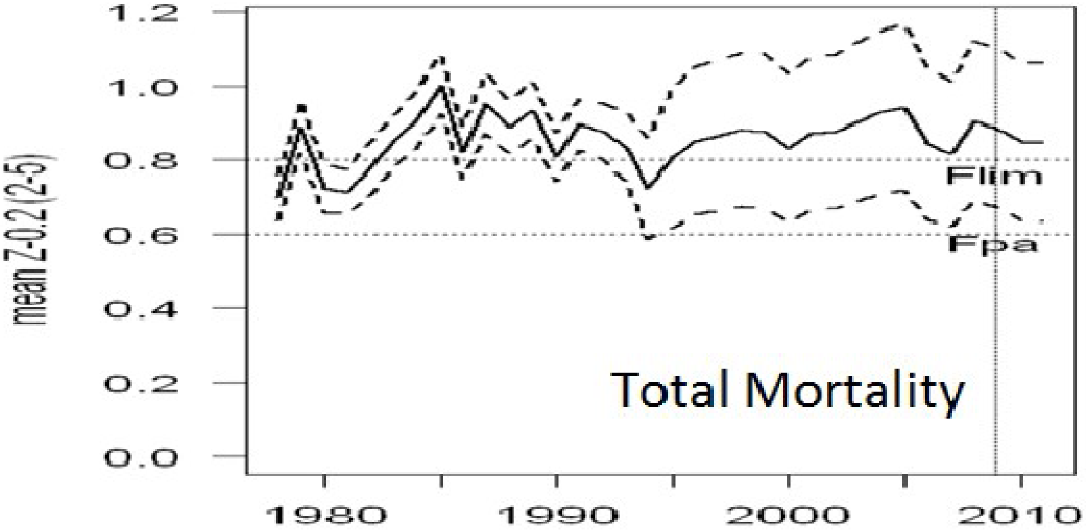

Figure 22. Fishing mortality of West of Scotland cod, 1978–2010. Dotted lines are 95% confidence intervals. Values after 2009 are forecasts (Figure from ICES 2010).

Faroe Bank

No reference points have been defined for the Faroe Bank cod stock, but survey CPUE data indicate SSB is at very low levels. ICES had recommended no fishing since 2008, and the fishery has been closed since 1 January 2009 (ICES 2010). Because the fishery is closed, Seafood Watch® does not provide a recommendation on this fishery.

Rockall

No reference points have been defined for the Rockall cod stock, and there is not enough data for an assessment. Official landings have declined from 1,000 to 2,000 t in the 1980s and early 1990s to less than 100 t since 2004. There are no specific management objectives for this stock (ICES 2010). As the majority of factors are unknown, the stock is deemed a moderate conservation concern.

Synthesis

In the initial iteration of this report (November 2005), the majority of cod stocks were classified as overexploited, and only two stocks (Northeast Arctic and Celtic Sea/Western Channel) had acceptable spawning stock biomass levels. The status of several stocks, including the Northeast Arctic and Iceland stocks that sustain the largest fisheries, have improved since then. The stock status of Northeast Arctic cod is a moderate conservation concern due to biomass being well above the management reference point and increasing in the short-term, fishing mortality being below the management reference point, and spawning distribution parameters being skewed. As the Icelandic stock appears to be rebuilding, short-term abundance is up and overfishing is no longer occurring, and stock uncertainty is low, Seafood Watch deems it a moderate conservation concern. In the eastern Baltic, spawning stock biomass has increased since 2005 and is currently not considered to be a candidate for a precautionary limit, though biomass relative to B_{MSY} is still unknown. Recent fishing mortality is also below F_{pa} and F_{MSY}. The stock is thus deemed a moderate conservation concern. Cod biomass in the western Baltic has fluctuated around the precautionary limit for the last decade. However, recent fishing mortality is much higher than F_{MSY}, so the stock is deemed in poor condition. While fishing mortality on the Faroe Plateau stock has decreased, short-term biomass has increased and there is low uncertainty in the recent stock assessment; thus, according to Seafood Watch criteria, overfishing is still occurring. The stock is thus deemed a high conservation concern. The Celtic Sea stock is also deemed to be a high conservation concern, as current fishing mortality is likely higher than F_{MSY} (though F_{MSY} is undetermined) and spawning biomass is unknown. No cod is currently available from the Faroe Bank stock as the fishery has been closed since January 2009 due to CPUE indices indicating very low stock levels. There is very little information on the Rockall stock and it provides less than a tenth of one percent of the global catch (there’s no directed fishery and catches are bycatch in the haddock and monkfish fisheries). Catches are less than 10% of catches from 20 years ago, but the reasons for this are unclear. The stock is deemed a moderate concern as the majority of factors are unknown. The remaining stocks ((Norwegian coastal; North Sea, eastern Channel, Skagerrak; Greenland; Kattegat; Irish Sea; and West of Scotland) are considered overfished with overfishing still occurring, and are thus deemed a critical conservation concern under SFW criteria.

Table 3. Stock status of cod in the Northeast Atlantic and European waters, in descending order by landings. Box colors illustrate SFW ranking for each stock (yellow=moderate/rebuilding, red=poor, black=critical).

Stock	**Spawning Biomass in Relation to B_{pa}**	**Fishing Mortality in Relation to F_{pa}**	**Fishing Mortality in Relation to Highest Yield**	**Abundance Trends**	**Age/Size/Sex Distribution**	**Degree of Uncertainty in Stock Status**	**Sources**
Northeast Arctic	Full reproductive capacity	$F<F_{pa}$	Appropriate	Long-term variable, short-term increase	Skewed	Low	Nordeide 1998; Godø 2003; ICES 2009; ICES 2010
Icelandic	$SSB>B_{pa}$	F_{MSY} or F_{pa} reference points not defined but F lowest in 40 years and below target in 2008-2009 (F/F0.4=0.95) but unknown in 2010 (F/F0.2=unknown)	Not classified	Long-term decline, short-term increase	Skewed	Low	Schopka 1994; Marteinsdottir and Thorarinsson 1998; ICES 2009; Pardoe, Vainikka et al. 2009; ICES 2010
Baltic (eastern)	Reference points not defined, but SSB_{2010} considered above any candidate for B_{pa}	F2009 below F_{MSY} and F_{pa}	Not classified	Increasing from 1966 to early 1980s, declining until 2005, increasing since then	Unknown	Moderate	ICES 2010
Baltic (western)	$SSB_{current}$ at B_{pa}	F_{2009} much higher than F_{MSY}	Not classified	Fluctuating around B_{pa} for ten years	Unknown	Moderate	ICES 2010
Norwegian coastal	Reduced reproductive capacity	ICES has advised no fishing since 2004; catches were around 25,000 t for 2005-2009	Not classified	SSB at historical low	Unknown	Moderate	ICES 2010
North Sea, eastern Channel, Skagerrak	Reduced reproductive capacity	$F=F_{lim}$; Harvested unsustainably	Unknown	Long-term decline since 1963, increase since 2007	Skewed	Moderate	Rochet and Munch 2002; Yoneda and Wright 2004;ICES 2010
Faroe Plateau	Risk of reduced reproductive capacity	Risk of being harvested unsustainably (F>Fpa)	Not classified	Long-term variable, short-term increase	Unknown	Low	ICES 2010
Celtic Sea	Unknown	F current likely higher than F_{MSY} (F_{MSY} undetermined)	Not classified	Unknown	Skewed age structure	High	ICES 2010
Greenland	Reference points not defined, but considered depleted	Reference points not defined but overfishing likely	Overexploited (ICES recommends no fishing due to stock depletion, but a new directed fishery started recently)	Declining since 1990, increasing since 2005	Unknown	Moderate	ICES 2010

Kattegat	Reduced reproductive capacity	Very likely harvested unsustainably when unreported catches are included	Not classified	Long-term, steady decline since 1971	Unknown	Moderate	Svedäng and Bardon 2003; ICES 2010
Irish Sea	Reduced reproductive capacity	$F>F_{lim}$; Harvested unsustainably	Not classified	Stable long-term trend until 1990, declining since then	Unknown	Moderate	ICES 2010
West of Scotland	Reduced reproductive capacity	$F>F_{lim}$; Harvested unsustainably	Not classified	Steady decline since 1985	Unknown	Moderate	ICES 2010
Rockall	Reference points not defined	Reference points not defined	Not classified	Unknown	Unknown	High	ICES 2010

Status of Wild Stocks Rank:

Northeast Arctic (61% of landings in 2008), Icelandic (19%), Baltic (eastern) (6%), Rockall (<1%)

Healthy 🟩 [✓ Moderate/Rebuilding 🟨] Poor 🟥 **Critical** 🟥

Baltic (western) (3%), Faroe Plateau (1%), Celtic Sea (1%)

Healthy 🟩 Moderate/Rebuilding 🟨 [✓ Poor 🟥] **Critical** 🟥

North Sea (4%), Norwegian coastal (3%), Greenland (3%), Kattegat (<1%), Irish Sea (<1%), West of Scotland (<1%)

Healthy 🟩 Moderate/Rebuilding 🟨 Poor 🟥 [✓ **Critical** ⬛]

CRITERION 3: NATURE AND EXTENT OF BYCATCH

Seafood Watch® defines sustainable wild-caught seafood as marine life captured using fishing techniques that successfully minimize the catch of unwanted and/or unmarketable species (i.e., bycatch). Bycatch is defined as species that are caught but subsequently discarded (injured or dead) for any reason. Bycatch does not include incidental catch (non-targeted catch) if it is utilized, accounted for and/or managed in some way.

Total global discard estimates from all fisheries are uncertain and vary based on the methodology used, but range from 7.3 million t (Kelleher 2005) to 17.9-39.5 (average 27) million t (Alverson, Freeberg et al. 1994). More recent data suggests that Kelleher (2005) may have underestimated catches in at least one area (English Channel, Western approaches, Celtic and Irish Seas) by at least 50% (Enever, Revill et al. 2007). Expanding the definition of bycatch from discards to 'catch that is either unused or unmanaged,' Davies, Cripps et al. (2009) conservatively estimate bycatch as 38.5 million t, or 40.4% of global marine catches. In the northeast Atlantic, Davies, Cripps et al. (2009) estimate bycatch across all fisheries (in the form of discards) to be 25% of landings. The authors note that many fisheries operating in the region have extremely high discard rates, particularly the bottom trawling fleet which generates far more bycatch than marketable fish. Bottom trawls typically account for a large component of the cod catch, though other gears are also used. Nearly three quarters (72% in 2008) of Northeast Arctic cod, for example, are caught by bottom trawl. In a typical year, the Norwegian component of the fishery (which accounted for 44% of the catch in 2008) uses bottom trawls (30% of the Norwegian catch), bottom gillnets (30%), bottom longline (15%), Danish seine (15%) and handline (10%).[7] Similarly, Icelandic cod are caught by bottom trawls (43% in 2008), bottom longline (36%), bottom gillnet (13%), Danish seine (5%), handline (2%) and other gears (Figure 23) (Statistics-Iceland 2010). In the eastern Baltic, 70% of official landings in 2009 were from trawls, with the remainder from gillnets (ICES 2010).

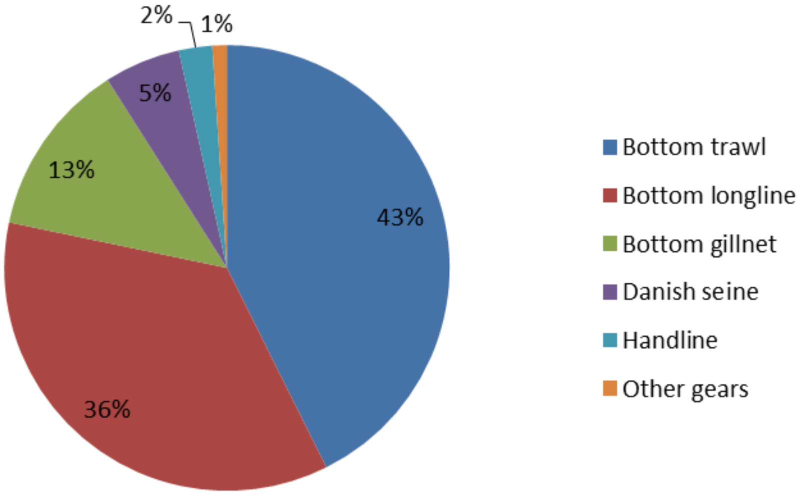

Figure 23. Gear used to catch cod in Iceland, 2008 (Statistics-Iceland 2010).

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[7] http://www.fisheries.no/ecosystems-and-stocks/marine_stocks/fish_stocks/cod/

Hook and line fishing gear such as handlines and jigs are typically considered to have few bycatch problems as they are selective and hauled frequently (thus reducing chances of bycatch mortality). In contrast, bottom trawls, bottom gillnets, bottom longlines are typically considered unselective gears (Chuenpagdee, Morgan et al. 2003; Living Oceans Society 2008). Typical bycatch consists of juvenile commercial species such as cod, whiting, saithe and haddock and low/no value commercial species such as elasmobranchs and some flatfish (Kelleher 2005). For example, common bycatch species in Scottish groundfish fisheries for cod, haddock and whiting (primarily bottom trawl and Scottish seine) include plaice, lemon sole, dogfish, skates, witch, megrim, redfish, dab, hake, and turbot with fewer quantities of catfish, fork beard, grenadier, tusk, halibut, turbot, Greenland halibut, brill and pollock.[8] The total number of species caught is often far higher, however. For example, 165 species are recorded as being caught by English and Welsh otter trawlers operating in the English Channel, Western Approaches, Celtic and Irish Seas from 2002 to 2005 (Figure 24) (Enever, Revill et al. 2007).

Discarding can thus be a moderate or even serious conservation concern in fisheries using these gears. Kelleher (2005) identified the North Sea as having the greatest number of recorded annual discards globally. Some 800,000–950,000 t of fish and invertebrates are discarded each year (13% of the global total in 1999), mainly by otter trawl fisheries for *Nephrops* and cod, and beam trawl fisheries for flatfish (Catchpole, Frid et al. 2005). This equates to about one third of the total weight landed and one tenth of the entire biomass of fish in the North Sea (Catchpole, Frid et al. 2005). Enever, Revill et al. (2009) estimate that 84% of the catch (as estimated by Kelleher 2005) is fish, cephalopods and *Nephrops*, and the remaining 16% is miscellaneous benthic invertebrates.

A review of 2002–2005 catch data from the English and Welsh fishing fleet operating in the English Channel, Western approaches, Celtic and Irish Seas indicates that discards for the otter trawl component of this fleet (all target species) were greater than landings (180%) in terms of numbers (Enever, Revill et al. 2007). The French otter trawl fleet targeting cod and other gadoids in the Celtic Sea appeared to have comparable discards in terms of weight (51% of landings for the English and Welsh fleet, 34% for the French fleet) so discards in terms of numbers may also be similar (no data in terms of numbers is given for the French fleet) (Rochet, Péronnet et al. 2002; Enever, Revill et al. 2007). Discards in the net (trammel, tangle and gillnets) and long-line (possibly including pelagic longlines) components of the English and Welsh fishery are considerably lower than in otter trawls in terms of numbers (56% of landings for nets, 49% for long lines) (Enever, Revill et al. 2007).

Updated data (2003–2006) suggest that discards in the English and Welsh otter trawl fishery operating in the English Channel, Western Approaches, Celtic and Irish Seas have decreased since the studies by Kelleher 2005 and Enever, Revill et al. 2007, perhaps as a result of changes in mesh size or other measures (Enever, Revill et al. 2009). In terms of numbers of fish, 44% of the otter trawl catch was discarded (Enever, Revill et al. 2009), which is equivalent to 79% of landings. The discard to landings ratio appears to be similar for the gillnet sector (89%), but nets accounted for a much lower percentage of discards overall (<1%) (Enever, Revill et al. 2009).

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[8] http://www.scotland.gov.uk/Topics/marine/marine-environment/species/fish/demersal

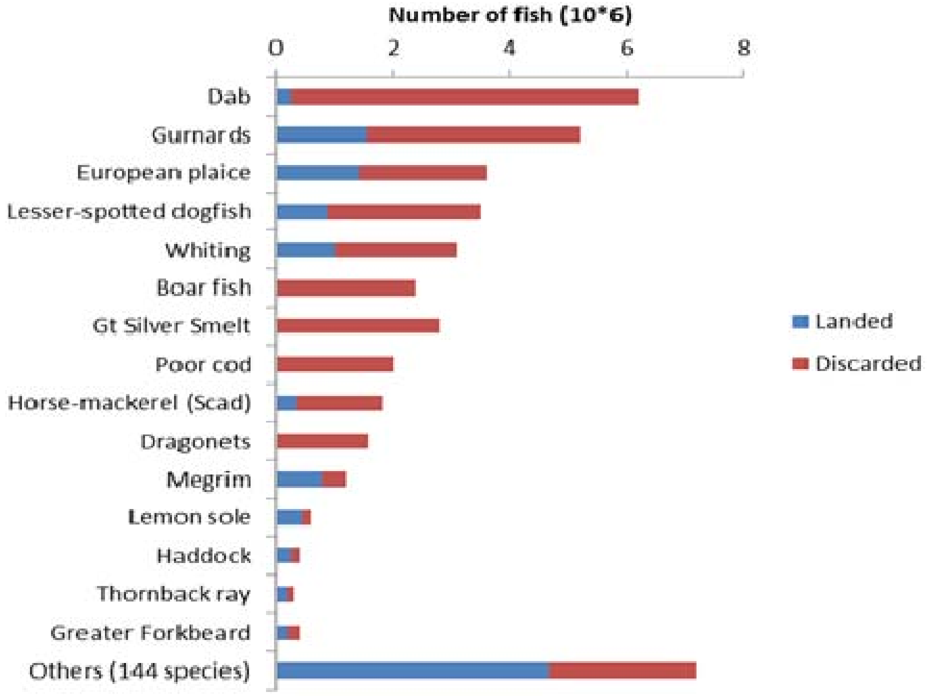

Figure 24: Top ten most discarded species and significant commercial species, English and Welsh-registered otter trawlers in the English Channel, Western approaches, Celtic and Irish Seas, 2002–2005 (Enever, Revill et al. 2007).

Although there are various estimates of discards from specific fleets, estimates of total discard rates in the northeast Atlantic are generally not available (Langaard, Jensen et al. 2008; ICES 2010). However, ICES and other authors do provide estimates of discard/landing rates for the main targeted species, at least in some areas (Table 4). Continuing the North Sea cod fishery example above, discards are mainly of undersized fish of the target species (ICES 2008). In recent years, the discard/landings ratio by number for cod is 43%–100%, haddock 43%–69%, and whiting 100%–186% (Catchpole, Frid et al. 2005; ICES 2010). Similar and even higher discard ratios are seen for cod fisheries operating across the northeast Atlantic (Table 4). Furthermore, surveys indicate that year classes are depleting faster than would be expected based on estimated landings and discards, indicating substantial unaccounted removals (mainly from fisheries though changes in natural mortality may also have an influence). In the North Sea in 2009, for example, landings of cod were 30,800 t, estimated discards were 14,600 t, and modeled unreported removals were some 46,000 t (ICES 2010). The discard/landings ratio may then be as high as 200%. However, as the source of the estimated unreported removals is unknown, and multiple fisheries catch cod as a target or as bycatch (some of which have higher discard rates than the multispecies otter trawl fisheries e.g. the Nephrops trawl and beam trawl fisheries), they cannot be attributed to the fisheries that land cod. They do, however, indicate that the discard problem, at least in the North Sea, is likely worse than official estimates suggest.

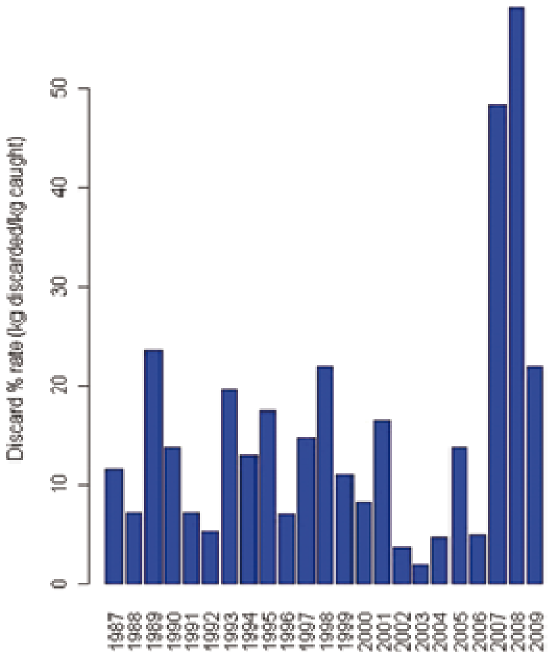

Figure 25: North Sea cod discards (percentage weight) in Scottish bottom trawls (Marine Scotland data presented in WWF-Scotland 2009).

These very high discard ratios have moved some countries to establish a ban on discarding. Examples in the northeast Atlantic include Norway, Russia, Iceland, Greenland and the Faroe Islands (ICES 2010; Langaard, Jensen et al. 2008). Catch quota trials where all catches are recorded and discards are prohibited are underway in other countries such as Scotland and Denmark,[9] while in Germany attempts to initiate discard ban projects have failed (Catchpole and Gray 2010). Discard bans typically apply to only the commercially important species (and often only a subset of those) for the purpose of ensuring actual fishing mortality is reflected in the landings. For example, Norway's discard ban was introduced for cod in 1983, and today includes saithe, redfish, Greenland halibut, herring, mackerel, capelin, European smelt/greater argentine, whiting, blue whiting, monkfish, shrimps, and snow crabs (Langaard, Jensen et al. 2008). Reported discards are low for the major species caught in the Icelandic fleet (0.6%–7.1% of landings weight for cod, haddock, saithe, redfish, plaice—all gears are within this range) and discards of these species is taken into account in stock assessments (Pálsson 2007; ICES 2008; Kristjánsdóttir 2010). In 2009, the sampling rate was sufficient to accurately estimate discards of cod and haddock only (Pálsson, Bjornsson et al. 2010). In terms of numbers, discards as a percentage of landings of both species was amongst the lowest (cod: 2.34%) and the single lowest (haddock: 2.00%) in the time series 2001–2009 (means 2001–2009 for cod and haddock are 2.93% and 7.27% respectively (Figure 26) (Pálsson, Bjornsson et al. 2010). Pálsson, Bjornsson et al. (2010) do not present discard rate by gear in terms of number of fish[10], but data by gear is presented in terms of weight (as a percentage of landings). Since 2001, the discard rate of cod and haddock varies with year and gear type, but has not typically exceeded 10% of

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[9] http://wwf.panda.org/what_we_do/how_we_work/policy/wwf_europe_environment/news/?197637/WWF-welcomes-EU-Norway-agreement-to-reduce-discards

[10] At least in English – discards but not landings are presented in terms of numbers, hence discard rate by number is unavailable

landings in any year/gear combination. There is less data available on discards of other species (and none in 2009), which as noted above for other otter trawl fisheries can be substantial (e.g. Table 4).

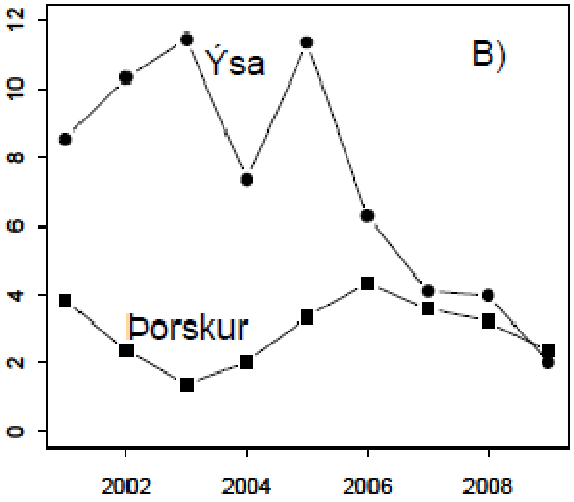

Figure 26: Combined discard rate (discards/landings, by number) of Icelandic cod (Þorskur) in the longline, gillnet, Danish seine and bottom trawl fisheries and haddock (Ýsa) in the longline, Danish seine and bottom trawl, 2001–2009 (Pálsson, Bjornsson et al. 2010).

While the magnitude of bycatch or discards is unknown for such countries as Norway and Russia (ICES 2010), it is still thought to be substantial for cod, haddock and saithe in some periods (Langaard, Jensen et al. 2008). It is likely the proportion of young fish discarded at sea fluctuates with recruitment success and size composition of the stock, with the market demand for small fish, and with the effective mesh size used (Langaard, Jensen et al. 2008). Increases in stock size can also lead to more discarding. In the Irish Sea, for example, relative discard rates stayed largely constant from 1994 to 2008 for cod, but increased for haddock and whiting (all gears combined). As other factors (mesh size, technological improvement, management of quotas) remained the same over the period, the authors attribute the trends to the increase in stock size of haddock and whiting (Viana, Norman et al. 2011).

Table 4: Discard to landings ratios by cod stock. Note that discard estimates are from all fisheries in that area, not just those targeting cod (except for the North Sea). Unless otherwise noted, sources are ICES 2008 Ecosystem Overviews and ICES 2010 Stock Summaries.

Stock	**Discard/landing ratio**
Northeast Arctic	Discarding illegal in Russia and Norway. Actual rates unknown but unreported catches/landings estimates for cod and haddock from the Barents Sea are 20%. Not included in stock assessments.
Icelandic	Discarding illegal in Iceland. ITQ system has a built in incentive to direct effort to catch more valuable fish (high-grading). Actual ratio estimated at 0.6%–8% by weight for cod, haddock, saithe, redfish, plaice (ICES 2008 p11; Kristjánsdóttir 2010). Not included in stock assessments. Discards of non-target species unknown.
Baltic (east and west)	Discards unknown.
North Sea	Discard/landings by number are 43%–100% for cod, 43%–69% for haddock, and 100%–186% for whiting (Catchpole, Frid et al. 2005; ICES 2010 Book 6). Discard estimates are included in stock assessments.
Norwegian Coast	Discards unknown (catch is mainly from gillnets, Danish seine and bottom long and handlines; 3% from trawls).
Greenland	Discards unknown.
Faroe Plateau	ICES considers discards of commercially valuable species likely low due to effort regulations. Discards of non-commercial and non-commercial size fish is unknown.
Celtic Sea	May be as high as 66%–150% by number for all fish caught.
Irish Sea	Accurate discard rates are not available and are not included in stock assessments. Modeling suggests discard/landings ratio could be 100%–200% for cod.
Kattegat	Cod 350% (Unallocated removals/landings. Unallocated removals includes discards and from biological issues). Discards not included in stock assessments.
West of Scotland	Cod 600%, haddock 60% by weight. Excluded from stock assessments from 1995 onward.
Faroe Bank	ICES considers discards of commercially valuable species likely low due to effort regulations. Discards of non-commercial and non-commercial size fish is unknown.
Rockall	Discards unknown.

Seabirds

Gillnets in the Baltic Sea contribute to the bycatch of common guillemots (*Uria aalge*); the bycatch of this species in several fisheries is thought to be the most serious population threat (Osterblom, Fransson et al. 2002). The set gillnet cod fishery in the Baltic Sea accounted for 22.3% of common guillemot bycatch from 1972 to 1999 (Osterblom, Fransson et al. 2002). Although the amount of common guillemot bycatch in the cod fishery is small relative to the amount in the salmon fishery (65.5%), the survival rate for birds caught in cod nets was 0%, compared to 20.3% in the salmon fishery (Osterblom, Fransson et al. 2002). The overall bycatch of common guillemots has been increasing over time due to an increase in fishing effort with cod gillnets (Osterblom, Fransson et al. 2002), thus a decrease in adult guillemot survival may be attributed to bycatch in cod gillnets (Olsson, Nilsson et al. 2000). In the Icelandic net fisheries for cod, there are not thought to be population consequences of the bycatch of thick-billed murres[11], but the population consequences of bycatch of razorbills and common murres are

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[11] In Europe, thick-billed murres are also known as Brünnich's guillemot.

unknown (CAFF 1998). In Norway, net fisheries for cod are thought to have a significant effect on the populations of common murres, but the population consequences for cormorants, razorbills, black guillemots, common eiders, and various loon species are unknown (CAFF 1998). Considerable uncertainty remains regarding the quantity and trend of seabird bycatch in the Icelandic and Northeast Arctic cod gillnet fisheries, but the Northeast Arctic cod fishery is not considered to have a high seabird bycatch rate (Løkkeborg, pers. comm.). However, the spring fisheries for cod and year-round setting of shallow nets in fjords may have higher seabird bycatch than the winter fishery for cod, when nets are set deeper in the water column (Follestad and Strann 1991).

Bottom longlines used in Iceland may be up to 20 km long with up to 16,000 hooks (IMF 2003). North Atlantic bottom longline fleets account for large numbers of seabird bycatch (FAO 1999), and Icelandic and Norwegian fleets are the primary bottom longliners in the North Atlantic targeting cod, haddock, and tusk (Gilman 2001). Bottom longline fisheries in the North Atlantic are considered by the Food and Agriculture Organization of the United Nations (FAO) to be problem fisheries due to high seabird bycatch (FAO 1999). There are limited data for seabird bycatch in Iceland, as bycatch data that has been collected is based on seabird species that have been tagged, and does not include information on great northern loons or thick-billed murres (Petersen 1998). In the U.S. Alaskan, Icelandic, Faroese, and Norwegian longline fisheries, northern fulmar bycatch is thought to be between 9,000 and 100,000 birds annually, but the continued bycatch is not thought to be putting the species at risk due to its large population size (Dunn and Steel 2001). The longline fishery could in some areas have high bycatch of Northern fulmar (Løkkeborg 1998; Lokkeborg 2001; Løkkeborg and Robertson 2002; Løkkeborg 2003) but due to the extensive use of bird-scaring lines, this bycatch has now been reduced to a minimum (Løkkeborg, pers. comm.). Icelandic longline fisheries are also known from band recoveries to take great skua as bycatch, of which Iceland holds 40% of the European population (Dunn and Steel 2001). Overall, it is estimated that between 100,000 and 200,000 seabirds are killed annually in fishing gear in Iceland (Petersen 2002), with unknown population consequences.

For birds tagged in Iceland, however, longlines are the second most important source of mortality. Due to the lack of reliable data, it is also thought that seabird bycatch in cod nets is underestimated (Petersen 1998). The bird species caught depends on the fishing gear, with common and thick-billed murres and razorbills frequently caught in cod nets, and northern fulmars and great skuas frequently caught on longlines (Petersen 1998). Some seabird bycatch from cod nets is consumed, either locally or by the general public via illegal auctions (Petersen 1998). Utilizing seabird bycatch for consumption is illegal in Iceland, but there is no enforcement of this regulation (Petersen 1998). In particular, future research should include data collection on the quantity of bycatch for two species, the red-throated loon and great northern loon, both of which breed only in Iceland (Petersen 1998). There may be some local population effects of this seabird bycatch (Petersen 1998). In Norway, northern fulmars, gannets, black-legged kittiwakes, common murres, and Atlantic puffins are caught on longlines; extensive seabird bycatch has been documented in the winter cod net fishery in Norway, as well as in shallow nets set for cod (Bakken and Falk 1998). The population effects of this bycatch are unknown.

There is almost no information available on seabird bycatch in trawl fisheries within EU waters (WGSE 2010).

Mammals

Harbour porpoises are taken as bycatch in EU bottom gillnet fisheries for many species, including cod (IFAW 1999). In one bycatch study conducted in the North Sea, the bycatch estimate over a four-year period was approximately 7,000 harbour porpoises annually in bottom gillnet fisheries (IFAW 1999). Mean estimates of small cetacean bycatch in the Danish gillnet fishery and wreck net fishery for cod in the North Sea range from 111 to 1,400 individuals per year from 1987 to 2001, depending on the gear and season (ICES 2002). However, these estimates do not take into account the now mandatory use of pingers in the wreck net fishery, thereby possibly inflating the bycatch estimates which began in the third quarter of 2000 (ICES 2002). The following areas have been identified as having sufficient levels of harbour porpoise bycatch to negatively affect the harbour porpoise population: western English Channel and Celtic Shelf; Channel and southern Bight of the North Sea; central/southern North Sea; northern North Sea; Skagerrak; Kattegat; and the Baltic Sea (ICES 2002). Ghost fishing by lost gillnets is another source of continued harbour porpoise bycatch (ICES 2002).

Turtles

Turtle bycatch is mainly a concern in tropical and subtropical waters. Only one species of turtle is likely found in the cold waters of the northeast Atlantic—the leatherback. This species has been sighted in Icelandic waters, for example, though only very rarely.[12] Turtle bycatch is thus not likely a concern in northeast Atlantic groundfish fisheries.

Synthesis

A wide variety of gear is used to catch cod and other demersal species in the Northeast Atlantic. Hook and line (not bottom longline) gear is typically considered to have few bycatch problems. In contrast, bottom trawls, bottom gillnets, and bottom longlines are generally considered unselective gears. Unfortunately, uncertainty generally remains high regarding actual bycatch quantity and trends in the Northeast Atlantic cod fisheries. Discarding juvenile cod and other target species appears to be a serious problem for managers of several stocks, particularly in bottom trawl fisheries. These discards are sometimes taken into account in ICES stock assessments when quantified and/or considered significant. Several countries operating in the northeast Atlantic have implemented discard bans for the main commercial species, but discards typically remain unquantified. Iceland is an exception, and has recorded discards <10% for the main commercial species. Iceland also operates a 'bycatch bank' to assist in commercializing unwanted fish, reducing the incentive to discard further (Sanchirico, Holland et al. 2005). Discards of the remaining species remains unknown, however. Absolute levels of seabird bycatch are unknown. EU gillnet fisheries are known to catch both marine mammals and seabirds, and bottom longlines catch seabirds. Given the general uncertainty of bycatch in Atlantic cod fisheries, bycatch ranks as a "moderate" conservation concern, except when using hook and line gear (e.g. handlines, jigs) which is deemed a "low" conservation concern.

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[12] http://www.fisheries.is/ecosystem/marine-life/marine-mammals/

Nature of Bycatch Rank:

Hook-and-lines (e.g. handlines, jigs)

[✓ Low 🟩] **Moderate** 🟨 High 🟥 Critical ⬛

All other gear (e.g. bottom trawl, bottom gillnet, bottom longline, Danish seine)

Low 🟩 [✓ **Moderate** 🟨] High 🟥 Critical ⬛

CRITERION 4: EFFECT OF FISHING PRACTICES ON HABITATS AND ECOSYSTEMS

Habitat Effects

Bottom trawls

Bottom trawling has biological and physical impacts on cod habitats, particularly on the seafloor. Bottom trawls generally damage benthic organisms such as corals and sponges, and disturb complex habitats that provide shelter for juveniles of commercially important fish species (Auster and Langton 1999; Chuenpagdee, Morgan et al. 2003). Bottom trawls can reduce the complexity of the seafloor, potentially disturbing critical benthic habitats (Lindholm, Auster et al. 2001) for juvenile ground fish. In general, organisms in stable sediments such as gravel and mud suffer more adverse effects than those in unconsolidated sediments (Collie, Hall et al. 2000). Beam trawling in the North Sea has been shown to decrease macrofaunal abundance (Bergman and Hup 1992), and in the Irish Sea, has been shown to reduce epifauna such as hydroids and corals by as much as 50% (Kaiser and Spencer 1996). An indirect effect of bottom trawling on corals is the re-suspension of bottom sediments (Pilskaln, Churchill et al. 1998). Even in soft-bottom habitats, the removal of habitat structure can decrease ecosystem biodiversity (Thrush, Schultz et al. 2002). Mobile bottom gear such as bottom trawls reduces the complexity of the seafloor, thus reducing the protection for juvenile cod afforded by bottom structure (Lindholm, Auster et al. 2001).

The environmental damage caused by bottom trawling can be substantial and irreversible (Watling and Norse 1998). The scraping action inherent in bottom trawling is highly destructive to marine habitats and has been compared to forest clear-cutting in terrestrial habitats (Watling and Norse 1998). Bottom trawling has both biogenic and physical effects on the seafloor. Bottom trawls damage benthic organisms such as corals and sponges, and disturb complex habitat that provides shelter for juvenile commercially important fish species (Chuenpagdee, Morgan et al. 2003). Bottom-trawl nets can plow deep furrows in the seafloor, remove rocks and corals, stir up sediments that smother benthic organisms, remove or harm non-target organisms, and smooth out natural topography until the seafloor resembles a plowed field (Pilskaln, Churchill et al. 1998; NRC 2002).

The degree of impact is determined by many factors, most notably: 1) the type and weight of gear used, 2) the resilience of the seabed, and 3) the amount and frequency of the disturbance. The disturbance to the seabed caused by bottom trawls is mainly a function of bottom type (rock, sand, mud, etc.) and gear type (dredge, beam, otter trawl, etc.). Some types of trawling gear cause less damage (*e.g.*, otter trawl vs. scallop dredge) and some sediment types are more resilient to disturbances caused by trawling. In a review of fishing effects, Collie, Hall et al. (2000) found that recovery rates appeared to be slower in muddy and structurally complex habitats than in sandy bottom habitats. In general, organisms in stable sediments such as gravel and mud suffer more adverse effects than those in unconsolidated sediments (Collie, Hall et al. 2000). For soft bottom habitats, scraping the ocean bottom causes: 1) sediment re-suspension (turbidity) and smoothing, 2) removal of and/or damage to non-target species, and 3) destruction of three-dimensional habitats (Auster and Langton 1999).

In addition to impacting the habitat, bottom trawling can also impact benthic organisms and thus entire ecosystems. Emergent epifauna may be destroyed by mobile gear such as trawls (Hall 1999), and changes in both infaunal and epifaunal communities have been observed, with effects expected to cascade through the entire community (Barnette 2001). Bottom trawling has been shown to change the relative abundance of bottom-dwelling organisms, favoring fast-growing, opportunistic species and decreasing the abundance of slow-growing, low-fecundity species (Schwinghammer, Gordon et al. 1998; Simboura, Zenetos et al. 1998; Wells, Cowan Jr. et al. 2008). While overall biodiversity often decreases under heavy trawling, the bottom-trawl regime can increase the abundance of certain commercially desirable organisms such as shrimp (Simboura, Zenetos et al. 1998) or prey for commercial fish species (Engel and Kvitek 1998). Many areas are trawled several times per year, allowing no time for bottom fauna to recover to a pre-trawled condition (Watling and Norse 1998).

The effects of bottom trawling are related to sediment size (Lindholm, Auster et al. 2004). Hiddink, Jennings et al. (2006) found that communities on mud or muddy sand habitat were less severely impacted by trawling than those on sand or gravel substrates, while Collie, Hall et al. (2000) found that disturbance to benthic communities was more severe in gravel and muddy sand habitats than in either mud or sand habitats. However, sediment type is expected to be less important than the frequency of natural disturbance, which may correlate with sediment type (Hiddink, Jennings et al. 2006). Areas with muddy substrates and deeper waters are typically associated with lower rates of natural disturbance, so these areas may be more sensitive to trawling impacts than coarse sediment bottom habitats in areas prone to high rates of natural disturbance (Hiddink, Jennings et al. 2006). While soft bottom habitats are generally less sensitive to disturbance by trawling than rocky bottoms and coral reefs, studies have found decreased habitat heterogeneity and epifaunal abundance in heavily trawled areas in both sandy bottom (Engel and Kvitek 1998) and muddy bottom habitats (Queirós, Hiddink et al. 2006; Hixon and Tissot 2007). Numerous reviews and meta-analyses document the severe effects of bottom trawling on epifaunal communities in low-disturbance muddy bottom habitats (Auster and Langton 1999; Norse and Watling 1999; Kaiser, Collie et al. 2002; NRC 2002; Thrush and Dayton 2002; Kaiser, Clarke et al. 2006).

In a comprehensive review of the habitat impacts of trawling, the National Research Council (NRC 2002) noted the following possible effects of otter trawling on sandy and muddy habitats:

uprooting of submerged vegetation, smothering of submerged vegetation via re-suspended sediments, reduction of epifaunal coverage on sandy and muddy substrates, reduction of infaunal productivity and biodiversity, compression of sediments and alteration of the natural topography of sandy and muddy substrates (Tuck, Hall et al. 1998; Auster and Langton 1999; Barnette 2001; Jennings, Pinnegar et al. 2001; NRC 2002). More recent studies from around the world have confirmed the findings of the NRC (2002) that otter trawling may have severe impacts on soft sediment habitats. Hiddink, Jennings et al. (2006) found a large negative effect of beam and otter trawling on biomass, production and species richness in shallow, soft-sediment habitats in the North Sea. In agreement with previous studies, they found that impacts were less severe in areas more prone to natural disturbance. Kaiser, Clarke et al. (2006) reviewed fishing effects and recovery times for a variety of habitat types and fishing gear and found that soft sediment habitats (particularly muddy sand) were surprisingly vulnerable, having a long recovery time from trawling impacts. Otter trawls were found to have strong effects on biota in mud and muddy sand habitats. Hixon and Tissot (2007) compared trawled and untrawled areas of mud seafloor in Oregon and found evidence of the adverse effects of trawling, including reduced abundance and species richness of finfish and dramatically reduced benthic invertebrate abundance. In a comparison of fishing effects along a gradient of fishing effort in the Irish Sea, Hinz, Prieto et al. (2009) found that chronic otter trawling had a significant, negative effect on benthic infauna abundance, epifauna abundance, biomass and species richness, and significantly changed community structures. Their results underscored the cumulative nature of trawling impacts, and they noted that manipulative experiments investigating short-term effects of trawling are likely to underestimate the long-term ecological impacts of repeated trawling.

Danish seines

Danish seining, also called anchor dragging, involves a boat setting an anchor and then seining around it. The Danish seine net, which resembles a trawl net complete with codend, is attached to a buoy and a small vessel with wire warps or towing-lines. After the buoy is set, the boat sails a half circle around a school of fish, sets the net, and sails back to the buoy. The buoy is then taken aboard and the boat drags the net forward while gradually pulling together the warps, which herds the fish into the net. Finally, the warps and the full net are pulled aboard the boat using a power block. Danish seining requires large areas of clear bottom and thus likely has some impact on bottom habitats (Sainsbury 1996). Different from bottom trawls, Danish seines have no braces to keep the net mouth open, no rock-hopping gear and no chains. During fishing, the weighted ropes used to herd the fish are in contact with the seafloor over lengths of several hundred meters, and the rope may cut into the seafloor while the seines are in use (Rose, Carr et al. 2000). Thus, while Danish seine ground gear is generally lighter than bottom trawl ground gear, it still does create habitat disturbance (Thrush, Hewitt et al. 1998 Rose, Carr et al. 2000; Valdemarson and Suuronen 2001). A review of the environmental effects of bottom trawling on the benthos by Jones (1992) grouped bottom trawling, dredges and Danish seines together as having similar impacts. However, studies have also demonstrated Danish seines to have less impact on the substrate compared to bottom trawls (Gillet 2008).

A study of the impacts of a similar fishing method, Scottish seining or fly dragging, in an Iceland fjord was published in 2010 (Thórarinsdóttir, Einarsson et al. 2010). Though the study found no differences in species composition between a site open to Scottish seining compared to a comparable closed area, the abundance of benthic organisms was generally higher in the closed area. However, it is not clear whether these results can be generalized to other areas or whether the differences were due to the habitat impacts of the Scottish seines or the reduced fishing pressure. Because Danish seines are a mobile gear fished in contact with the bottom over a large area using groundgear that is lighter than that used in otter trawling (R. Cook, Fisheries Research Scotland Marine Laboratory, pers. comm.), they are considered to have a lesser impact than bottom trawls but greater than set gear such as bottom gillnets and bottom longlines. For the purposes of the Seafood Watch® habitat impact criteria, Danish seines are considered to have great impact.

Bottom gillnets, bottom longlines

Bottom gillnets and bottom longlines can also have destructive impacts on benthic communities (Auster and Langton 1999; ICES 2002), by destroying emergent epifauna (Hall 1999) and topographic complexity. Although bottom longlines have limited contact with the seafloor, both the hooks and lines may snag on bottom structure as the gear is set and retrieved (Chuenpagdee, Morgan et al. 2003). However, the magnitude of these impacts is less severe than those of bottom trawls and Danish seines.

Hook-and-line

Hook-and-line gear does not contact the seafloor, and thus has no detrimental habitat impacts.

Resilience of habitat

Atlantic cod in the Northeast Atlantic are primarily found in shallow seas where the majority of the area is continental shelf (North Sea, Celtic Sea, West of Scotland, Irish Sea, Kattegat, Baltic Sea), though the Barents Sea is deeper (average 230 m), and the shelf quickly falls away to canyons and slope habitat (>200 m) west of Norway and Ireland, south of Iceland and around Greenland (ICES 2008). The species is considered a demersal fish, meaning it lives on or near the seafloor. It is distributed over a variety of substrate types from the shoreline to depths of over 600 m, but is mostly found on the continental shelf between 150-200 m (Froese and Pauly 2005). The primary substrate type around Iceland and Greenland, the western and northern Baltic, and slope around the Faroe Plateau and west of the UK and Norway is hard rocky bottom. Most other areas are more mixed substrate, including muds and sands, gravel and pebbles. In the shallow southern North Sea, concentrations of boulders are becoming scarcer, as boulders caught in beam trawls are often landed (ICES 2008).

Vulnerable habitats

The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) designated several habitats (including deep-sea sponge aggregations and *Lophelia pertusa* reefs) that occur in the Arctic (north of latitude 62°N, including Iceland) as under threat or in decline (OSPAR 2005). *Lophelia pertusa* is known to occur in the North Sea (off Norway), Iceland, Faroe Plateau, Barents Sea (off northern Norway), north of Scotland (the Darwin Mounds in the northern Rockall Trough), and west of Ireland (the Porcupine Seabight) (Figure 27) (Rogers 2004; ICES 2008; Hall-Spencer and Stehfest 2009). In Icelandic waters, for example, the species is known to occur in 39 locations (Carlgren 1939, Copley *et al.* 1996 in ICES 2008) (Figure 27). The distribution is mainly confined to the Reykjanes Ridge and near the shelf break off the South coast of Iceland. The depth of these corals ranged from 114 to 875 m, with most occurrences between 500 and 600 m deep (ICES 2006). In Norwegian waters, where the reefs are perhaps the most extensive and largest yet found, *Lophelia* is found from 40 to 3000 m depth, but most commonly along the shelf edge at 200-500 m (Fosså, Mortensen et al. 2002; Husebø, Nøttestad et al. 2002).

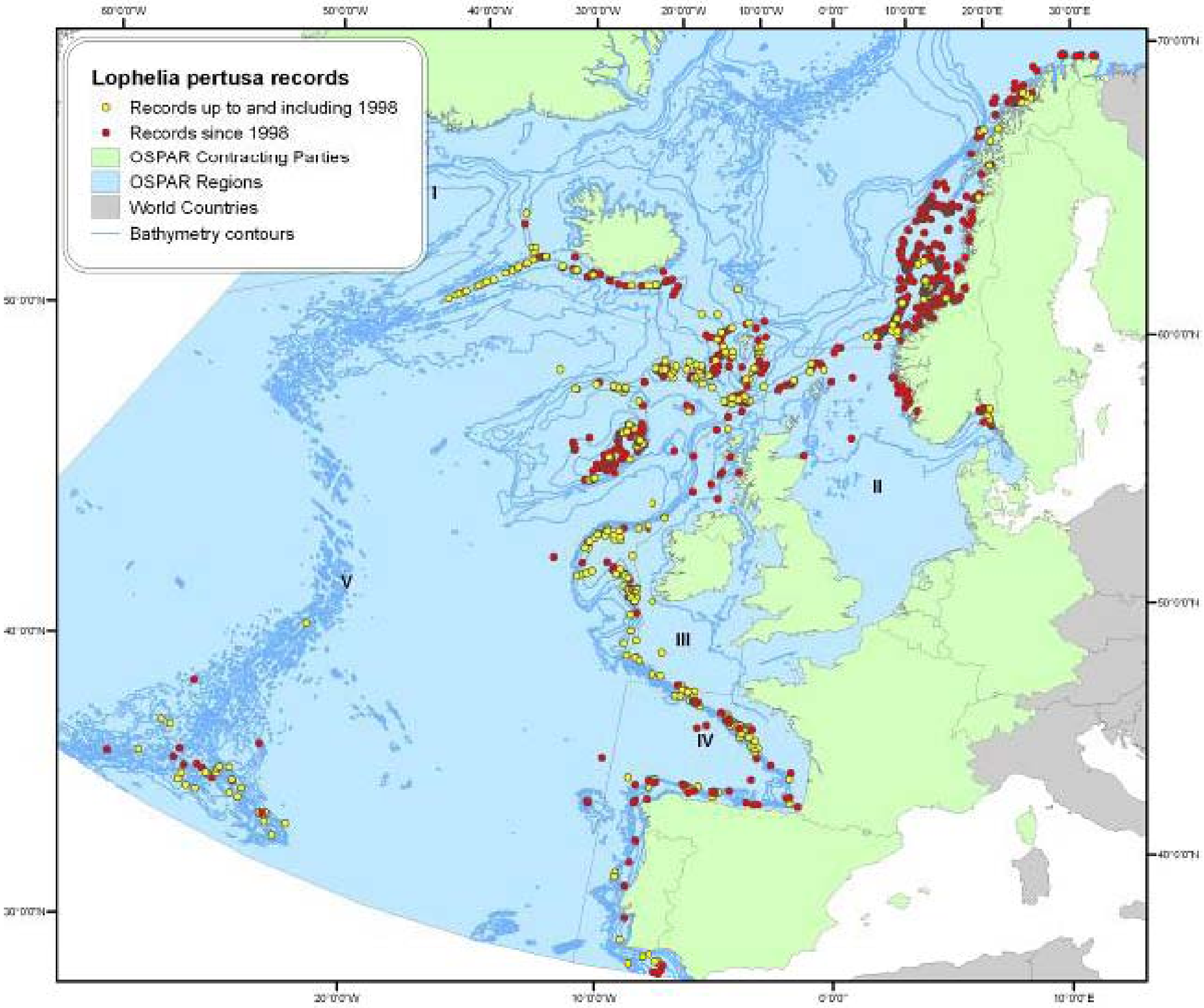

Figure 27. Location of known *Lophelia pertusa* habitat in the Northeast Atlantic (Figure from Hall-Spencer and Stehfest 2009).

The stony coral species *Madrepora oculata* and *Solenosmilia variabilis* also build or contribute to reefs in the Northeast Atlantic (Hall-Spencer and Stehfest 2009). Other species form dense and often biodiverse aggregations, such as soft corals and sea pens on the shelf and slope, respectively, in the Bering Sea (*Lophelia* only forms clumps rather than reefs in the Bering Sea) (Fosså and Kutti 2010). These so called “coral gardens” occur on a wide range of soft and hard seabed subtrata, such as solitary scleractinians, sea pens or certain types of bamboo corals on soft substrates and gorgonians, stylasterids, and/or black corals on hard substrates (Christiansen 2010). In addition to corals, large aggregations of sponges are known in some areas, such as the Barents Sea (e.g. *Geodia* spp.), Svalbard, East Greenland, the Faroe Plateau slope, and Iceland

(ICES 2008; Fosså and Kutti 2010). Reefs created by the tubeworm *Sabellaria spinulosa* are also found in the North Sea, though their extent is not known (ICES 2008).

Coral reefs and gardens provide complex, structural habitat and often have substantially higher biodiversity than surrounding areas (Fosså, Mortensen et al. 2002; Husebø, Nøttestad et al. 2002; Rogers 2004; OSPAR 2005). For example, *L. pertusa* reefs in the Northeast Atlantic are home to some 1300 species (Roberts, Wheeler et al. 2006). Like corals, deep-sea sponge reefs provide habitat and structure for a diverse number of organisms; a study of Faroe Island waters found 242 species associated with 11 species of massive sponges (Klitgaard 1995 in OSPAR 2005). Corals and sponges are also often fragile and long-lived (hundreds or even thousands of years old), making them vulnerable to disturbance (Hall-Spencer and Stehfest 2009). Research continues to better understand the distribution and ecological importance of corals and sponge species in the Northeast Atlantic (Hall-Spencer and Stehfest 2009).

Few studies have specifically evaluated the impacts of trawl disturbance on Arctic benthic ecosystems (Fosså and Kutti 2010). In an assessment for the Barents Sea (Norwegian Directorate of Fisheries 2004) it is stated that the bottom substrate in the Barents Sea seems robust in relation to bottom trawling. However, knowledge is limited and further research is necessary. Within a fishery protection zone in the Barents Sea, trawling was shown to not have any significant effect on the hard-bottom and soft-bottom fauna (Kutti, Hoisaeter et al. 2004). An English summary of an experiment comparing four intensively trawled areas to four undisturbed areas in Icelandic waters states that only a few species were affected by trawling.[13]

The impacts on coral and sponge areas are likely much greater. In Iceland, for example, surveys using ROVs have found devastated reefs and damaged sponges in areas marked with the characteristic furrows and tracks of bottom trawls and dead coral fragments together with the remains of fishing gear (ICES 2002; Garcia *et al.* 2007)). *Lophelia* occurs near the continental shelf break to the south and west of Iceland (ICES 2002), and damage by fishing gear (bottom trawling) is a primary threat to these reefs (OSPAR 2005). Detailed maps of both fishing effort and deepwater coral habitats in Iceland confirm that trawling and other fishing activities are ongoing in these sensitive coral habitats (Garcia *et al.* 2007). Bottom trawling has damaged coldwater coral reefs in many other areas of the Northeast Atlantic too, including the waters off Norway (Fosså, Mortensen et al. 2002), the UK (Rogers 2004) and the Faroes (ICES 2008). Indeed, bottom trawling is considered a primary threat to Lophelia reefs (OSPAR 2005), and as having the greatest potential to disturb benthic habitats more generally (Fosså and Kutti 2010). In addition, qualitative data indicate that fishing gear is known to take sponges and, in many locations, fishers are no longer seeing as many sponges as in the past (OSPAR 2005).

Atlantic cod are found on or over a variety of substrates, including low resilience coral habitat (Husebø, Nøttestad et al. 2002). Fishing for cod with bottom trawls, bottom longlines and gillnets may thus occur in habitats with either moderate or low resilience to fishing. Because Danish seines can generally be used only on smooth substrates such as sand, fishing with Danish seines occurs in habitats with moderate resilience.

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[13] http://www.hafro.is/undir_eng.php?ID=16&REF=2

Spatial scale of impact

Iceland provides detailed data on the location of fishing effort.[14] The demersal trawl fishery (including the separate deeper water fishery for Greenland halibut and the northern shrimp fishery which operates primarily north of the country) occurs over a large portion of the Icelandic seafloor in deep water and nearshore habitats (Figure 28). Based on the geographic distribution of the fishery, the spatial scale of fishing impacts is considered moderate. The same is assumed for other fisheries targeting cod stocks in the Northeast Atlantic.

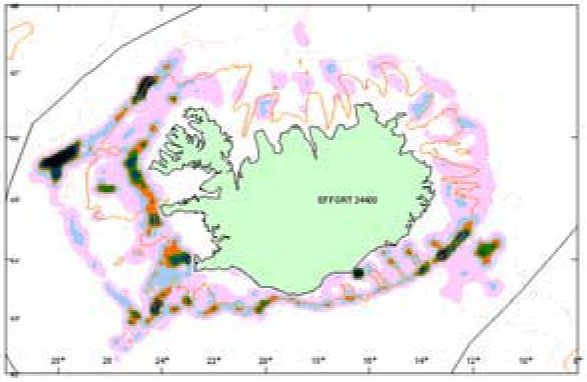

Figure 28. Trawling effort for demersal fish in Icelandic waters (Figure from ICES 2006b). *Note:* The dark colors show the areas of greatest fishing effort are off the southeast, west, and northwest coasts of Iceland.

Ecosystem Effects

The removal of large predators such as cod has been shown to cause trophic cascades through four trophic levels in the Northwest Atlantic. For instance, the reduction of large predator biomass has been linked to increases in small pelagic fishes and benthic invertebrates, as well as increases in grey seals (Frank, Petrie et al. 2005). Worm and Myers (2003) found an increase in the biomass of macroinvertebrates following a decline in cod stocks in nine continental shelf ecosystems.

In the North Sea, there is also evidence of the ecosystem effects of fishing practices, such as changes in the size and species composition of several fish species (Rice and Gislason 1996), including a decreased abundance of cod (Pope and Macer 1996; Cook, Sinclair et al. 1997). Decreases in cod abundance have been concomitant with increases in shrimp and lobster abundance (ICES 2003). In the North Sea, changes in size structure are evidence of the effects of fishing, as is a decrease in the trophic level of the demersal fish community between 1982 and 2000 (Jennings, Greenstreet et al. 2002).

Synthesis

Bottom trawling is known to damage the seafloor and occurs over a variety of habitats in Northeast Atlantic and European waters, including sensitive habitat such as cold-water corals, which are biodiversity hotspots and serve as habitat for other commercially valuable fishes. The reduction of habitat complexity as a result of bottom trawling reduces the survivorship of juvenile cod. Although bottom gillnets and bottom longlines have a lesser impact than bottom trawls, they still affect bottom habitat such as corals through entanglement while the gear is set

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[14] http://www.fisheries.is/fisheries/fishing-gear/bottom-trawl/

and retrieved. Danish seining which uses lighter ground gear than bottom (otter) trawling and is conducted only in habitats of high or moderate resilience, likely has a greater impact than set gears but a lesser impact than bottom trawling. The effects of bottom trawls and Danish seines are considered severe while the effect of bottom gillnets and bottom longlines are considered moderate. Gears that do not touch the seafloor, such as handlines and jigs, are deemed benign for habitat effects. In addition, the removal of large predators such as cod has been shown to affect the biomass at other trophic levels, including small pelagic fishes and grey seals in the Northwest Atlantic.

Effect of Fishing Practices Rank:

Hook-and-line (e.g. handlines, jigs):

Benign 🟩 Moderate 🟨 Severe 🟥 Critical ⬛

Bottom gillnets, bottom longlines:

Benign 🟩 **Moderate** 🟨 Severe 🟥 Critical ⬛

Bottom trawls, Danish seines:

Benign 🟩 Moderate 🟨 **Severe** 🟥 Critical ⬛

CRITERION 5: EFFECTIVENESS OF THE MANAGEMENT REGIME

Northeast Arctic (main fishing nations: Norway and Russia)

Stock status

Annual robust stock assessments are conducted by ICES.

Scientific monitoring

Both fisheries-dependent (one commercial CPUE index) and fisheries-independent (three surveys) data are used in stock assessments. Discards are not accounted for, and the bycatch of juvenile cod is unknown.

Scientific advice

The current management plan (2004) is considered to be consistent with ICES' precautionary approach (ICES 2010). ICES provides an annual catch limit that corresponds to its advice for that year. Up until 2004, that catch limit was typically exceeded by the agreed-upon TAC and annual catch. In 2004, the Joint Russian-Norwegian Fisheries Commission decided on a management rule for setting the TAC, which includes estimating the average TAC level for the next three years based on F_{pa}, and considering a lower TAC if the spawning stock falls below B_{pa} (ICES 2004). Other than 2005 and 2006, TACs have been set higher than the limits advised by

ICES. In 2007 and 2008, catches (including estimated unreported catches) exceeded the set TACs.

Bycatch

Fisheries are regulated through mesh size limits, minimum catching size, maximum bycatch of undersized fish, maximum bycatch of non-target species, closure of areas with high densities of juveniles, and other seasonal and area restrictions (ICES 2010). In addition, sorting grids have been mandatory in the trawl fishery since 1997 (ICES 2004), and research is underway on improving gear selectivity (NMFCA 2010). Norway and Russia both have a discard ban for the commercially most important species (Langaard, Jensen et al. 2008). Discard bans alone are not necessarily enough to reduce discards, as seen in Tanzania's shrimp trawl fishery where the ban is poorly enforced and 78% of the catch is discarded (Kelleher 2005). Discard bans can also simply lead to the landing of bycatch for the purpose of turning into fishmeal or animal feed rather than fishermen actively avoiding areas of high concentrations of unwanted or undersize fish (Kelleher 2005). For example, a high fishmeal manufacturing capacity likely contributes to Iceland's relatively low discard rates (Pitcher, Kalikoski et al. 2008). In Norway, legislation and regulations are specifically designed to control catches, both of target species and unwanted species. For 26 commercial non-target species there is a maximum limit for bycatch of 10% of total catch (Pitcher, Kalikoski et al. 2008). In Norwegian legislation, the *catch* of 'illegal' fish is prohibited, compared to the *landing* of illegal catch as is the case in EU legislation, for example (Kelleher 2005). One measure used to ensure compliance is permanent or temporary closure of areas along the Norwegian Coast and in the Barents Sea where the proportion (by number) of undersized cod, haddock and saithe exceeds 15% (Langaard, Jensen et al. 2008; ICES 2010). Permanent closures are in place for bottom trawls, and a real-time closure system is in place for trawls in other areas and other gears. Areas are identified by fishermen, scientists and the coast guard, and verified by inspectors in Norway's Surveillance Service. Closures can be implemented within 2–4 hours of notice for domestic vessels and 7 days for foreign vessels. Fishermen are also obliged to change fishing ground if they're catching large numbers of undersized fish (Kvamme 2005 in Langaard, Jensen et al. 2008; ICES 2010). Norway also has a limited compensation scheme in place to provide fishermen in the whitefish sector for unintentional catch (NMFCA 2010).

According to Isaksen, Gamst et al. (1998), the real-time closure system is regarded as the single most important technical measure contributing to the recovery of cod and haddock in the Barents Sea (Langaard, Jensen et al. 2008). However, ICES has not evaluated the total effects of the bycatch regulations, and total discard rates are largely unknown (Langaard, Jensen et al. 2008 ICES 2010) because observers are not currently required in the Norwegian cod fishery (Dagfinn Lilleng, FKD, pers. comm. in Langaard, Jensen et al. 2008).

Collaboration between Norway and Russia appears to have been integral in reducing discards (and overfishing), and the real-time closure system is a joint effort between the two countries (NMFCA 2010). In a recent review of nations' compliance with the bycatch components of the UN Code of Conduct for Responsible Fishing (CCRF), Norway received among the highest scores for all countries in minimizing bycatch of non-target species, minimizing discards and controlling ghost fishing (Pitcher, Kalikoski et al. 2008). Russia, in contrast, received among the lowest scores for minimizing bycatch and discards (but placed 11 out of 53 for ghost fishing).

Although this review provides only a broad picture across all fisheries in each country rather than for the cod fishery specifically, it does suggest that bycatch remains a bigger issue in Russia than in Norway across all fisheries generally.

Habitats and ecosystems

Research in Norway has indicated substantial damage to *Lophelia pertusa* reefs in Norway, primarily from bottom trawls and other fishing gears (Fosså, Mortensen et al. 2002; Hall–Spencer, Allain et al. 2002). The authorities have responded with laws prohibiting intentional and negligent destruction of coral reefs and requiring precaution when fishing in their vicinity (since 1999) (Hall-Spencer and Stehfest 2009). The laws also ban the use of bottom tending mobile fishing gear in the vicinity of particularly valuable reefs (Langaard, Jensen et al. 2008). As of 2008, several areas had been afforded this protection, including the Sula Reef (1999), Iverryggen Reef (2000), Rost Reef (2003), Tisler and Fjellknausene Reef (2003), Selligrunnen Reef (temporary protections), and a 20 nm zone around Bear Island (Langaard, Jensen et al. 2008). Norwegian satellite tracking shows that these restrictions are respected by the fishing fleet (Fosså and Kutti 2010). Other than the closures, however, *Lophelia* reefs are not mapped on fishery and navigational charts, lessening the effectiveness of the protections (Christiansen 2010). There are also no specific measures in place to protect coral garden habitats (other than those occurring in conjunction with *Lophelia* reefs (Christiansen 2010).

Mass occurrences of sponges are also known in Norwegian waters, particularly in the Barents Sea. Although these areas are thought to be highly biodiverse and vulnerable to fishing gear, no management efforts have yet been made in Norway (Elena, Ragnarsson et al. 2006; Fosså and Kutti 2010). Overall, there is still a lack of knowledge on the location of important habitats, though efforts are underway to better map the Barents Sea (Pitcher, Kalikoski et al. 2008). According to Pitcher, Kalikoski et al. (2008), Norway has among the highest compliance with the CCRF in implementing protected and no-take areas. Russia received a more moderate score.

Enforcement

There are various enforcement measures in place in the demersal fisheries in the northeast Atlantic, including a requirement to report to catch-control points when entering and leaving EEZs, VMS tracking of some fleets, random vessel inspections when landing fish, and mandatory logbooks for most vessels (ICES 2010). According to ICES 2010, large portions of the fleet report to the authorities daily. As noted above, there is currently no requirement for an observer program in Norwegian fisheries, though there has been in the past. This is a concern because an on-board observer or video surveillance program is the only way of enumerating non-commercial catches (MRAG 2006).

Illegal, Unreported and Unregulated (IUU) fishing has been a serious problem in the past, especially in the Russian fishing fleet.[15] For example, landings of Northeast Arctic cod from 1987 to 2003 exceeded the TAC 13 times (76% of the time), and landings exceeded the predicted catch corresponding to ICES advice 12 times over the same time period (ICES 2004). This is likely due to a lack of enforcement in the national zones of the Barents Sea (Nakken 1998). In 2006, the unreported catch was estimated at 28-000-127000 t, or 5%–21% of the catch (ICES 2010). Pitcher, Kalikoski et al. (2008) suggest that Norway's efforts in controlling IUU fishing

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[15] http://www.fiskeridir.no/english/fisheries/reports/russian-cod-fishing-transhipment-at-sea

are among the best in the world, while Russia's are among the worst. However, recent cooperative efforts by the Norwegian and Russian authorities appears to have been effective in reducing IUU to insignificant levels;[16] ICES provisionally estimates an IUU fishing mortality of 0t in 2009 (ICES 2010). According to Pitcher, Kalikoski et al. (2008), Norway is number two of the world's 53 top fishing nations (after Namibia) in terms of compliance with the CCRF in monitoring, control and surveillance (and only one of two countries that meets that study's score for a 'good' level of compliance). Russia, in contrast, is among the least compliant (43rd).

Management track record
For many years, the stock was overfished with overfishing occurring. IUU fishing was a major problem, especially for Russian fisheries. Management efforts in the mid-2000s have brought reported fishing mortality and IUU fishing under control and fully recovered the stock.

Norwegian coastal (main fishing nation: Norway)

Stock status
Annual stock assessments are conducted by ICES, but are based only on survey trends.

Scientific monitoring
Both fisheries-dependent (catch-at-age) and fisheries-independent (one acoustic survey) data are used in stock assessment. Recreational catches are estimated and uncertain, but are included in assessment (ICES 2010).

Scientific advice
A rebuilding plan has been developed by the Norwegian authorities and is currently being evaluated by ICES (ICES 2010). Norwegian coastal cod is regulated under the same management measures as the Northeast Arctic cod stock (ICES 2004), but is assessed and given a TAC independent of the other fishery. In 2004, the TAC for Norwegian coastal cod was lowered from 40,000 mt to 20,000 mt, and new regulations were implemented to close several fjords to directed cod fishing for vessels larger than 15 m (ICES 2004). These regulations, however, were ineffective at reducing fishing pressure on coastal cod (ICES 2004). Since 2004, ICES has recommended a recovery plan be developed, and advised that no fishing occur on the stock. However, the current TAC system does not restrict the overall catches of coastal cod; catches have remained above 20,000 t since 2004 (ICES 2010).

Bycatch, Habitat and ecosystem, and Enforcement
See Northeast Arctic discussion above.

Management track record
Relative to ICES advice, fishing mortality has been too high and biomass too low for at least a decade. Although fishing mortality has declined, it is still way above the zero fishing advice from ICES, and biomass is currently close to the lowest observed level (ICES 2010).

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[16] http://www.fisheries.no/resource_management/control_monitoring_surveillance/No_IUU_fishing_of_cod_in_the_Barents_Sea/

Icelandic (main fishing nation: Iceland)

Stock status
Annual stock assessments for cod are conducted by MRI and peer-reviewed by ICES (MRI 2010).

Scientific monitoring
Both fisheries-dependent (landings-at-age) and fisheries-independent (age-structured spring and fall surveys) data are used in stock assessment. Discards are not accounted for but are considered low.

Scientific advice
Management sets TACs according to the harvest control rule (HCR) in the latest management plan. The most recent plan was finalized in 2009 and is considered consistent with ICES' precautionary approach (ICES 2010). Four times over 14 fishing seasons (from 1995/1996 to 2008/2009) the cod TAC was set higher than that corresponding to the HCR, and landings exceeded the TAC on all but one occasion (though only by a small margin in some years) (ICES 2010). Since the 2002–2003 fishing season, the TAC has been set at, close to, or even below that corresponding to the HCR on the majority of occasions (ICES 2010).

Bycatch
Icelandic regulations prohibit the discarding of most fish specimens for which there are TACs (and are consequently part of the ITQ program—Arnason 1993; Runolfsson 1999) or species for which a market value exists (Pitcher, Kalikoski et al. 2008). Demersal species with TACs since 2001/2002 are cod, haddock, saithe, demersal redfish, tusk, ling, Atlantic catfish, Greenland halibut, monkfish, plaice, witch flounder, dab, long rough dab, and lemon sole.[17] Exceptions to the discard prohibition rule include cod <50 cm long and haddock caught by hook and line and <45 cm, both of which must be released (ICES 2010). As these 14 species have TACs (and so are managed and accounted for), only discards of these species are considered bycatch according to Seafood Watch (in addition to species for which there is no TAC). Discards of the most important commercial species are reported to be <10%, but Pitcher, Kalikoski et al. (2008) report that there is insufficient attention given to discards of non-commercial invertebrate species, such as echinoderms, tunicates, sponges and crabs. Indeed, discard sampling conducted on the demersal fisheries in 2006–2008 was sufficient only to estimate discards of cod, haddock, redfish, saithe and plaice (Pálsson 2007), and more recent reports only estimated discards of cod and haddock (Pálsson, Bjornsson et al. 2010; Valtýsson, pers. comm.[18]). Nonetheless, Pitcher, Kalikoski et al. (2008) score Iceland among the top few countries (of the 53 reviewed) for consistency with the bycatch and discard minimization guidelines of the CCRF (and within the top 20 in controlling ghost fishing).

Measures in place include maximum mesh sizes in gillnets, and minimum mesh size in trawl codends (as well as small fish grids in some areas). The effectiveness of these measures has not been evaluated by ICES (ICES 2010). In addition, Iceland has had a quick closure system in

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[17] Other species/stocks with TACs are Icelandic herring, capelin, offshore shrimp, inshore shrimp, Iceland scallop, *Nephrops* lobster. http://www.fisheries.is/management/total-allowable-catch/

[18] Dr Hreiðar Þór Valtýsson, University of Akureyri, pers. comm. April 2011

place since 1976, whereby the authorities can close an area where inspectors observe too many (>25% by number) small (<55cm) cod in the catch (ICES 2010). Closures are relatively small and can last for two weeks or more, but longer closures can be implemented if deemed necessary (Christensen, Hegland et al. 2009; ICES 2010). According to ICES 2010, a preliminary evaluation of the temporary closure system is that it likely does not contribute significantly to the protection of juveniles. An exception may be where several consecutive closures effectively result in larger closures for longer time periods, but this has not been evaluated. Other closures include 2–3 week-closures in spawning areas during spawning season and various permanent closures for all fisheries or for specific gears to protect juveniles and habitat. For example, fishing by bottom trawl, midwater trawl and Danish seine is prohibited within 12 miles of the northwest and north coast.[19] Neither the seasonal or permanent closures have been evaluated by ICES (ICES 2010).

The discard ban has been coupled with a “bycatch bank” since 1989, the purpose of which is to help commercialize fish species caught as bycatch, thereby reducing the incentive to discard (Sanchirico, Holland et al. 2005; Guðfinnsson, Sigurjónsson et al. 2010). The program has led to directed fisheries for megrim, witch-pole dab and rough dab, and trading channels for others such as starry ray, great silver smelt, grenadiers and piked dogfish (Pitcher, Kalikoski et al. 2008). Other mechanisms in place to de-incentivize discarding include rollover allowances, species quota exchanges, retrospective balancing, and temporary quota exchanges between vessels (Sanchirico, Holland et al. 2005).

In summary, none of the retained catch would be considered bycatch by SFW as it is landed, accounted for and managed in some way.[20] Discards of the commercially most important species is low. Management measures such as the discard ban and bycatch bank are likely effective in reducing discards of commercial species. However, concerns remain over management of bycatch species without a TAC, especially invertebrates. Moreover, measures implemented to reduce bycatch such as mesh size regulations and closures have either not been evaluated by ICES or have been found to be ineffective in reducing bycatch of juveniles.

Habitats and ecosystems

Iceland does have a policy that “Every effort shall be made to preserve the biodiversity and ecosystem of the ocean,” (Pitcher, Kalikoski et al. 2008) and has implemented a program of permanent, seasonal and temporary closures. While most of these are to reduce discards of small cod and other species or for socio-economic reasons (Elena, Ragnarsson et al. 2006), specific closures have been implemented to protect three *Lophelia pertusa* reefs (Hall-Spencer and Stehfest 2009) and one area of hydrothermal vents (Elena, Ragnarsson et al. 2006; ICES 2010). Other permanent closures that may mitigate habitat damage from fishing activities include the closure of all waters within 12 miles of the North and Northwest coasts to bottom trawl, midwater-trawl and Danish seine; all waters within 12 miles of the East, South and West coasts

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[19] http://www.fisheries.is/management/fisheries-management/area-closures/

[20] Bycatch is defined as species that are caught but subsequently discarded because they are of undesirable size, sex or species composition. Unobserved fishing mortality associated with fishing gear (e.g. animals passing through nets, breaking free of hooks or lines, ghost fishing, illegal harvest and under or misreporting) is also considered bycatch. Bycatch does not include incidental catch (non-targeted catch) if it is utilized, is accounted for, and is managed in some way.

to bottom trawlers (smaller bottom trawlers can enter waters between 4 and 12 miles in some areas);[21] and, in 2010, various additional areas to Danish seining.[22] However, there are no specific measures to protect other vulnerable habitat types found in Icelandic waters, such as sponge-dominated biotopes, mearl beds and cold seeps (Elena, Ragnarsson et al. 2006; Christiansen 2010). Overall, implementing protected and no-take areas does not appear to have been a priority in Iceland, and the country is considered in the bottom 50% of 53 nations reviewed by Pitcher, Kalikoski et al. (2008) for compliance with MPA guidelines in the UN Code of Conduct for Responsible Fishing (CCRF).

Enforcement
Iceland has a surveillance system for monitoring landings, catches and vessel activity. Measures include a video monitoring system (VMS) and vessel-boarding by the coast guard to monitor catches and gear (Sanchirico, Holland et al. 2005; Asgeirsson Undated; FAO 2010). Logbooks are also required, and all catches are weighed by officials at the port of landing.[23] In addition, there 15 port inspectors and 22 onboard inspectors to monitor catches and landings (Asgeirsson Undated). Logbook catch data is verified by these authorities by requiring the vessel to return to the same fishing area with the observer onboard (Jóhann Sigurjónsson; Director General; Marine Research Institute; pers. comm.). Given that there were 1,642 Icelandic fishing vessels at the end of 2007,[24] observer coverage would appear low (actual information about the Icelandic observer system is hard to find—Pitcher, Kalikoski et al. 2008). Pitcher, Kalikoski et al. (2008) consider the Icelandic observer scheme moderately effective, and the catch inspection, VMS, and IUU-prevention schemes all effective (IUU is not a big problem in Iceland). Overall, Iceland ranks among the best in the world in terms of compliance with the CCRF for monitoring, control and surveillance (Pitcher, Kalikoski et al. 2008).

Management track record
Management has recently reduced fishing mortality on cod to the lowest level in 40 years, and biomass has begun to increase. The stock is not yet fully recovered however, and problems persist in several other stocks that are caught with Icelandic cod.

Baltic Sea, North Sea (including eastern Channel and Skagerrak), Celtic Sea, Irish Sea, Kattegat, West of Scotland, Rockall (main fishing nations/blocs: EU and Norway (North Sea and West of Scotland))

Stock status
ICES conducts annual assessments on all cod stocks in (primarily) EU waters except Rockall. Those in the Baltic Sea, North Sea, Irish Sea, Kattegat, West of Scotland can be considered robust. Those in the Celtic Sea are not robust (ICES states that the available data are inadequate to establish reliable stock assessments and evaluate stock trends). There is no scientific analysis of the limited data available for Rockall.

Scientific monitoring

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[21] http://www.fisheries.is/management/fisheries-management/area-closures/
[22] http://www.stjornartidindi.is/Advert.aspx?ID=31e2c614-3ff4-48f3-be07-7b7ee626a1d7
[23] http://www.fisheries.is/management/fisheries-management/enforcement/
[24] http://www.fisheries.is/fisheries/fishing-vessels/

Baltic Sea (both stocks), North Sea: Both fisheries-dependent and fisheries independent are used for stock assessment. Discards are included.
Celtic Sea, Irish Sea, Kattegat, West of Scotland: Fisheries-independent indices only in 2010, and discards not included.
Rockall: Very limited fisheries-dependent data.

Scientific advice

- Baltic Sea: ICES considers the most recent management plan (2007) to be in accordance with the precautionary approach. Agreed TAC has exceeded that corresponding to ICES advice by several fold in all years from 1989 to 2003. Since 2004, separate management including TACs have been in place for the two stocks. TACs for the eastern stock have generally been set at the limit recommended by ICES (i.e. in 2004 ICES advice <29.4 t, agreed TAC was 29.4 t), except in 2008 and 2009 when the TACs were exceeded. Catches since 2004 have generally been below the TAC (ICES 2010). ICES advice for the western stock from 2004 to 2008 was a very low (<14.9 t) or zero TAC. Agreed TACs were over 40,000 t in those years. ICES advice in 2008 and 2009 was a much higher TAC (consistent with the 2007 management plan), and the agreed TAC was roughly comparable (ICES 2010).

- North Sea, eastern Channel and Skagerrak: ICES has recommended lowest possible catch (i.e. zero)/catches of zero/closure for most years since 2001 in all three areas (ICES 2010). For the 2010 fishing season, ICES advice was to set a TAC in line with the most recent (2008) management plans, corresponding to <40.3 t for all three areas. This advice was based on ICES evaluation of the plans, which were found to be in accordance with the precautionary approach *only if properly implemented and enforced* (as discarding accounts for half of the total fishing mortality). ICES notes that under the "present implementation and enforcement approach, a large reduction in F and the recovery of the stock are unlikely." Although efforts to reduce discards are now underway, it is too early for ICES to evaluate their impacts on stock dynamics. The agreed TAC was set at 40.4 t, separated further into the three areas, and official landings were 30,800 t in total (ICES 2010). For the 2011 fishing season, ICES noted that adhering to the TAC requirements of the plans (which limit interannual changes in the TAC to 20% to improve fisheries stability) would not lead to the fishing mortality reduction objectives of the plans (under this scenario, the maximum TAC would be set at 32,240 t). ICES thus provides two additional scenarios, based on the precautionary approach (zero catch) and transition to an MSY approach (5,700 t to 40,900 t for transition to the MSY framework by 2011 and 2015, respectively) (ICES 2010). The final 2011 TAC was set at 32,912 t;[25] above the levels of both the plan advice and precautionary advice.
- Celtic Sea: There is no management plan (or specific management measures) for cod stocks in the Celtic Sea. ICES advice has generally been major (40%–90%) reductions in F or a zero catch since 2001, with very low (<5.3) and declining corresponding catch. The agreed TAC has exceeded ICES advice in every year for the last decade. Catches have generally been below the agreed TAC but above ICES advice, even including estimates of discards, high grading and misreporting. Various seasonally closed areas have been implemented to

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[25] http://www.france24.com/en/20101215-eu-cuts-cod-fishing-quota-north-sea

reduce fishing mortality on cod since 2005. Some (e.g. North Cornwall) appear to have been potentially effective, while the effectiveness of others (e.g. Irish Coast) is less clear.

- Irish Sea: The most recent management plan (2008) is considered *not* in accordance with the precautionary approach, and management is not controlling mortality levels. ICES has recommended a zero catch/fishery closure since before 2001. Actual TACs were low but not zero (generally <3 t); catches were generally less than the TAC.
- Kattegat: The most recent management plan (2008) is considered not in accordance with the precautionary approach because of unaccounted removals being up to five times the TAC. ICES has recommended no catch/no fishery since 2002. The agreed TACs were low but not zero (generally <3 t and decreasing annually). Reported landings were generally less than the agreed TAC, but do not include unreported catches.
- West of Scotland: ICES cannot evaluate whether the most recent management plan is in accordance with the precautionary approach because unaccounted mortality is very high and uncertain. ICES does state that management is currently not controlling mortality levels, however. ICES has recommended a zero catch/fishery closure since 2001. The agreed TACs were low but not zero (generally <5 t and decreasing annually). Reported landings were generally less than the agreed TAC, but do not include unreported catches.
- Rockall: There is no management plan or specific management objectives for this stock. ICES has not provided any scientific advice.

Bycatch

In direct contrast to the discard policies of Norway, Russia and Iceland, the EU's Common Fisheries Policy (CFP) requires that all fish that cannot be landed legally be discarded. The CFP defines "catch limit" as a "limit on landings," effectively setting TACs for landed fish rather than caught fish (Gezelius 2008). Thus, although an actual estimate of discards is hard to come by for most EU cod fisheries (especially as observer coverage is generally low— e.g. MRAG 2006), estimates that do exist suggest discard rates are typically very high (see bycatch section and particularly Table 4). This policy has been heavily criticized because it undermines the monitoring of total fishing mortality (Gezelius 2008). There has been a ban on high grading in the North Sea since 2009 (WWF-Scotland 2009), but it is possible some still occurs (ICES 2010 puts high-grading forward as one plausible explanation for unaccounted removals in the North Sea, eastern Channel and Skagerrak).

Some EU member countries, including Scotland and Denmark, have established trial programs designed to evaluate the potential for full-documentation catch schemes in their fleets.[26] Scotland, which accounts for 70% of UK landings, launched the (then) voluntary Scottish Conservation Credits Scheme in February 2008 (WWF_Scotland 2009). The program aimed to meet the 2009 Cod Recovery Plan goal of a decrease in cod mortality of 25% by avoiding cod (and thereby discards) and then by reducing effort (WWF_Scotland 2009). A system of temporary, seasonal and permanent closures provide a foundation to the program (Figure 29).[27] Real Time Closures (RTCs) can be triggered when Scottish or Norwegian inspection vessels find high levels of cod. These close automatically for three weeks, which has been shown to be long

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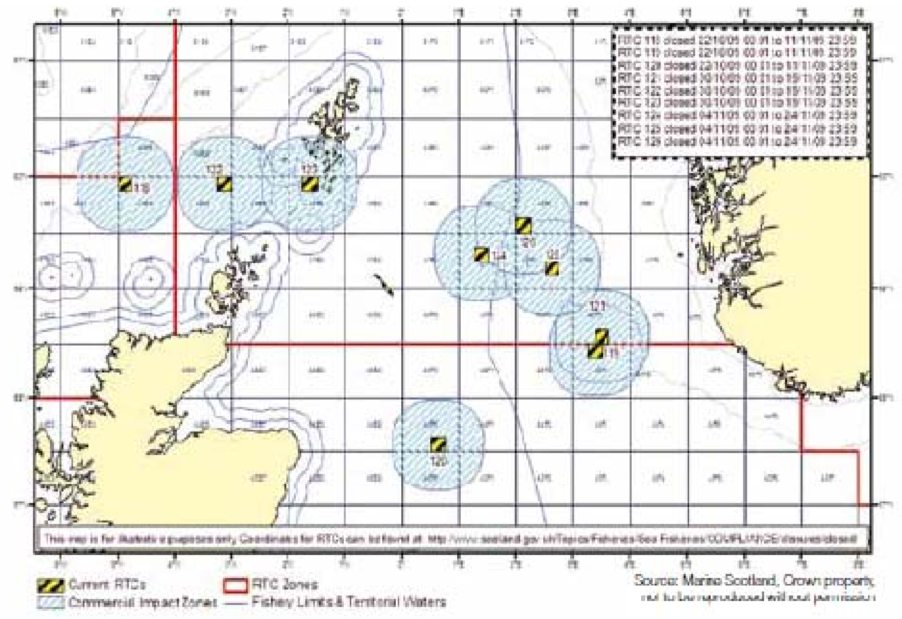
[26] http://wwf.panda.org/what_we_do/how_we_work/policy/wwf_europe_environment/news/?197637/WWF-welcomes-EU-Norway-agreement-to-reduce-discards

[27] More details on the Scottish Conservation Credits Scheme and RTCs available at http://www.scotland.gov.uk/Topics/marine/Sea-Fisheries/17681/closures

enough for cod aggregations to disperse. Up to nine RTCs of up to 50 square miles can be in place at any one time, with six as the goal (WWF_Scotland 2009). In addition, 'amber' areas with a high probability of high cod abundance are identified through VMS and landings data and are revised quarterly. While fishermen are not punished for fishing in these areas, they can sign up to avoid these areas and receive additional days-at-sea. A handful of permanent (i.e. the 'windsock' area) and seasonal (i.e. 'long hole,' Pappa Bank, Coral Edge, Stanhope Ground) closures are also in place (WWF_Scotland 2009).

Real Time Closures on 11 November 2009



Q4 Amber Areas 1 November 2009 to 31 January 2010

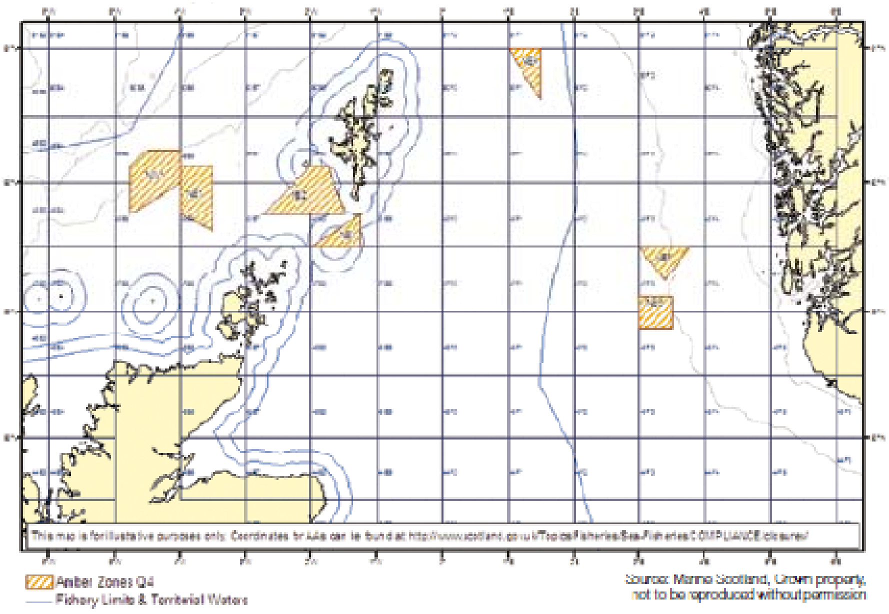


Figure 29: Real Time Closures and Amber Areas in the Scottish Conservation Credits Scheme (WWF_Scotland 2009)

Participants in the program must also use only regulated gear (the 'one net rule') and also have an incentive to move to more selective gear (trials are underway on more selective bottom trawls such as the Orkney and Shetland trawls[28]). Trials are also underway to improve catch documentation through observer programs and/or video surveillance (WWF_Scotland 2009). According to WWF, a high level of participation and compliance with the measures above in the voluntary scheme led to it becoming compulsory in 2009 (WWF_Scotland 2009). However, while the pilot helped Scottish fishermen obtain additional days-at-sea and extra cod quotas, it is unclear whether the scheme has led to decreased discards of cod (Catchpole and Gray 2010). Nonetheless, recent agreements between Norway and the EU will likely result in the expansion of discard-reduction trials and RTC in EU waters (the text of the agreement also indicates that discards and catches of cod were reduced under the trials)[29,30] Furthermore, in October 2009, Scottish, UK, Danish and German Ministers signed the Aalborg declaration[31,32] calling for a system of catch quotas in a fully documented fishery (using onboard CCTV) (WWF_Scotland 2009).

Habitats and ecosystems

Since 1992, member states have had an obligation under the EU's Habitats Directive to propose areas for inclusion in Natura 2000, an EU-wide network of nature protected areas. This includes both terrestrial and marine areas. Member countries' compliance with the Habitats Directive/Natura 2000 requirements is evaluated twice a year (annually from 2010) and statistics on the number of sites and total area protected are provided on the Natura 2000 section of the EU website.[33] However, to date only terrestrial protected areas have been evaluated; evaluation of the marine component is currently underway.[34] In terms of area, the marine component now accounts for some 133,000 square km, or 20% of the entire network. This includes all MPAs, however, so all areas might not be closed to even a single type of fishing activity. Several member states expanded their marine protected areas in 2010, including Germany, Denmark, France, the Netherlands and the UK (all of which fish in the North Sea and surrounding seas). Protected areas include Lophelia reefs on the Darwin Mounds and four reefs in Irish waters and on the Northwest Rockall Bank (Hall-Spencer and Stehfest 2009). According to the Natura 2000 December 2010 newsletter, significant gaps still exist, especially in offshore waters.[35] Furthermore, some NGOs have voiced concerns that the number of marine habitat types protected under Natura 2000 is too few (there are five marine habitats: sandbanks, *Posidonia* beds, reefs, submarine structures made by leaking gases, and submerged caves, plus four coastal habitats: estuaries, mudflats and sandflats, coastal lagoons, large shallow inlets and bays[36]). Important habitat types such as corals (presumably non-reef building corals), sponges, kelp and maerl beds are thus not included.[37]

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[28] http://www.seafish.org/media/Publications/Discards_NewDevelopments_2010_201012.pdf

[29] http://www.fishsec.org/downloads/1291814790_16721.pdf

[30] http://www.fiskeridir.no/english/fisheries/rtc

[31] http://www.fvm.dk/Admin/Public/DWSDownload.aspx?File=%2fFiles%2fFiler%2fEnglish%2fFisheries%2fJoint_statement_okt2009.pdf

[32] http://assets.wwf.org.uk/downloads/wwf_parlimentary_briefing_fish_nov09.pdf

[33] http://ec.europa.eu/environment/nature/natura2000/index_en.htm

[34] http://ec.europa.eu/environment/nature/info/pubs/docs/nat2000newsl/nat29_en.pdf p8

[35] http://ec.europa.eu/environment/nature/info/pubs/docs/nat2000newsl/nat29_en.pdf p9

[36] http://ec.europa.eu/environment/nature/natura2000/marine/docs/marine_guidelines.pdf

[37] http://eu.oceana.org/en/eu/media-reports/features/the-natura-2000-network

Pitcher, Kalikoski et al. (2008) found high variability in EU member states' compliance with the CCRF in implementing protected and no-take areas. Among the top 53 fishing nations worldwide, Denmark, Germany and Sweden had a relatively high score (top 13), Ireland and France had above average scores (top 26), while the UK was below average (35th) and Poland was among the lowest (49th). However, according to the scoring in that study, only 3 of the 53 countries (Norway, Netherlands, and the USA) received a 'good' compliance rating, (Pitcher, Kalikoski et al. 2008).

Enforcement
Pitcher, Kalikoski et al. (2008) found that the major EU fishing nations are generally in the top 20 fishing nations worldwide for compliance with the CCRF in monitoring, control and surveillance. This measure includes evaluation of the observer program, catch inspection scheme, and vessel monitoring system, as well as control of IUU and flags of convenience. However, even the most compliant EU country, Germany, is only moderately so. Controls over IUU and regulation-avoidance (e.g. flags of convenience) are reasonably effective in Germany, but the catch inspection scheme and VMS are only moderately effective, and there is very little observer coverage (Pitcher, Kalikoski et al. 2008). Both Denmark's and Poland's observer scheme, catch inspection scheme and VMS are only moderately effective. There are serious concerns over illegal and unreported fishing in Denmark, and Poland's control over IUU is very limited. For example, Denmark is thought to be among the leading culprits of IUU fishing in the North Sea (Pitcher, Kalikoski et al. 2008). Sweden falls at number 26 in the rankings, and there are similar concerns regarding Denmark and Poland.

Management track record
The management track record for cod stocks by the EU and its member states is generally poor. While the eastern Baltic Sea stock has improved and is now likely recovering or even recovered, other stocks are still considered overfished and/or have overfishing occurring.

Faroe Plateau (main fishing nation: Faroe Islands (Denmark))

Stock status
ICES conducts a robust annual assessment on the Faroe Plateau stock.

Scientific monitoring
Fisheries-independent data (spring and summer survey) are used in stock assessment for the Faroe Plateau stock.

Scientific advice

- Faroe Plateau: ICES considers the most recent management plan and target exploitation rate of 33% of the cod stock (by numbers) to be inconsistent with the precautionary approach. ICES recommended reductions in F from 2000 to 2004 and a rebuilding plan and large reductions/no fishing for 2005–2010. No TAC was agreed upon, but landings generally exceeded ICES advice (even when the advice was to allow some fishing to continue) by considerable margins.

Bycatch
Fisheries management in the Faroes has been one of effort (rather than catch or landings) regulation since 1996. The system has limited entry, vessel-specific limits on fishing days, a discard ban, and regulations to protect juvenile fish (closed areas, small-fish regulations and mesh-size regulations) (Gezelius 2008). Fishermen are essentially permitted to catch, land and sell whatever they can during their allotted time. As there are no incentives to discard incidental catch or misreport it, ICES does not consider discards to be a big problem. There are, however, no data on discarding in the fishery (ICES 2010). Gezelius (2008) notes that the system likely makes enforcement easier and probably improves fishing mortality monitoring data. Closed areas include year-round closure of the majority of the shelf (<200 m) to trawlers (it is mainly used by longliners), and seasonal closures to all gears in the main spawning areas for cod (ICES 2010).

Habitats and ecosystems
As most of the cod catch is made using longlines (72%) and jigs (18%) (ICES 2010), there is less concern over habitat destruction than for many other cod fisheries. Cod caught in trawls targeting saithe does still comprise a significant (18%) portion of the catch, however. Closures in place for trawl fisheries include all areas within 12 miles of the coast, which includes most shelf habitat, much of the Faroe Bank (60% of the area to 200m depth), and several banks on Faroes Plateau (Pitcher, Kalikoski et al. 2008; Hall-Spencer and Stehfest 2009). Three areas have been closed since 2005 to protect Lophelia reefs specifically (Hall-Spencer and Stehfest 2009), but no specific measures have been implemented to protect coral garden habitats (Christiansen 2010).

Enforcement
Pitcher, Kalikoski et al. (2008) found the Faroe Islands within the top 10 of major fishing nations for compliance with the CCRF in monitoring, control and surveillance. There is no observer coverage on fisheries operating in Faroese waters (there is limited Icelandic coverage on fisheries managed by RFMOs such as ICCAT), there's little if any IUU fishing by Faroese vessels and no Faroes vessels thought to be flying flags of convenience on the high seas. The catch inspection scheme and VMS are moderately effective to effective (Pitcher, Kalikoski et al. 2008).

Management track record
Faroese fisheries for cod have operated under an effort management system since 1996, with the aim of harvesting on average 33% in numbers of the exploitable stock. Upon evaluation, ICES noted the plan is not consistent with a precautionary approach. Fishing mortality has varied widely since then, but has always been above F_{pa} (and above F_{lim} in the early 2000s). Biomass has generally decreased since 1996 and, despite a recent uptick, is still below B_{pa}.

Greenland (main fishing nations: Greenland (west) and EU, Norway, Faroes (east))

Stock status
ICES conducts a stock assessment annually, but based only on stock trends.

Scientific monitoring

The 2010 stock assessment used three survey indices. No commercial indices are available as the offshore fishery has been closed since 1992.

Scientific advice
The current management agreement between Greenland and the EU (valid 2007-2012) sets up a variable TAC regulation (15,000t in 2008) and stock transfer of unutilized quota should biomass increase rapidly (ICES 2010). The agreement has not been evaluated by ICES. ICES recommended very low (<10 t) catch from 1987 to1989, no fishing on the offshore complex from 1994 to 1999, no commercial fishing from 2000 to 2004, and no fishing at all from 2005 to 2011. Total agreed TACs were more than 54 t through 2003, followed by TACs of 20 t or less. Actual catches exceeded the agreed TAC from 2005 through 2008, but was lower (13 t) than the agreed TAC (20 t) in 2009. There was no directed offshore fishery off West Greenland from 1993 to the mid-2000s, at which time it reopened but then closed again in 2010 (NWWG 2010). Most of the offshore waters along East Greenland (i.e. north of 61N) were closed for directed cod fisheries in 2009, so recent offshore landings have been from south Greenland (NWWG 2010). EU, Norwegian and Greenland offshore quotas were not met in 2009 (NWWG 2010). Landings from the inshore fleet have increased tenfold in the last decade (ICES 2010).

Bycatch, Habitats and ecosystems
Fishing in Greenland is divided into a domestic coastal fleet and an international offshore fleet. According to the FAO, nearly all of the commercial catch (of cod and other species) is landed and exported; domestic consumption is limited.[38] The coastal fishery is made up of small vessels with mixed gears including gillnets, longlines, pound nets, traps and hand dredges (NWWG 2010). There is also an inshore trawl fishery for shrimp. Cod are targeted primarily with pound nets and gillnets. The fleet almost exclusively operates in West Greenland (NWWG 2010). Until 2009, the coastal fleet was under no restrictions other than a minimum landing size of 40 cm, but is now regulated by licenses, TAC and closed areas (for cod and a few other species). No discard data is available, but bycatch is mainly of wolffish and Greenland cod (*Gadus ogac)* (NWWG 2010). Greenland's offshore cod resources are exploited by an international fleet from EU, Norway and Greenland. Directed cod fisheries are currently (since 2009/2010) closed in most of the offshore waters in both East and West Greenland, so recent catches have been exclusively from south Greenland. The fleet is comprised mainly of large trawlers, but longliners also catch cod on the East Coast (NWWG 2010). The inshore fleet has accounted for the majority of catches in most years in the last decade, although the offshore catch in 2008 comprised close to half the catch (ICES 2010). The offshore fleet is managed by TAC, minimum landing sizes, gear specifications and irregularly closed areas (NWWG 2010).

Cod is thus primarily taken in a targeted trawl fishery in offshore waters and in pound nets and gillnets in inshore waters. Trawls typically have high bycatch of finfish, especially juvenile target species, and a significant impact on the seafloor. The closed areas are primarily to protect the spawning stock and the strong 2005 year class (ICES 2010; NWWG 2010) rather than juveniles or habitat. Catches in recent years are more from the pound net and gillnet sector, however, both of which have less impact on the seafloor than trawls. Discard estimates are not available for any gear type.

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[38] http://www.fao.org/fishery/countrysector/FI-CP_GL/en. Information in fishery overview document.

Enforcement
Greenland's Fisheries License Control administers the program to ensure compliance with license and quota regulations. The agency employs on average 50 fisheries license inspectors. Since 1989, and due to problems with discards, two inspectors are now required on all offshore vessels, both domestic and foreign. Logbooks and email reports must be submitted daily. Fisheries inspections are also conducted by Greenland Command (defense vessels). Greenland also controls landings by requiring processing plants to close on very short notice.[39] As the coastal fleet has only recently received any real regulation (other than minimum landing sizes) it remains to be seen how effective enforcement is in this fishery.

Management track record
The offshore component of Greenland's cod stock has been severely depleted since 1990, but has largely been closed since 1992 and has started to recover since the mid-2000s. Biomass and fishing mortality are unknown for the inshore stock, but landings have increased tenfold over the last ten years.

Synthesis

The management effectiveness of fisheries catching cod in the northeast Atlantic is summarized in Table 5 below. Management is moderately effective in most cases. Effective data collection and utilization in robust stock assessments is fairly common for cod stocks, but these positive aspects are typically undermined by poor track records of maintaining stock productivity and a failure to follow scientific advice when setting TACs. Furthermore, most fisheries have only moderately effective enforcement, bycatch and habitat protection measures. One exception to this rule is Norwegian management, which would be amongst the best in the whole region if managers followed the advice of scientists when setting TACs (Barents Sea stock) and didn't have such a poor track record of maintaining the stock health (Norwegian coastal stock). The only two management systems that are deemed highly effective are for Iceland and the Eastern Baltic, both of which follow scientific advice and have moderately good track records. Management is considered ineffective for the offshore Greenland trawl fishery (failure to follow scientific advice when setting allowable catch, or to follow a dearth of measures to reduce bycatch and habitat impacts), and the small fishery operating on the Rockall stock (very little information is being collected, there is no stock assessment, and it has a poor track record).

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[39] http://www.oecd.org/dataoecd/9/48/34431581.pdf

Table 5: Summary of management effectiveness by stock (green=effective, red=ineffective, n/a= not applicable because of no data or low/moderate gear impacts). * Not all gear types listed are necessarily used in each case (Greenland, for example, does not appear to have Danish seine fishery that catches cod (NWWG 2010)).

	Management Factor									Overall		
Stock/Country	Stock Status	Scientific Monitoring	Scientific Advice	Enforcement	Track Record	Bycatch (Hook and Line)	Bycatch (All other gears)	Habitat and Ecosystem (All other gears)	Habitat and Ecosystem (Bottom trawl, Danish seine)*	Hook and Line	Gillnet, Longline, Pound net*	Bottom trawl, Danish seine*
NE Arctic (Barents Sea) (Norway)	🟩	🟩	🟥	🟩	🟩	n/a	🟩	n/a	🟩	🟨	🟨	🟨
NE Arctic (Barents Sea) (Russia)	🟩	🟩	🟥	🟨	🟨	n/a	🟨	n/a	🟨	🟨	🟨	🟨
Norwegian Coastal	🟩	🟩	🟥	🟩	🟥	n/a	🟩	n/a	🟩	🟨	🟨	🟨
Iceland	🟩	🟩	🟩	🟩	🟨	n/a	🟨	n/a	🟨	🟩	🟩	🟩
Baltic (East)	🟩	🟩	🟩	🟨	🟩	n/a	🟨	n/a	🟨	🟩	🟩	🟩
Baltic (West)	🟩	🟩	🟥	🟨	🟥	n/a	🟨	n/a	🟨	🟨	🟨	🟨
North Sea, eastern Channel, Skagerrak	🟩	🟩	🟥	🟨	🟥	n/a	🟨	n/a	🟨	🟨	🟨	🟨
Irish Sea	🟩	🟨	🟥	🟨	🟥	n/a	🟨	n/a	🟨	🟨	🟨	🟨
Kattegat	🟩	🟨	🟥	🟨	🟥	n/a	🟨	n/a	🟨	🟨	🟨	🟨
West of Scotland	🟩	🟨	🟥	🟨	🟥	n/a	🟨	n/a	🟨	🟨	🟨	🟨
Celtic Sea	🟨	🟨	🟥	🟨	🟥	n/a	🟨	n/a	🟨	🟨	🟨	🟨
Rockall	🟥	🟥	n/a	🟨	🟥	n/a	🟨	n/a	🟨	🟥	🟥	🟥
Faroe Plateau	🟩	🟩	🟥	🟩	🟥	n/a	🟨	n/a	🟨	🟨	🟨	🟨
Greenland	🟨	🟩	🟥	🟨	🟨	n/a	🟥	n/a	🟥	🟨	🟨	🟥

Effectiveness of Management Rank:

Iceland, East Baltic (all gears):

[✓ Highly Effective 🟩] **Moderately Effective** 🟨 Ineffective 🟥 Critical ⬛

Northeast Arctic, Norwegian coastal, North Sea, Irish Sea, Kattegat, West of Scotland, Celtic Sea, Faroe Plateau (all gears);
Greenland (all gears except bottom trawls

Highly Effective 🟩 [✓ **Moderately Effective** 🟨] Ineffective 🟥 Critical ⬛

Greenland (bottom trawls;
Rockall (all gears):

Highly Effective 🟩 Moderately Effective 🟨 [✓ **Ineffective** 🟥] Critical ⬛

IV. Overall Evaluation and Seafood Recommendation

Atlantic cod exhibits life history characteristics that should make it inherently resilient to fishing pressure, such as a high intrinsic rate of increase and moderate age at maturity. Atlantic cod aggregates to spawn, and exhibits population variability in response to environmental conditions. Fourteen Atlantic cod stocks in the Northeast Atlantic, which are assessed on an individual basis, are encompassed in this report (the fishery on the Faroe Bank has been closed since January 2009 and so is not evaluated). The two most commercially important cod stocks are the Northeast Arctic cod (Barents Sea cod) and Icelandic cod stocks. The stock status of Northeast Arctic cod is a moderate conservation concern due to biomass being above the management target and increasing in the short-term, fishing mortality being below the management target, and spawning distribution parameters being skewed. As the Icelandic stock appears to be rebuilding, short-term abundance is up and overfishing is no longer occurring, and stock uncertainty is low, Seafood Watch deems it a moderate conservation concern. In the eastern Baltic, spawning stock biomass has increased since 2005 and currently no precautionary limit is being considered. Recent fishing mortality is also below F_{MSY}. All other stocks (except Rockall which supports a very small fishery) are considered to be in poor or critical condition due to being overfished and/or experiencing overfishing.

Bottom trawls account for the majority of Atlantic cod caught in most regions, but some countries have a more varied cod fishery. In Norway’s Barents Sea fishery, for example, trawls and bottom gillnets each account for 30% of the cod catch, while bottom longline (15%), Danish seine (15%) and handline (10%) account of the remainder. In Iceland, Atlantic cod is primarily caught with bottom trawls (43%), bottom longlines (22%), and bottom gillnets (19%). Catch from the Norwegian coastal stock has almost all been from the inshore fishery in recent years, which primarily uses pound nets and gillnets. In the Faroes, longlines (72%) and jigs (18%) account for the major part of the cod catch, although bottom trawls account for most (18%) of the remainder. The major bycatch problems in cold water seafloor fisheries using these gears are finfish (including juveniles) and invertebrates in the trawl and Danish seine fisheries, and seabirds and mammals in gillnet and longline fisheries. Jigs and handlines typically have low bycatch. Discard prohibition policies in Norway and Iceland likely reduce discards of species of commercial interest (reports suggest to levels below 10% of the catch), but little information is available on non-commercial species. Discarding is also thought to be of little concern in the Faroes, where fishermen are permitted to catch, land and sell anything they like. There is again little data on discards of species that have no commercial value, however. There is also little data on the quantity and trend of seabird and marine mammal bycatch in the gillnet and longline fisheries. Especially in areas where there is habitat-creating epifauna such as cold-water corals and sponge aggregations, bottom trawls may cause great damage to the seafloor. Bottom longlines, bottom gillnets and pound nets may also affect the bottom habitat, although to a lesser degree. Danish seining, which uses lighter ground gear than bottom trawling and is conducted only in habitats of high or moderate resilience, likely has a greater impact than set gears but a lesser impact than bottom trawling. Gears that do not contact the seafloor such as hook-and-line and jigs are deemed to have no habitat impacts.

Management of cod fisheries is only moderately effective in most cases. Effective data collection and utilization in robust stock assessments is fairly common for cod stocks, but these positive aspects are typically undermined by poor track records and a failure to follow scientific advice when setting TACs. Furthermore, most fisheries have only moderately effective enforcement, bycatch and habitat protection measures. One exception to this rule is Norwegian management, which would be amongst the best in the whole region if managers followed the advice of scientists when setting TACs (Barents Sea stock) and didn't have such a poor track record (Norwegian coastal stock). The only two management systems that are deemed highly effective are for Iceland and the Eastern Baltic, both of which follow scientific advice and have moderately good track records. Management is considered ineffective for the Greenland trawl fishery (failure to follow scientific advice when setting allowable catch, or to follow a dearth of measures to reduce bycatch and habitat impacts), and the small fishery operating on the Rockall stock (very little information is being collected, there is no stock assessment, and a poor track record).

Overall, the only Best Choice for Northeast Atlantic cod is hook-and-line-caught cod from the Northeast Arctic, Iceland or the eastern Baltic. Cod caught with other gears (including trawls) from these stocks is a Good Alternative, as is cod caught with bottom longline, bottom gillnet or hook and line from the western Baltic, Celtic Sea and the Faroe Plateau. All other sources are on the Avoid list.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criterion	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks		√ (Northeast Arctic, Icelandic, East Baltic)	√ (West Baltic, Faroe Plateau, Celtic	√ (Norwegian Coastal, North Sea, Greenland, Kattegat, West of Scotland)
Nature of Bycatch	√ (Hook and line)	√ (All other gears)		
Habitat Effects	√ (Hook and line)	√ (Bottom gillnet, bottom longline, pound net)	√ (Bottom trawl, Danish seine)	
Management Effectiveness	√ (Iceland, East Baltic)	√ (Northeast Arctic, Norwegian coastal, Greenland (other gears), North Sea, Irish Sea, Kattegat, West of Scotland, Celtic Sea, Faroe Plateau)	√ (Greenland (trawl), Rockall)	

Overall Seafood Recommendation:

Northeast Arctic, Icelandic, East Baltic (hook and line)

Best Choice 🟩 Good Alternative 🟨 **Avoid** 🟥

Northeast Arctic, Icelandic, East Baltic (other gears)
Western Baltic, Celtic Sea, Faroe Plateau (bottom gillnet, bottom longline, hook and line, pound net)

Best Choice 🟩 **Good Alternative** 🟨 Avoid 🟥

Western Baltic, Celtic Sea, Faroe Plateau (bottom trawl, Danish seine)
Norwegian Coastal, North Sea, Greenland, Kattegat, West of Scotland, Rockall (all gears)

Best Choice 🟩 Good Alternative 🟨 **Avoid** 🟥

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VI. Appendices

Appendix A: February 2011 updates

The original 2005 report deemed most stocks Avoid, mostly because of concerns over stock status (critical concerns) and management (high concern). Exceptions were cod from the Northeast Arctic and Iceland caught with gears other than bottom trawl, in which both stock status (high concern) and management (moderate concern) were slightly better. At that time, however, ALL stocks were considered either a high concern or a critical concern. In 2010, most stocks remained a high or critical concern, but a few had improved considerably (Northeast Arctic, Icelandic, East Baltic, and the Faroe Plateau stock). One major factor in the improvements seen in many stocks is more effective management, which is also reflected in the updates. Hook and line fisheries (i.e. handlines and jigs rather than bottom longlines) have been separated out as a low conservation concern for bycatch as opposed to the moderate concern when using more unselective gears. In addition, more information is now available (though it's still limited) on discard rates in some fisheries. While this information did not change the ranking under the Bycatch Criterion, it is nonetheless reflected in the discussion. The management discussion and ranking also reflects the fact that there is less need for stringent measures to control bycatch and habitat damage in gears that have low (or moderate in the case of habitat) impacts. As a result of these updates, the ranking for several cod sources has been changed:

- Hook-and-line caught cod:
    - Northeast Arctic and Icelandic to Best Choice from Good Alternative
    - Eastern Baltic to Best Choice from Avoid
    - Faroe Plateau, Western Baltic and Celtic Sea to Good Alternative from Avoid

- Bottom longline and bottom gillnet caught cod:
    - Eastern Baltic, Western Baltic, Celtic Sea, and Faroe Plateau to Good Alternative from Avoid

- Bottom trawl caught cod
    - Northeast Arctic, Icelandic, Eastern Baltic to Good Alternative from Avoid

Appendix B: Capture Fisheries Evaluation for Atlantic Cod

MONTEREY BAY AQUARIUM®
Seafood
WATCH

Capture Fisheries Evaluation

Species: *Atlantic cod*
Region: *Imported Sources (except Canada)*
Analyst: *Marsh/Roberts*
Date: *22 Nov 2005 (updated: Apr 2011)*

Seafood Watch^{T}defines sustainable seafood as originating from sources, whether fished[40] or farmed, that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

The following **guiding principles** illustrate the qualities that capture fisheries must possess to be considered sustainable by the Seafood Watch program. Species from sustainable capture fisheries:

- have a low vulnerability to fishing pressure, and hence a low probability of being overfished, because of their inherent life history characteristics;
- have stock structure and abundance sufficient to maintain or enhance long-term fishery productivity;
- are captured using techniques that minimize the catch of unwanted and/or unmarketable species;
- are captured in ways that maintain natural functional relationships among species in the ecosystem, conserves the diversity and productivity of the surrounding ecosystem, and do not result in irreversible ecosystem state changes; and
- have a management regime that implements and enforces all local, national and international laws and utilizes a precautionary approach to ensure the long-term productivity of the resource and integrity of the ecosystem.

Seafood Watch has developed a set of five sustainability **criteria,** corresponding to these guiding principles, to evaluate capture fisheries for the purpose of developing a seafood recommendation for consumers and businesses. These criteria are:

1. Inherent vulnerability to fishing pressure
2. Status of wild stocks
3. Nature and extent of discarded bycatch
4. Effect of fishing practices on habitats and ecosystems
5. Effectiveness of the management regime

Each criterion includes:

- Primary factors to evaluate and rank
- Secondary factors to evaluate and rank
- Evaluation guidelines[41] to synthesize these factors
- A resulting **rank** for that criterion

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[40] "Fish" is used throughout this document to refer to finfish, shellfish and other wild-caught invertebrates.

[41] Evaluation Guidelines throughout this document reflect common combinations of primary and secondary factors that result in a given level of conservation concern. Not all possible combinations are shown – other combinations should be matched as closely as possible to the existing guidelines.

Once a rank has been assigned to each criterion, an **overall seafood recommendation** for the species in question is developed based on additional evaluation guidelines. The ranks for each criterion, and the resulting overall seafood recommendation, are summarized in a table. Criterion ranks and the overall seafood recommendation are color-coded to correspond to the categories of the Seafood Watch pocket guide:

Best Choices/Green: Consumers are strongly encouraged to purchase seafood in this category. The wild caught species is sustainable as defined by Seafood Watch.

Good Alternatives/Yellow: Consumers are encouraged to purchase seafood in this category, as they are better choices than seafood in the Avoid category. However there are some concerns with how this species is fished and thus it does not demonstrate all of the qualities of a sustainable fishery as defined by Seafood Watch.

Avoid/Red: Consumers are encouraged to avoid seafood in this category, at least for now. Species in this category do not demonstrate enough qualities to be defined as sustainable by Seafood Watch.

CRITERION 1: INHERENT VULNERABILITY TO FISHING PRESSURE

Guiding Principle: Sustainable wild-caught species have a low vulnerability to fishing pressure, and hence a low probability of being overfished, because of their inherent life history characteristics.

Primary Factors[42] to evaluate

Intrinsic rate of increase (‘r’)

- High (> 0.16) **<u>0.24-1.15</u>** [✓ 🟩]
- Medium (0.05 - 0.16) 🟨
- Low (< 0.05) 🟥
- Unavailable/Unknown ⬜

Age at 1st maturity **(Age at 50% maturity used)**

- Low (< 5 years) **Other stocks** [✓ 🟩]
- Medium (5 - 10 years) **Iceland, Northeast Arctic, Norwegian Coastal** [✓ 🟨]
- High (> 10 years) 🟥
- Unavailable/Unknown ⬜

Von Bertalanffy growth coefficient (‘k’)

- High (> 0.16) **Celtic Sea, North Sea, West of Scotland** [✓ 🟩]
- Medium (0.05– 0.15) **Icelandic, Kattegat, Norway Coastal, Northeast Arctic** [✓ 🟨]
- Low (< 0.05) 🟥
- Unavailable/Unknown ⬜

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[42] These primary factors and evaluation guidelines follow the recommendations of Musick et al. (2000). Marine, estuarine, and diadramous fish stocks at risk of extinction in North America (exclusive of Pacific salmonids). Fisheries 25:6-30.

Maximum age

- Low (< 11 years) 🟩
- Medium (11–30 years) **25 yrs** [✓ 🟨]
- High (> 30 years) 🟥
- Unavailable/Unknown ⬜

Reproductive potential (fecundity)

- High (> 100 inds./year) **1 million eggs/female/yr** [✓ 🟩]
- Moderate (10– 100 inds./year) 🟨
- Low (< 10 inds./year) 🟥
- Unavailable/Unknown ⬜

Secondary Factors to evaluate

Species range

- Broad (e.g. species exists in multiple ocean basins, has multiple intermixing stocks or is highly migratory) [✓ 🟩]
- Limited (e.g. species exists in one ocean basin) 🟨
- Narrow (e.g. endemism or numerous evolutionary significant units or restricted to one coastline) 🟥

Special Behaviors or Requirements: Existence of special behaviors that increase ease or population consequences of capture (e.g. migratory bottlenecks, spawning aggregations, site fidelity, unusual attraction to gear, sequential hermaphrodites, segregation by sex, etc., OR specific and limited habitat requirements within the species' range).

- No known behaviors or requirements OR behaviors that decrease vulnerability (e.g. widely dispersed during spawning) 🟩
- Some (i.e. 1– 2) behaviors or requirements **Spawning aggregations, population variability due to environmental conditions** [✓ 🟨]
- Many (i.e. > 2) behaviors or requirements 🟥

Quality of Habitat: Degradation from non-fishery impacts

- Habitat is robust [✓ 🟩]
- Habitat has been moderately altered by non-fishery impacts 🟨
- Habitat has been substantially compromised from non-fishery impacts and thus has reduced capacity to support this species (e.g. from dams, pollution, or 🟥

coastal development)

Evaluation Guidelines

1) Primary Factors
   a) If ‘r’ is known, use it as the basis for the rank of the Primary Factors.
   b) If ‘r’ is unknown, then the rank from the remaining Primary Factors (in order of importance, as listed) is the basis for the rank.

2) Secondary Factors
   a) If a majority (2 out of 3) of the Secondary Factors rank as Red, reclassify the species into the next lower rank (i.e. Green becomes Yellow, Yellow becomes Red). No other combination of Secondary Factors can modify the rank from the Primary Factors.
   b) No combination of primary and secondary factors can result in a Critical Conservation Concern for this criterion.

Conservation Concern: Inherent Vulnerability

- Low (Inherently Resilient) [✓ 🟩]
- Moderate (Inherently Neutral) 🟨
- High (Inherently Vulnerable) 🟥

CRITERION 2: STATUS OF WILD STOCKS

Guiding Principle: Sustainable wild-caught species have stock structure and abundance sufficient to maintain or enhance long-term fishery productivity.

Primary Factors to evaluate

Management classification status

- Underutilized OR close to virgin biomass 🟩
- Fully fished OR recovering from overfished OR unknown [✓ 🟨]
  Northeast Atlantic, Icelandic, Eastern Baltic, Faroe Plateau (fully fished/ recovering), Celtic, Rockall (unknown)
- Recruitment or growth overfished, overexploited, depleted or "threatened" [✓ 🟥]
  Western Baltic, Norwegian Coastal, North Sea, Greenland, Kattegat, Irish Sea, West of Scotland

Current population abundance relative to B_{MSY} **(B_{pa} used as a proxy when B_{MSY} not available, though Bpa is typically less conservative)**

- At or above B_{MSY} (> 100%) [✓ 🟩]
  Northeast Arctic, Eastern Baltic, Western Baltic
- Moderately Below B_{MSY} (50 – 100%) OR unknown [✓ 🟨]
  Icelandic, Faroe Plateau, (50-100% B_{MSY}), Celtic, Rockall (unknown)
- Substantially below B_{MSY} (< 50%) [✓ 🟥]
  Norwegian Coastal, North Sea , Greenland, Kattegat, Irish Sea, West of Scotland

Occurrence of overfishing (current level of fishing mortality relative to overfishing threshold)

- Overfishing not occurring ($F_{curr}/F_{msy} < 1.0$) [✓ 🟩]
  Northeast Arctic, Icelandic, Eastern Baltic
- Overfishing is likely/probable OR fishing effort is increasing with poor understanding of stock status OR Unknown **Icelandic (unknown), Greenland, Kattegat, Irish Sea, West of Scotland (overfishing likely), Rockall (unknown)** [✓ 🟨]
- Overfishing occurring ($F_{curr}/F_{msy} > 1.0$) [✓ 🟥]
  Western Baltic, Celtic, Norwegian Coastal, North Sea , Faroe Plateau

Overall degree of uncertainty in status of stock **(rankings also reflect uncertainties over discards and misreporting)**

- Low (i.e. current stock assessment and other fishery-independent data are robust OR reliable long-term fishery-dependent data available) **Northeast Arctic, Icelandic, Faroe Plateau** 🟩

- Medium (i.e. only limited, fishery-dependent data on stock status are available) **Eastern Baltic, Norwegian Coastal, North Sea, Western Baltic, Greenland, Kattegat, Irish Sea, West of Scotland** 🟨

- High (i.e. little or no current fishery-dependent or independent information on stock status OR models/estimates broadly disputed or otherwise out-of-date) **Celtic, Rockall** 🟥

Long-term trend (relative to species' generation time) in population abundance as measured by either fishery-independent (stock assessment) or fishery-dependent (standardized CPUE) measures

- Trend is up 🟩
- Trend is flat or variable (among areas, over time or among methods) OR Unknown **Northeast Arctic, Eastern Baltic, Faroe Plateau, Western Baltic, Greenland, Kattegat, Irish Sea (flat/variable), Celtic, Rockall (Unknown)** 🟨
- Trend is down **Icelandic, Norwegian Coastal, North Sea, West of Scotland** 🟥

Short-term trend in population abundance as measured by either fishery-independent (stock assessment) or fishery-dependent (standardized CPUE) measures

- Trend is up **Northeast Arctic, Icelandic, Eastern Baltic, North Sea, Faroe Plateau, Greenland** 🟩
- Trend is flat or variable (among areas, over time or among methods) OR Unknown **Western Baltic (flat/variable), Celtic, Rockall (Unknown)** 🟨
- Trend is down **Norwegian Coastal, Kattegat, Irish Sea, West of Scotland (decline/stable)** 🟥

Current age, size or sex distribution of the stock relative to natural condition

- Distribution(s) is(are) functionally normal 🟩
- Distribution(s) unknown **All others** 🟨
- Distribution(s) is(are) skewed **Northeast Arctic, Icelandic, North Sea, Celtic** 🟥

Evaluation Guidelines

A “Healthy” Stock:

1) Is underutilized (near virgin biomass)
2) Has a biomass at or above BMSY AND overfishing is not occurring AND distribution parameters are functionally normal AND stock uncertainty is not high

A “Moderate” Stock:

1) Has a biomass at 50%–100% of BMSY AND overfishing is not occurring
2) Is recovering from overfishing AND short-term trend in abundance is up AND overfishing not occurring AND stock uncertainty is low
3) Has an Unknown status because the majority of primary factors are unknown.

A “Poor” Stock:

1) Is fully fished AND trend in abundance is down AND distribution parameters are skewed
2) Is overfished, overexploited or depleted AND trends in abundance and CPUE are up.
3) Overfishing is occurring AND stock is not currently overfished.

A stock is considered a **Critical Conservation Concern** and the species is ranked “Avoid,” regardless of other criteria, if it is:

1) Overfished, overexploited or depleted AND trend in abundance is flat or down
2) Overfished AND overfishing is occurring
3) Listed as a “threatened species” or similar proxy by national or international bodies

Conservation Concern: Status of Stocks

- Low (Stock Healthy) 🟩
- Moderate (Stock Moderate or Unknown) 🟨
  Northeast Arctic, Icelandic, Eastern Baltic, Rockall
- High (Stock Poor) 🟥
  Western Baltic, Celtic Sea, Faroe Plateau
- Stock Critical ⬛
  Norwegian Coastal, North Sea, Greenland, Kattegat, Irish Sea, West of Scotland

CRITERION 3: NATURE AND EXTENT OF DISCARDED BYCATCH[43]

Guiding Principle: A sustainable wild-caught species is captured using techniques that minimize the catch of unwanted and/or unmarketable species.

Primary Factors to evaluate

Quantity of bycatch, including any species of "special concern" (i.e. those identified as "endangered", "threatened" or "protected" under state, federal or international law)

- Quantity of bycatch is low (< 10% of targeted landings on a per number basis) AND does not regularly include species of special concern [✓ 🟩]
  <u>Hook-and-line (e.g. handlines and jigs)</u>
- Quantity of bycatch is moderate (10%– 100% of targeted landings on a per number basis)
  AND does not regularly include species of special concern OR Unknown [✓ 🟨]
  <u>Bottom trawls (including Iceland due to the unknown catch of non-commercial species), bottom gillnets, bottom longlines, Danish seines</u>
- Quantity of bycatch is high (> 100% of targeted landings on a per number basis) OR bycatch regularly includes threatened, endangered or protected species 🟥

Population consequences of bycatch

- Low: Evidence indicates quantity of bycatch has little or no impact on population levels 🟩
- Moderate: Conflicting evidence of population consequences of bycatch OR Unknown [✓ 🟨]
- Severe: Evidence indicates quantity of bycatch is a contributing factor in driving one or more bycatch species toward extinction OR is a contributing factor in limiting the recovery of a species of "special concern" 🟥

Trend in bycatch interaction rates (adjusting for changes in abundance of bycatch species) as a result of management measures (including fishing seasons, protected areas and gear innovations):

- Trend in bycatch interaction rates is down 🟩
- Trend in bycatch interaction rates is flat OR Unknown **<u>Other gears</u>** [✓ 🟨]
- Trend in bycatch interaction rates is up 🟥
- Not applicable because quantity of bycatch is low **<u>Hook and line</u>** [✓ ▯]

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[43] Bycatch is defined as species that are caught but subsequently discarded because they are of undesirable size, sex or species composition. Unobserved fishing mortality associated with fishing gear (e.g. animals passing through nets, breaking free of hooks or lines, ghost fishing, illegal harvest and under or misreporting) is also considered bycatch. Bycatch does not include incidental catch (non-targeted catch) if it is utilized, is accounted for, and is managed in some way.

Secondary Factor to evaluate

Evidence that the ecosystem has been or likely will be substantially altered (relative to natural variability) in response to the continued discard of the bycatch species

- Studies show no evidence of ecosystem impacts 🟩
- Conflicting evidence of ecosystem impacts OR Unknown [✓ 🟨]
- Studies show evidence of substantial ecosystem impacts 🟥

Evaluation Guidelines

Bycatch is “**Minimal**” if:

1) Quantity of bycatch is <10% of targeted landings AND bycatch has little or no impact on population levels.

Bycatch is “**Moderate**” if:

1) Quantity of bycatch is 10%–100% of targeted landings
2) Bycatch regularly includes species of “special concern” AND bycatch has little or no impact on the bycatch population levels AND the trend in bycatch interaction rates is not up.

Bycatch is “Severe” if:

1) Quantity of bycatch is > 100% of targeted landings
2) Bycatch regularly includes species of “special concern” AND evidence indicates bycatch rate is a contributing factor toward extinction or limiting recovery AND trend in bycatch is down.

Bycatch is considered a **Critical Conservation Concern** and the species is ranked “Avoid,” regardless of other criteria, if:

1) Bycatch regularly includes species of special concern AND evidence indicates bycatch rate is a factor contributing to extinction or limiting recovery AND trend in bycatch interaction rates is not down.
2) Quantity of bycatch is high AND studies show evidence of substantial ecosystem impacts.

Conservation Concern: Nature and Extent of Discarded Bycatch

- Low (Bycatch Minimal) **Hook and line** [✓ 🟩]
- Moderate (Bycatch Moderate) **All other gears** [✓ 🟨]
- High (Bycatch Severe) 🟥
- Bycatch Critical ⬛

CRITERION 4: EFFECT OF FISHING PRACTICES ON HABITATS AND ECOSYSTEMS

Guiding Principle: Capture of a sustainable wild-caught species maintains natural functional relationships among species in the ecosystem, conserves the diversity and productivity of the surrounding ecosystem, and does not result in irreversible ecosystem state changes.

Primary Habitat Factors to evaluate

Known (or inferred from other studies) effect of fishing gear on physical and biogenic habitats

- Minimal damage (i.e. pelagic longline, midwater gillnet, midwater trawl, purse seine, hook and line, or spear/harpoon) **hook and line, jig** [✓ 🟩]
- Moderate damage (i.e. bottom gillnet, bottom longline or some pots/ traps) **bottom longline, bottom gillnet** [✓ 🟨]
- Great damage (i.e. bottom trawl or dredge) **bottom trawl, Danish seine** [✓ 🟥]

For specific fishery being evaluated, resilience of physical and biogenic habitats to disturbance by fishing method

- High (e.g. shallow water, sandy habitats) 🟩
- Moderate (e.g. shallow or deep water mud bottoms, or deep water sandy habitats) **Danish seine** [✓ 🟨]
- Low (e.g. shallow or deep water corals, shallow or deep water rocky bottoms) **Bottom trawl, bottom gillnet, bottom longline** [✓ 🟥]
- Not applicable because gear damage is minimal **hook and line, jig** [✓ ⬜]

If gear impacts are moderate or great, spatial scale of the impact

- Small scale (e.g. small, artisanal fishery or sensitive habitats are strongly protected) 🟩
- Moderate scale (e.g. modern fishery but of limited geographic scope) 🟨
- Large scale (e.g. industrialized fishery over large geographic areas) [✓ 🟥]
- Not applicable because gear damage is minimal ⬜

Primary Ecosystem Factors to evaluate

Evidence that the removal of the targeted species or the removal/deployment of baitfish has or will likely substantially disrupt the food web

- The fishery and its ecosystem have been thoroughly studied, and studies show no evidence of substantial ecosystem impacts 🟩
- Conflicting evidence of ecosystem impacts OR Unknown [✓ 🟨]

- Ecosystem impacts of targeted species removal demonstrated 🟥

Evidence that the fishing method has caused or is likely to cause substantial ecosystem state changes, including alternate stable states

- The fishery and its ecosystem have been thoroughly studied, and studies show no evidence of substantial ecosystem impacts 🟩
- Conflicting evidence of ecosystem impacts OR Unknown **All (unknown)** [✓ 🟨]
- Ecosystem impacts from fishing method demonstrated 🟥

Evaluation Guidelines

The effect of fishing practices is **"Benign"** if:

1) Damage from gear is minimal AND resilience to disturbance is high AND neither Ecosystem Factor is red.

The effect of fishing practices is **"Moderate"** if:

1) Gear effects are moderate AND resilience to disturbance is moderate or high AND neither Ecosystem Factor is red.
2) Gear results in great damage AND resilience to disturbance is high OR impacts are small scale AND neither Ecosystem Factor is red.
3) Damage from gear is minimal and one Ecosystem factor is red.

The effect of fishing practices **is "Severe"** if:

1) Gear results in great damage AND the resilience of physical and biogenic habitats to disturbance is moderate or low.
2) Both Ecosystem Factors are red.

Habitat effects are considered a **Critical Conservation Concern** and a species receives a recommendation of "**Avoid,"** regardless of other criteria if:

- Four or more of the Habitat and Ecosystem factors rank red.

Conservation Concern: Effect of Fishing Practices on Habitats and Ecosystems

- Low (Fishing Effects Benign) **Hook and line, jig** [✓ 🟩]
- Moderate (Fishing Effects Moderate) **Bottom longline, bottom gillnet** [✓ 🟨]
- High (Fishing Effects Severe) **Bottom trawl, Danish seine** [✓ 🟥]
- Critical Fishing Effects ⬛

CRITERION 5: EFFECTIVENESS OF THE MANAGEMENT REGIME

Guiding Principle: The management regime of a sustainable wild-caught species implements and enforces all local, national and international laws and utilizes a precautionary approach to ensure the long-term productivity of the resource and integrity of the ecosystem.

Primary Factors to evaluate

Stock Status: Management process utilizes an independent scientific stock assessment that seeks knowledge related to the status of the stock

- Stock assessment complete and robust **Northeast Arctic, Norwegian Coastal, Iceland, Eastern Baltic, Western Baltic, North Sea, Irish Sea, Kattegat, West of Scotland, Faroe Plateau** 🟩
- Stock assessment is planned or underway but is incomplete OR stock assessment complete but out-of-date or otherwise uncertain **Celtic Sea, Greenland** 🟨
- No stock assessment available now and none is planned in the near future **Rockall** 🟥

Scientific Monitoring: Management process involves regular collection and analysis of data with respect to the short and long-term abundance of the stock

- Regular collection and assessment of both fishery-dependent and independent data **Northeast Arctic, Norwegian Coastal, Iceland**, **Baltic (east and west), North Sea Faroe Plateau, Greenland** 🟩
- Regular collection of fishery-dependent data only **Irish Sea, Kattegat, West of Scotland, Celtic Sea** 🟨
- No regular collection or analysis of data **Rockall** 🟥

Scientific Advice: Management has a well-known track record of consistently setting or exceeding catch quotas beyond those recommended by its scientific advisors and other external scientists:

- No **Iceland, Baltic (East)** 🟩
- Yes **Northeast Arctic, Baltic (west), Norwegian Coastal, North Sea, Celtic Sea, Irish Sea, Kattegat, West of Scotland, Faroe Plateau, Greenland** 🟥
- Not enough information available to evaluate OR not applicable because little or no scientific information is collected **Rockall** ⬜

Bycatch: Management implements an effective bycatch reduction plan

- Bycatch plan in place and reaching its conservation goals (deemed effective) **Northeast Arctic, Norwegian Coastal, Faroe Plateau** 🟩

- Bycatch plan in place but effectiveness is not yet demonstrated or is under debate **Iceland (lacking data on non-commercial species, and measures have proven ineffective or otherwise not evaluated by ICES), Baltic (east and west), North Sea, Faroe Plateau, Celtic Sea, Irish Sea, West of Scotland, Rockall** 🟨
- No bycatch plan implemented or bycatch plan implemented but not meeting its conservation goals (deemed ineffective) **Greenland** 🟥
- Not applicable because bycatch is "low" **Any stock/country: hook and line, jig** ⬜

Fishing practices: Management addresses the effect of the fishing method(s) on habitats and ecosystems

- Mitigative measures in place and deemed effective **Northeast Arctic** 🟩
- Mitigative measures in place but effectiveness is not yet demonstrated or is under debate **All others** 🟨
- No mitigative measures in place or measures in place but deemed ineffective **Greenland** 🟥
- Not applicable because fishing method is moderate or benign **All bottom gillnets, bottom longlines, hook and lines, jigs** ⬜

Enforcement: Management and appropriate government bodies enforce fishery regulations

- Regulations regularly enforced by independent bodies, including logbook reports, observer coverage, dockside monitoring and similar measures **Northeast Arctic, Iceland, Faroe Plateau** 🟩
- Regulations enforced by fishing industry or by voluntary/honor system **All others** 🟨
- Regulations not regularly and consistently enforced 🟥

Management Track Record: Conservation measures enacted by management have resulted in the long-term maintenance of stock abundance and ecosystem integrity

- Management has maintained stock productivity over time OR has fully recovered the stock from an overfished condition **Northeast Arctic, Eastern Baltic** 🟩
- Stock productivity has varied and management has responded quickly OR stock has not varied but management has not been in place long enough to evaluate its effectiveness OR Unknown **Iceland, Greenland** 🟨
- Measures have not maintained stock productivity OR were implemented only after significant declines and stock has not yet fully recovered **All others** 🟥

Evaluation Guidelines

Management is deemed to be "**Highly Effective**" if the majority of management factors are green AND the remaining factors are not red.

Management is deemed to be "**Moderately Effective**" if:
1) Management factors "average" to yellow
2) Management factors include one or two red factors

Management is deemed to be "**Ineffective**" if three individual management factors are red, including especially those for Stock Status and Bycatch.

Management is considered a **Critical Conservation Concern** and a species receives a recommendation of "**Avoid**", regardless of other criteria if:
1) There is no management in place
2) The majority of the management factors rank red.

Conservation Concern: Effectiveness of Management

- Low (Management Highly Effective) 🟩
  Iceland and Eastern Baltic (all gears)
- Moderate (Management Moderately Effective) 🟨
  Northeast Arctic, Norwegian Coastal, Greenland (other gears), North Sea, Irish Sea, Kattegat, West of Scotland, Celtic Sea, Faroe Plateau (all gears)
- High (Management Ineffective) 🟥
  Greenland (bottom trawls), Rockall (all gears)
- Critical (Management Critically Ineffective) ⬛

Appendix C: Evaluation of European Plaice caught in Icelandic Cod Fishery

Capture Fisheries Evaluation

Species: *European Plaice* **Region**: *Iceland*

Analyst: *Atcheson/Roberts* **Date**: *April 1 2011*

Seafood Watch™ defines sustainable seafood as originating from sources, whether fished[44] or farmed, that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

The following **guiding principles** illustrate the qualities that capture fisheries must possess to be considered sustainable by the Seafood Watch program. Species from sustainable capture fisheries:

- have a low vulnerability to fishing pressure, and hence a low probability of being overfished, because of their inherent life history characteristics;
- have stock structure and abundance sufficient to maintain or enhance long-term fishery productivity;
- are captured using techniques that minimize the catch of unwanted and/or unmarketable species;
- are captured in ways that maintain natural functional relationships among species in the ecosystem, conserves the diversity and productivity of the surrounding ecosystem, and do not result in irreversible ecosystem state changes; and
- have a management regime that implements and enforces all local, national and international laws and utilizes a precautionary approach to ensure the long-term productivity of the resource and integrity of the ecosystem.

Seafood Watch has developed a set of five sustainability **criteria,** corresponding to these guiding principles, to evaluate capture fisheries for the purpose of developing a seafood recommendation for consumers and businesses. These criteria are:

1. Inherent vulnerability to fishing pressure
2. Status of wild stocks
3. Nature and extent of discarded bycatch
4. Effect of fishing practices on habitats and ecosystems
5. Effectiveness of the management regime

Each criterion includes:

- Primary factors to evaluate and rank
- Secondary factors to evaluate and rank
- Evaluation guidelines[45] to synthesize these factors

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[44] "Fish" is used throughout this document to refer to finfish, shellfish and other wild-caught invertebrates.

[45] Evaluation Guidelines throughout this document reflect common combinations of primary and secondary factors that result in a given level of conservation concern. Not all possible combinations are shown – other combinations should be matched as closely as possible to the existing guidelines.

- A resulting **rank** for that criterion

Once a rank has been assigned to each criterion, an **overall seafood recommendation** for the species in question is developed based on additional evaluation guidelines. The ranks for each criterion, and the resulting overall seafood recommendation, are summarized in a table. Criterion ranks and the overall seafood recommendation are color-coded to correspond to the categories of the Seafood Watch pocket guide:

Best Choices/Green: Consumers are strongly encouraged to purchase seafood in this category. The wild-caught species is sustainable as defined by Seafood Watch.

Good Alternatives/Yellow: Consumers are encouraged to purchase seafood in this category, as they are better choices than seafood in the Avoid category. However there are some concerns with how this species is fished and thus it does not demonstrate all of the qualities of a sustainable fishery as defined by Seafood Watch.

Avoid/Red: Consumers are encouraged to avoid seafood in this category, at least for now. Species in this category do not demonstrate enough qualities to be defined as sustainable by Seafood Watch.

Table of Contents

I. Executive Summary

European plaice (*Pleuronectes platessa)* inhabit the Northeastern Atlantic from the western Mediterranean to the North Sea and Iceland, and are occasionally found off of Greenland. This appendix only covers plaice caught in Icelandic waters, where it is primarily caught in mixed-species fisheries for cod, haddock, redfish, saithe and other species. Catches are mostly off the southwest and west coasts of Iceland, and range from 5,000 to 10,000 tons per year.

European plaice spawns at an early age and produces a lot of eggs. However, the species has only a moderate growth rate, and can live for over 30 years. As age at first maturity is low and the secondary factors are not red, the species is considered inherently resilient.

Iceland's Marine Research Institute conducts an annual assessment on the Icelandic plaice stock, but management has not classified the status of the stock, and no reference points have been defined. The groundfish survey index for plaice decreased in the long-term (since 1985) but increased in the short term (last decade) and is now around 35% of that at the beginning (and highest point) in the time series. The stock is deemed a moderate conservation concern because the majority of factors are unknown and the short-term trend in biomass is increasing.

The primary methods of capture of plaice in the Icelandic cod fishery are Danish seine (57% in 2008) and bottom trawl (39%) with the remainder taken by bottom gillnet and bottom longline. The major bycatch problems in cold water seafloor fisheries using these gears are finfish (including juveniles) and invertebrates in the trawl and Danish seine fisheries, and seabirds and mammals in gillnet and longline fisheries. Iceland's discard prohibition policy likely reduces discards of species of commercial interest (reports suggest to levels below 10% of the catch), but little information is available on non-commercial species. There is also little data on the quantity and trend of seabird and marine mammal bycatch in the gillnet and longline fisheries. Bycatch is thus considered a moderate conservation concern for all gears.

Relative to other gears, bottom trawls can cause great damage to seafloor habitats, especially in areas where there is habitat-creating epifauna such as cold-water corals and sponge aggregations. Like bottom trawls, Danish seines are mobile gears that can cause habitat disturbance as the groundgear is dragged along the seafloor. These gears are generally operated on sandy seafloors and with lighter groundgear than bottom trawls, however, and so likely cause less damage. Set gears such as bottom longlines, bottom gillnets and pound nets may also affect the bottom habitat, although to a lesser degree. The ecosystem effects of using these gears in Icelandic waters is unknown. The habitat and ecosystem effects of using mobile gears such as bottom trawls and Danish seines is thus deemed a high conservation concern, while that for bottom gillnets, bottom longlines and pound nets is a moderate conservation concern.

Icelandic management of the mixed-stock fisheries for demersal species including plaice is generally effective or moderately effective for most factors. However, managers have consistently set TACs above those recommended by their own scientists. Furthermore, measures to reduce bycatch (discards) have not been evaluated by ICES, and very little vulnerable habitat is protected. For these reasons, management is considered only moderately effective.

About the Overall Seafood Recommendation:

- A seafood product is ranked “**Avoid**” if two or more criteria are of High Conservation Concern (red) OR if one or more criteria are of Critical Conservation Concern (black) in the table above.
- A seafood product is ranked “**Good Alternative**” if the five criteria “average” to yellow (Moderate Conservation Concern) OR if the “Status of Stocks” and “Management Effectiveness” criteria are both of Moderate Conservation Concern.
- A seafood product is ranked “**Best Choice**” if three or more criteria are of Low Conservation Concern (green) and the remaining criteria are not of High or Critical Conservation Concern.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability		√		
Status of Stocks		√		
Nature of Bycatch*		√		
Habitat & Ecosystem Effects*		√ (Bottom gillnet, bottom longline)	√ (Bottom trawl, Danish seine)	
Management Effectiveness		√		

* Bycatch and Habitat rankings are taken from the Northeast Atlantic cod report. European plaice is not caught by hook-and-line in Iceland (Figure 4), so that gear has been excluded from the analysis and ensuing recommendations.

Overall Seafood Recommendation:

Best Choice 🟩 **Good Alternative** 🟨 Avoid 🟥

II. Introduction

European plaice (*Pleuronectes platessa)* is a species of flatfish inhabiting the Northeastern Atlantic from the western Mediterranean to the North Sea and Iceland, and are occasionally found off of Greenland (Fig. 1) (ICES 2010a). This appendix only covers plaice caught in Icelandic waters, where it is primarily caught in mixed-species fisheries for cod, haddock, redfish, saithe and other species. Catches are mostly off the southwest and west coasts of Iceland, and range from 5,000 to 10,000 tons per year and the primary method of capture is Danish seine with a considerable share also taken by trawl (Valtýsson 2010). The Marine Research Institute of Iceland is the major research body for fisheries research and recommends catch limits. The Ministry of Fisheries and Agriculture is the managing body for Icelandic fisheries and ultimately sets the total allowable catch based on research by the Marine Research Institute.

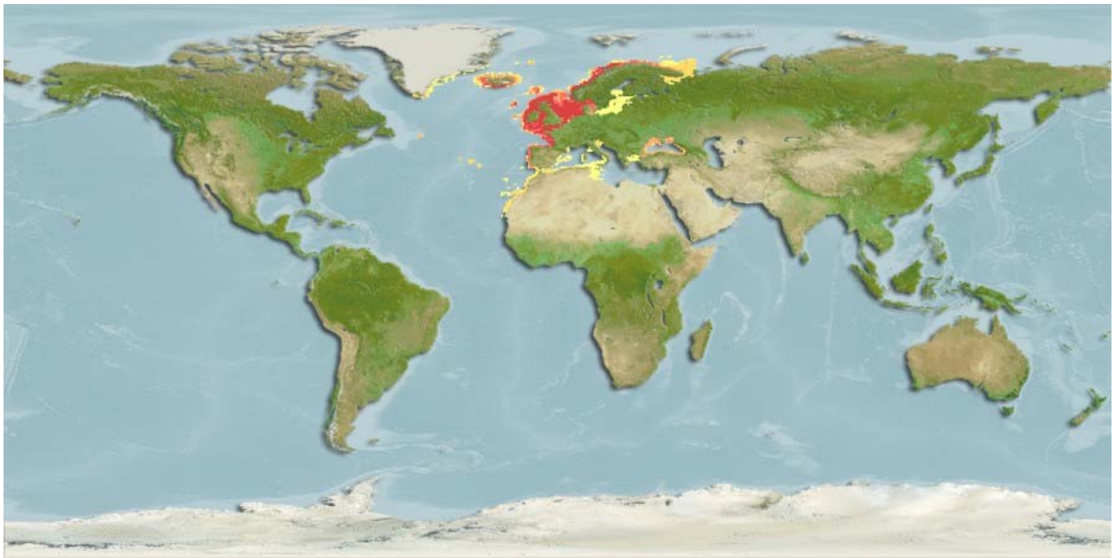

Figure 1. Distribution of European plaice (*Pleuronectes platessa)* Froese and Pauly 2010.

European plaice can reach a maximum size of 100 cm and age of 50 years (ICES 2010) but the maximum recorded size in Icelandic waters is 85 cm (Valtýsson 2010). In Iceland, plaice reach 50% maturity by age 5 (Valtýsson 2010). Spawning occurs in March and April in offshore waters with the highest production south and west of Iceland (Hjorleifsson and Palsson 2001). A 35 cm female can produce between 60,000 and 100,000 eggs (Valtýsson 2010). The larval stage is relatively long at 3–4 months and fish settle on the bottom after the left eye has shifted to the right side of the body, approximately 9–14mm (Hjorleifsson and Palsson 2001). Eggs and larvae are transported to coastal nurseries, and remain in coastal areas through one year of age, generally about 10 cm. Juveniles remain in coastal and estuarine waters but as plaice age they gradually move into deeper waters reaching 20–25 cm at age 2 (ICES 2010). Plaice show a preference for sandy bottoms whether coastal or offshore. Adult plaice are known to make use of tidal transport to the spawning grounds and feeding grounds. They stay in mid-water to move with the tide and rest on the bottom during the opposite tide showing no movement. They exhibit strong site fidelity, approximately 94% for the spawning grounds after one year and approximately 90% to the feeding area after 1 year (Solmundsson, Palsson et al. 2005). Females grow faster and ultimately larger than males. The 1960s and 70s were marked by an increased juvenile growth rate that has declined since the 1980s. Polychaetes, bivalves and small crustaceans make up the bulk of plaice diet. Plaice eggs are consumed by herring and sprat (ICES 2010).

European plaice in Iceland has been the subject of commercial fishing since the early 19th century by English and Scottish trawl fisherman who had depleted their resources closer to home (Hjorleifsson and Palsson 2001). In the last decade however, European plaice in Icelandic waters have been caught exclusively by Icelandic boats (Valtýsson 2010). Annual catch averages about 7,000 tons (Fig 2.)

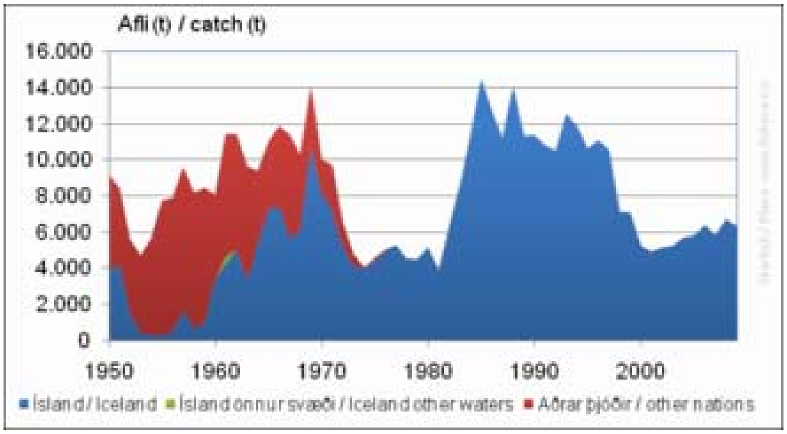

Figure 2: Plaice catch in Icelandic waters (t) Valtýsson 2010.

Iceland makes up a small portion (approximately 1/10) of the total catch of European plaice reported to the Food and Agriculture Organization (FAO) (Fig.3). According to the FAO, the Netherlands and Denmark obtain the largest catches of plaice.

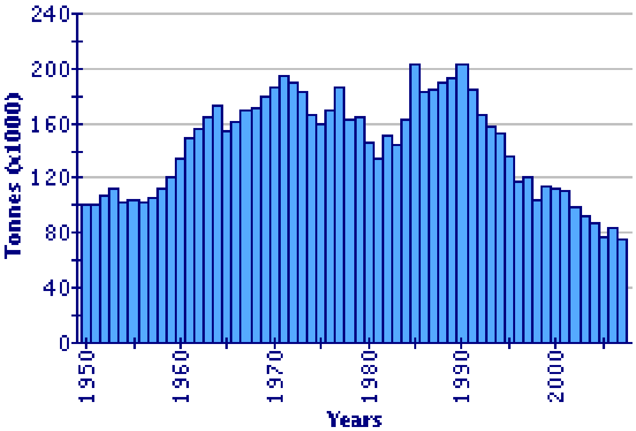

Figure 3: Total catch for European plaice reported to the FAO FAO 2010.

The primary method of capture is by Danish seine and secondarily by bottom trawl, while landings from other methods is negligible (Figure 4) (Statistics-Iceland 2010;Valtýsson 2010). The Danish seine consists of a bottom trawl-like net with light groundgear that essentially herds the fish into the net as it is pulled along the seafloor. It is not capable of covering the rougher bottoms that trawls do and requires calmer weather and currents, which is suitable for European plaice which inhabit sandy and muddy substrate (Sævaldsson and Valtýsson 2010). Danish seines are less bulky, less expensive, and more fuel efficient than traditional trawlers (Sævaldsson and Valtýsson 2010). Approximately two thirds of the European plaice catch in Iceland is from Danish seines. Most of the remainder of the fish are caught with bottom trawl. As their name implies, bottom trawls are funnel shaped nets dragged along the ocean floor. Iceland has the largest minimum mesh size (135 mm) for bottom trawls in the North Atlantic to enhance selectivity of the gear (Sævaldsson and Valtýsson 2010).

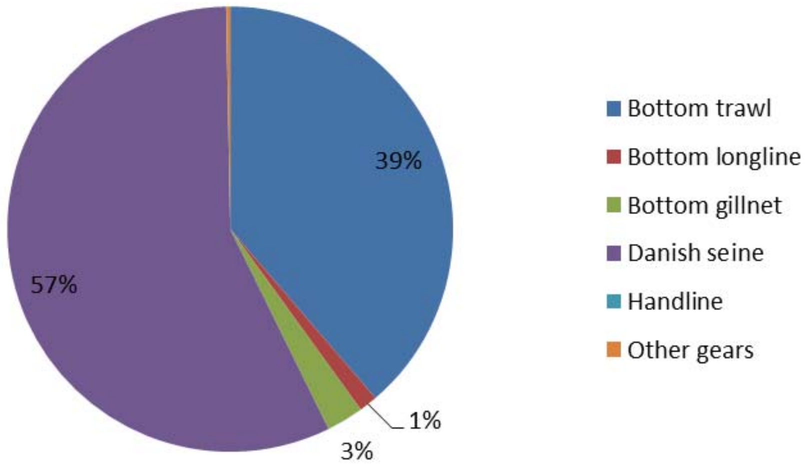

Figure 4: Gear used to catch plaice in Iceland, 2008 (Statistics-Iceland 2010).

Scope of the analysis and the ensuing recommendation:

This evaluation only covers plaice caught in Icelandic cod fisheries using Danish seine, bottom trawl, bottom gillnet and bottom longline.

Availability of Science

European plaice is a well-studied species, particularly in the North Sea. Primary literature, government documents and gray literature (i.e., internet pages) seem to be the prevalent forms of available information. Unfortunately, less information exists for the population surrounding Iceland. The International Council for the Exploration of the Sea (ICES) is an intergovernmental organization concerned with marine and fishery science in the North Atlantic. ICES publishes fishery advice based on the MSY approach for managing fisheries. The Icelandic fishery is one of the few that has not been reviewed.

Market Availability

Common and market names: Plaice, Flatfish, Fluke, Hen fish, Plaice-fluke (Froese and Pauly 2010).

Seasonal availability: Plaice are caught in Icelandic waters all year round, with highs in spring and fall.[46]

Product forms: Fresh and frozen, whole fish and fillets (Statistics-Iceland 2010; Valtýsson 2010).

Import and export sources and statistics: The vast majority of Icelandic plaice is exported to the UK (93% in 2009, 92% total from 2000 to 2009) (Statistics-Iceland 2010).[47] Some three-quarters of those exports are of fresh/chilled/on ice whole fish. No other country accounted for more than 2% of exports in 2009. The US imported just over 22 t in 2009, all frozen fillets (Statistics-Iceland 2010).[48] Other importing countries in 2009 are China, Germany, Netherlands, Belgium, Japan, Spain, Sweden, France, Denmark, Ireland and Croatia (Statistics-Iceland 2010).

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[46] http://www.fisheries.is/main-species/flatfishes/plaice/

[47] http://www.fisheries.is/main-species/flatfishes/plaice/: "more than 95% of the Icelandic catch is exported to the UK, the fillet being commonly eaten fried or battered and deep-fried in fish and chips."

[48] Note that National Marine Fisheries Statistics data indicates that the US imported only 7,908 kg of plaice from Iceland in 2009, all fresh fillets. It is not clear why the export data from Iceland and the import data from the US do not add up. Imports were in winter months (September through February, but mainly in September and October). Data at http://www.st.nmfs.noaa.gov/st1//trade/index.html Accessed 02/09/11.

III. Analysis of Seafood Watch® Sustainability Criteria for Wild-caught Species

CRITERION 1: INHERENT VULNERABILITY TO FISHING PRESSURE

Guiding Principle: Sustainable wild-caught species have a low vulnerability to fishing pressure, and hence a low probability of being overfished, because of their inherent life history characteristics.

Primary Factors[49] to evaluate

Intrinsic rate of increase (‘r’)

- High (> 0.16) 🟩
- Medium (0.05 - 0.16) 🟨
- Low (< 0.05) 🟥
- Unavailable/Unknown [✓ ☐]

Key relevant information

Jennings, Reynolds et al. (1998) note that ‘r’ cannot be calculated for *P. platessa* because the necessary data on egg production and cohort generation time are available only for exploited stocks (which biases ‘r’ through reduced lifespans).

Reference(s)

Jennings, S., J. D. Reynolds, et al. (1998). "Life history correlates of responses to fisheries exploitation." Proceedings of the Royal Society of London. Series B: Biological Sciences 265(1393): 333-339.

Age at 1st maturity

- Low (< 5 years) 🟩
- Medium (5–10 years) [✓ 🟨]
- High (> 10 years) 🟥
- Unavailable/Unknown ☐

Key relevant information

Plaice in the North Sea, Celtic Sea, Kattegat and Irish Sea reach 50% maturity at about age 3 (Denney, Jennings et al. 2002). Icelandic plaice grow more slowly, reaching 50% maturity around age 5 (Valtýsson 2010).

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[49] These primary factors and evaluation guidelines follow the recommendations of Musick et al. (2000). Marine, estuarine, and diadramous fish stocks at risk of extinction in North America (exclusive of Pacific salmonids). Fisheries 25:6-30.

Reference(s)

Valtýsson, H. ó. (2010). "Icelandic Fisheries - Plaice." Retrieved September, 2010, from http://www.fisheries.is/main-species/flatfishes/plaice/.

Von Bertalanffy growth coefficient (‘k’)

- High (> 0.16) 🟩
- [✓ Medium (0.05–0.15) 🟨]
- Low (< 0.05) 🟥
- Unavailable/Unknown ☐

Key relevant information

The growth coefficient (‘k’) for plaice varies with stock, from 0.06 in the Irish Sea to 0.15 in the North Sea (Denney, Jennings et al. 2002). Icelandic fish tend to grow more slowly than their more southern counterparts (R Cook, pers. comm., Myers, Mertz et al. 1997).

Reference(s)

Myers, R., G. Mertz, et al. (1997). "Maximum population growth rates and recovery times for Atlantic cod, Gadus morhua." Fishery Bulletin 95: 462-772.

Denney, N. H., S. Jennings, et al. (2002). "Life–history correlates of maximum population growth rates in marine fishes." Proceedings of the Royal Society of London. Series B: Biological Sciences 269(1506): 2229-2237.

Maximum age

- Low (< 11 years) 🟩
- Medium (11–30 years) 🟨
- [✓ High (> 30 years) 🟥]
- Unavailable/Unknown ☐

Key relevant information

The maximum age of *P. platessa* is 50 years (Froese and Pauly 2010).

Reference(s)

Froese, R. and D. Pauly (2010). "FishBase." World Wide Web Electronic Publication. from www.fishbase.org.

Reproductive potential (fecundity)

- High (> 100 inds./year) [✓ 🟩]
- Moderate (10–100 inds./year) 🟨
- Low (< 10 inds./year) 🟥
- Unavailable/Unknown ⬜

Key relevant information

An adult female can produce 40,000–100,000 eggs (Hjörleifsson and Pálsson 2001;Jennings, Reynolds et al. 1998). Instantaneous mortality of age-0 fish was estimated at 0.03/d (Hjörleifsson and Pálsson 2001).

Reference(s)

Hjörleifsson, E. and J. Pálsson (2001). "Settlement, growth and mortality of 0-group plaice (Pleuronectes platessa) in Icelandic waters." Journal of Sea Research 45(3-4): 321-324.

Jennings, S., J. D. Reynolds, et al. (1998). "Life history correlates of responses to fisheries exploitation." Proceedings of the Royal Society of London. Series B: Biological Sciences 265(1393): 333-339.

Secondary Factors to evaluate

Species range

- Broad (e.g. species exists in multiple ocean basins, has multiple intermixing stocks or is highly migratory) 🟩
- Limited (e.g. species exists in one ocean basin) [✓ 🟨]
- Narrow (e.g. endemism or numerous evolutionary significant units or restricted to one coastline) 🟥

Key relevant information

European Plaice are limited in range to the Northeast Atlantic along the coast of Europe, western Mediteranean, North Sea and Iceland. Occassionally found off Greenland (Froese and Pauly 2010; ICES 2010a).

Reference(s)

Froese, R. and D. Pauly (2010). "FishBase." World Wide Web Electronic Publication. from www.fishbase.org

ICES (2010a). "FishMap - Plaice." from http://www.ices.dk/marineworld/fishmap/ices/default.asp?id=Plaice

Special Behaviors or Requirements: Existence of special behaviors that increase ease or population consequences of capture (e.g. migratory bottlenecks, spawning aggregations, site fidelity, unusual attraction to gear, sequential hermaphrodites, segregation by sex, etc., OR specific and limited habitat requirements within the species' range).

- ➢ No known behaviors or requirements OR behaviors that decrease vulnerability (e.g. widely dispersed during spawning) 🟩
- ➢ Some (i.e. 1–2) behaviors or requirements [✓ 🟨]
- ➢ Many (i.e. > 2) behaviors or requirements 🟥

Key relevant information

Fidelity to spawning sites: Solmundsson, Palsson et al. (2005) estimate a minimum level of fidelity of mature Icelandic plaice of 90% after one year and 100% after two to three years.

Segregation by sex: Male Icelandic plaice (west of Iceland) are more active during the time of spawning and have a higher catchability than females during that time (Solmundsson, Karlsson et al. 2003)

Reference(s)

Solmundsson, J., J. Palsson, and H. Karlsson. 2005. Fidelity of mature Icelandic plaice (Pleuronectes platessa) to spawning and feeding grounds. Ices Journal of Marine Science 62:189-200.

Solmundsson, J., J. Palsson, et al. (2005). "Fidelity of mature Icelandic plaice (Pleuronectes platessa) to spawning and feeding grounds." ICES Journal of Marine Science 62(2).

Quality of Habitat: Degradation from non-fishery impacts

- ➢ Habitat is robust [✓ 🟩]
- ➢ Habitat has been moderately altered by non-fishery impacts 🟨
- ➢ Habitat has been substantially compromised from non-fishery impacts and thus has reduced capacity to support this species (e.g. from dams, pollution, or coastal development) 🟥

Key relevant information

Plaice is found on marine and estuarine sand and mud habitats from a few meters to about 100m (Froese and Pauly 2010). Sand and mud habitat is typically very common, so it is not likely compromised enough to reduce the capacity of the habitat to support the plaice stock. More generally, marine pollution appears to be negligible in the fishing grounds of the Iceland Shelf Large Marine Ecosystem (UNEP 2009).

Reference(s)

Froese, R. and D. Pauly (2010). "FishBase." World Wide Web Electronic Publication. from www.fishbase.org

UNEP (2009). The UNEP Large Marine Ecosystem Report: A Perspective on Changing Conditions in LMEs of the World's Regional Seas. p872. Iceland Shelf LME p563

Synthesis
The intrinsic rate of increase is unknown for European plaice. The species spawns at an early age and is highly fecund. However, the species has only a moderate growth rate, and can live for over 30 years. As intrinsic rate of increase is unknown, age at first maturity is low and the secondary factors are not red, Seafood Watch® considers the species to be inherently resilient to fishing pressure.

Evaluation Guidelines

1) Primary Factors
   a) If ‘r’ is known, use it as the basis for the rank of the Primary Factors.
   b) If ‘r’ is unknown, then the rank from the remaining Primary Factors (in order of importance, as listed) is the basis for the rank.

2) Secondary Factors
   a) If a majority (2 out of 3) of the Secondary Factors rank as Red, reclassify the species into the next lower rank (i.e. Green becomes Yellow, Yellow becomes Red). No other combination of Secondary Factors can modify the rank from the Primary Factors.
   b) No combination of primary and secondary factors can result in a Critical Conservation Concern for this criterion.

Conservation Concern: Inherent Vulnerability

- Low (Inherently Resilient) 🟩
- Moderate (Moderately Vulnerable) [✓ 🟨]
- High (Highly Vulnerable) 🟥

CRITERION 2: STATUS OF WILD STOCKS

Guiding Principle: Sustainable wild-caught species have stock structure and abundance sufficient to maintain or enhance long-term fishery productivity.

Primary Factors to evaluate

Management classification status

- Underutilized OR close to virgin biomass 🟩
- Fully fished OR recovering from overfished OR unknown [✓ 🟨]
- Recruitment or growth overfished, overexploited, depleted or "threatened" 🟥

Key relevant information

Stock assessments for most European plaice stocks are conducted by ICES (ICES 2010). The Icelandic assessment however is conducted by Iceland's Institute of Marine Research. The assessment is data-limited (see discussion on Criterion 5: Management effectiveness) and management has not classified the status of the stock (MRI 2009a).

Reference(s)

ICES (2010). Report of the ICES Advisory Committee, 2010. Copenhagen, Denmark, ICES. Books 1-11.

MRI (2009). "English summary of the State of Marine Stocks in Icelandic waters 2008/2009 – Prospects for the Quota Year 2009/2010." Retrieved October, 2010, from http://www.hafro.is/Astand/2009/35-englsummary.PDF.

Current population abundance relative to B_{MSY}

- At or above B_{MSY} (> 100%) 🟩
- Moderately Below B_{MSY} (50%–100%) OR unknown [✓ 🟨]
- Substantially below B_{MSY} (< 50%) 🟥

Key relevant information

Biological reference points have not been defined for this stock (MRI 2009a).

Reference(s)

MRI (2009). "English summary of the State of Marine Stocks in Icelandic waters 2008/2009 – Prospects for the Quota Year 2009/2010." Retrieved October, 2010, from http://www.hafro.is/Astand/2009/35-englsummary.PDF.

Occurrence of overfishing (current level of fishing mortality relative to overfishing threshold)

- Overfishing not occurring ($F_{curr}/F_{msy} < 1.0$) 🟩
- Overfishing is likely/probable OR fishing effort is increasing with poor understanding of stock status OR Unknown [✓ 🟨]
- Overfishing occurring ($F_{curr}/F_{msy} > 1.0$) 🟥

Key relevant information

Fishing mortality reference points have not been defined for this stock (MRI 2009a). Landings decreased from some 10–12,000 t in the early/mid-1990s to around 6,000 t in the 2000s (Statistics-Iceland 2010).

Reference(s)

MRI (2009). "English summary of the State of Marine Stocks in Icelandic waters 2008/2009 – Prospects for the Quota Year 2009/2010." Retrieved October, 2010, from http://www.hafro.is/Astand/2009/35-englsummary.PDF.

Statistics-Iceland (2010). Catch and value of catch databases. Accessed on 10 January 2010 at http://www.statice.is/Statistics/Fisheries-and-agriculture/Catch-and-value-of-catch.

Overall degree of uncertainty in status of stock

- Low (i.e. current stock assessment and other fishery-independent data are robust OR reliable long-term fishery-dependent data available) 🟩
- Medium (i.e. only limited, fishery-dependent data on stock status are available) [✓ 🟨]
- High (i.e. little or no current fishery-dependent or independent information on stock status OR models/estimates broadly disputed or otherwise out-of-date) 🟥

Key relevant information

Both CPUE and groundfish survey data are used for assessing the stock. However, there is no further modeling or analysis of the data (MRI 2009a; MRI 2009b).

Reference(s)

MRI (2009a). "English summary of the State of Marine Stocks in Icelandic waters 2008/2009 – Prospects for the Quota Year 2009/2010." Retrieved October, 2010, from http://www.hafro.is/Astand/2009/35-englsummary.PDF.

MRI (2009b). Hafrannsóknastofnunin Fjölrit nr. 153 (2009/2010 stock assessments in Icelandic). Accessed from http://www.hafro.is/undir.php?ID=26&REF=4.

Long-term trend (relative to species' generation time) in population abundance as measured by either fishery-independent (stock assessment) or fishery-dependent (standardized CPUE) measures

- Trend is up 🟩
- Trend is flat or variable (among areas, over time or among methods)

  OR Unknown 🟨
- Trend is down [✓ 🟥]

Short-term trend in population abundance as measured by either fishery-independent (stock assessment) or fishery-dependent (standardized CPUE) measures

- Trend is up [✓ 🟩]
- Trend is flat or variable (among areas, over time or among methods)

  OR Unknown 🟨
- Trend is down 🟥

Key relevant information

Long term abundance indices (fishable stock and juvenile biomass) from groundfish surveys have decreased from a high at the beginning of the series (1985), but have increased since 2000 (Figure 5) (MRI 2009b). The 2009/2010 index is at some 35% of that in 1985 (MRI 2009b). CPUE indices from the Danish seine and trawl fleet decreased from 1991 through 2000, but have since climbed to roughly the same level as at the beginning of the time series (1991) (Figure 6) (MRI 2009b). The survey indices suggest abundance had declined considerably by 1991, however (Figure 5).

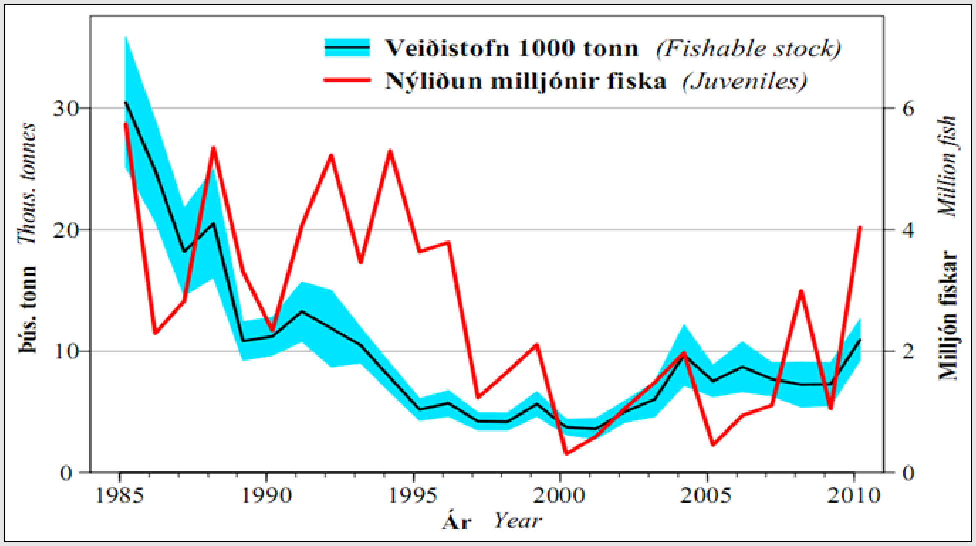

Figure 5: Icelandic plaice fishable stock and juvenile biomass from the groundfish survey, 1985–2010 (MRI 2009b)

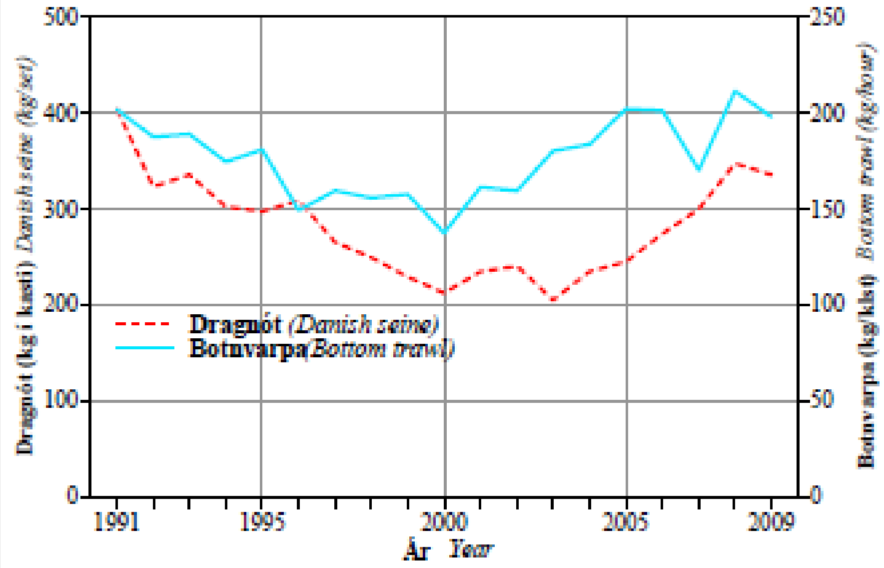

Figure 6: Plaice CPUE from seiners (kg/set) and from bottom trawl vessels (kg/hour), 1991–2009

Reference(s)

MRI (2009b). Hafrannsóknastofnunin Fjölrit nr. 153 (2009/2010 stock assessments in Icelandic). Accessed from http://www.hafro.is/undir.php?ID=26&REF=4.

Current age, size or sex distribution of the stock relative to natural condition

- Distribution(s) is(are) functionally normal 🟩
- Distribution(s) unknown [✓ 🟨]
- Distribution(s) is(are) skewed 🟥

Key relevant information

Icelandic plaice are skewed towards males on spawning grounds, but this phenomenon is common for demersal fish species including plaice (Solmundsson, Karlsson et al. 2003). We were unable to obtain (in English) specific evidence of fisheries-related skewed age, size or sex distribution in Icelandic plaice. However, drastic declines in biomass on the order of 90% or more (roughly the decline in fishable biomass of Icelandic plaice from 1985 to 2001) are known to be sufficient to produce phenotypic, and potentially genetic, changes to life history traits (Hutchings 2005). There is evidence that age and size at maturation has decreased significantly in European plaice in the North Sea, most likely a fisheries-induced evolutionary response (Grift, Rijnsdorp et al. 2003). The biomass of this stock has not been as low (relative to the stock's peak) as the Icelandic stock: For a decade from the mid 1990s, the stock was at its lowest point, roughly 50% of its peak (1987) (ICES 2010). There is also evidence that the distribution of other demersal stocks in Icelandic waters is skewed. For example, the age composition of the spawning stock (Marteinsdottir and Thorarinsson 1998; ICES 2004), age- and size-at-maturity (Pardoe, Vainikka et al. 2009), and possibly sex ratios (Jónsdóttir, Daníelsdóttir et al. 2001) are skewed in Icelandic cod. Thus, while we rank the stock unknown for this factor, it is entirely plausible that the stock is skewed in some way. Even a modest reduction in age-at-maturity can significantly affect population growth in some species. For example, a decrease in age from 6 to 4 years can reduce annual population growth in Atlantic cod by 25%–30% (Hutchings 2005).

References

Grift, R., A. D. Rijnsdorp, et al. (2003). "Fisheries-induced trends in reaction norms for maturation in North Sea plaice." Marine Ecology Progress Series 257: 247-257.

Hutchings, J. A. (2005). "Life history consequences of overexploitation to population recovery in Northwest Atlantic cod (Gadus morhua)." Canadian Journal of Fisheries and Aquatic Sciences 62: 824-832.

ICES (2004). Report of the ICES advisory committee on fishery management and advisory committee on ecosystems, 2004. Volume 1, Number 2. International Council for the Exploration of the Sea.

ICES (2010). Report of the ICES Advisory Committee, 2010. Copenhagen, Denmark, ICES. Books 1-11.

Jónsdóttir, Ó. D. B., A. K. Daníelsdóttir, et al. (2001). "Genetic differentiation among Atlantic cod (Gadus morhua L.) in Icelandic waters: temporal stability." ICES Journal of Marine Science 58(1): 114-122.

Marteinsdottir, G. and K. Thorarinsson (1998). "Improving the stock-recruitment relationship in Icelandic cod (Gadus morhua) by including age diversity of spawners." Canadian Journal of Fisheries and Aquatic Sciences 55: 1372-1377.

Pardoe, H., A. Vainikka, et al. (2009). "Temporal trends in probabilistic maturation reaction norms and growth of Atlantic cod (Gadus morhua) on the Icelandic shelf." Canadian Journal of Fisheries and Aquatic Sciences 66(10): 1719-1733.

Synthesis

No comprehensive stock assessment is conducted for Icelandic plaice, and no reference points have been defined. The groundfish survey index for plaice decreased in the long-term (since 1985) but increased in the short term (last decade) and is now around 35% of that at the beginning (and highest point) in the time series. The stock is deemed a moderate conservation concern because the majority of factors are unknown and the short-term trend in biomass is increasing.

Evaluation Guidelines

A "Healthy" Stock:

1) Is underutilized (near virgin biomass)
2) Has a biomass at or above BMSY AND overfishing is not occurring AND distribution parameters are functionally normal AND stock uncertainty is not high

A "Moderate" Stock:

1) Has a biomass at 50-100% of BMSY AND overfishing is not occurring
2) Is recovering from overfishing AND short-term trend in abundance is up AND overfishing not occurring AND stock uncertainty is low

3) Has an Unknown status because the majority of primary factors are unknown.

A "Poor" Stock:

1) Is fully fished AND trend in abundance is down AND distribution parameters are skewed
2) Is overfished, overexploited or depleted AND trends in abundance and CPUE are up.
3) Overfishing is occurring AND stock is not currently overfished.

A stock is considered a **Critical Conservation Concern** and the species is ranked "Avoid", regardless of other criteria, if it is:

1) Overfished, overexploited or depleted AND trend in abundance is flat or down
2) Overfished AND overfishing is occurring
3) Listed as a "threatened species" or similar proxy by national or international bodies

Conservation Concern: Status of Stocks

- Low (Stock Healthy) 🟩
- Moderate (Stock Moderate or Unknown) [✓ 🟨]
- High (Stock Poor) 🟥
- Stock Critical ⬛

CRITERION 3: NATURE AND EXTENT OF DISCARDED BYCATCH

Guiding Principle: A sustainable wild-caught species is captured using techniques that minimize the catch of unwanted and/or unmarketable species.

As Icelandic plaice is caught in the cod fisheries, a summary of Criterion 3 from the Northeast Atlantic cod report is presented here.

All gears used to catch Icelandic plaice are generally considered unselective gears. Bycatch in bottom trawls and Danish seines usually consists of unwanted fish and invertebrates, especially juvenile specimens of commercial species. Discards are banned for any species with a TAC in Icelandic fisheries, and reported discards of the major species are low (0.6%–7.1% of landings weight for cod, haddock, saithe, redfish, plaice) (ICES 2008; Kristjánsdóttir 2010). In 2009, the sampling rate was sufficient to accurately estimate discards of cod and haddock only (Pálsson, Bjornsson et al. 2010). In terms of numbers, discards as a percentage of landings of both species was amongst the lowest (cod: 2.34%) and the single lowest (haddock: 2.00%) in the time series 2001–2009 (means 2001–2009 for cod and haddock are 2.93% and 7.27% respectively (Pálsson, Bjornsson et al. 2010). Since 2001, the discard rate of cod and haddock varies with year and gear type, but has not typically exceeded 10% of landings (by weight) in any year/gear combination (Pálsson, Bjornsson et al. 2010). The quantity of discards of most other species is unknown, however. Gillnet fisheries operating in the Northeast Atlantic are known to catch both marine mammals and seabirds, and bottom longlines catch seabirds. Absolute levels of seabird and mammals bycatch is unknown, however.

Nature of Bycatch Rank:

Low 🟩 [✓ **Moderate** 🟨] High 🟥 Critical ⬛

CRITERION 4: EFFECT OF FISHING PRACTICES ON HABITATS AND ECOSYSTEMS

Guiding Principle: Capture of a sustainable wild-caught species maintains natural functional relationships among species in the ecosystem, conserves the diversity and productivity of the surrounding ecosystem, and does not result in irreversible ecosystem state changes.

As Icelandic plaice is caught in the cod fisheries, a summary of Criterion 4 from the Northeast Atlantic cod report is presented here.

Bottom trawling is known to damage the seafloor and occurs over a variety of habitats in Icelandic waters, including sensitive habitat such as cold-water corals, which are biodiversity hotspots and serve as habitat for other commercially valuable fishes. The reduction of habitat complexity as a result of bottom trawling reduces the survivorship of juvenile cod. Although bottom gillnets and bottom longlines have a lesser impact than bottom trawls, they still affect bottom habitat such as corals through entanglement while the gear is set and retrieved. Danish seining, which uses lighter ground gear than bottom (otter) trawling and is conducted only in habitats of high or moderate resilience, likely has a greater impact than set gears but a lesser impact than bottom trawling. The effects of bottom trawls and Danish seines are considered severe while the effect of bottom gillnets and bottom longlines are considered moderate.

Effect of Fishing Practices Rank:

Bottom gillnets, bottom longlines:

Benign 🟩 [✓ **Moderate** 🟨] Severe 🟥 Critical ⬛

Bottom trawls, Danish seines:

Benign 🟩 Moderate 🟨 [✓ **Severe** 🟥] Critical ⬛

CRITERION 5: EFFECTIVENESS OF THE MANAGEMENT REGIME

Guiding Principle: The management regime of a sustainable wild-caught species implements and enforces all local, national and international laws and utilizes a precautionary approach to ensure the long-term productivity of the resource and integrity of the ecosystem.

Primary Factors to evaluate

Stock Status: Management process utilizes an independent scientific stock assessment that seeks knowledge related to the status of the stock

- Stock assessment complete and robust [✓ 🟩]
- Stock assessment is planned or underway but is incomplete OR stock assessment complete but out-of-date or otherwise uncertain 🟨
- No stock assessment available now and none is planned in the near future 🟥

Key relevant information

The Marine Research Institute conducts an annual assessment on the Icelandic plaice stock, including VPA analysis (MRI 2009a; MRI 2009b; Valtýsson, pers. comm.).

Reference(s)

MRI (2009a). "English summary of the State of Marine Stocks in Icelandic waters 2008/2009 – Prospects for the Quota Year 2009/2010." Retrieved October, 2010, from http://www.hafro.is/Astand/2009/35-englsummary.pdf

MRI (2009b). Hafrannsóknastofnunin Fjölrit nr. 153 (2009/2010 stock assessments in Icelandic). Accessed from http://www.hafro.is/undir.php?ID=26&REF=4.

Scientific Monitoring: Management process involves regular collection and analysis of data with respect to the short and long-term abundance of the stock

- Regular collection and assessment of both fishery-dependent and independent data [✓ 🟩]
- Regular collection of fishery-dependent data only 🟨
- No regular collection or analysis of data 🟥

Key relevant information

Both CPUE and groundfish survey data are used for assessing the stock (MRI 2009a; MRI 2009b).

Reference(s)

MRI (2009a). "English summary of the State of Marine Stocks in Icelandic waters 2008/2009 – Prospects for the Quota Year 2009/2010." Retrieved October, 2010, from http://www.hafro.is/Astand/2009/35-englsummary.pdf

MRI (2009b). Hafrannsóknastofnunin Fjölrit nr. 153 (2009/2010 stock assessments in Icelandic). Accessed from http://www.hafro.is/undir.php?ID=26&REF=4.

Scientific Advice: Management has a well-known track record of consistently setting or exceeding catch quotas beyond those recommended by its scientific advisors and other external scientists:

- No 🟩
- [✓ Yes] 🟥
- Not enough information available to evaluate OR not applicable because little or no scientific information is collected ☐

Key relevant information

Iceland's Institute of Marine Research (MRI) recommends a TAC annually. Recent recommendations were 4,000 t from 1999/2000 to 2005/2006 and 5,000t from 2006/2007 to 2009/2010 (MRI 2009b). The TAC has generally been set at 1,000 t or more above the recommended TAC since 2001/2002 (MRI 2009b). Landings have also generally exceeded the TAC in the last decade (MRI 2009b).

Reference(s)

MRI (2009b). Hafrannsóknastofnunin Fjölrit nr. 153 (2009/2010 stock assessments in Icelandic). Accessed from http://www.hafro.is/undir.php?ID=26&REF=4.

Bycatch: Management implements an effective bycatch reduction plan

- Bycatch plan in place and reaching its conservation goals (deemed effective) 🟩
- [✓ Bycatch plan in place but effectiveness is not yet demonstrated or is under debate] 🟨
- No bycatch plan implemented or bycatch plan implemented but not meeting its conservation goals (deemed ineffective) 🟥
- Not applicable because bycatch is "low" ☐

Key relevant information

Icelandic regulations prohibit the discarding of most fish specimens for which there are TACs or species for which a market value exists (Pitcher, Kalikoski et al. 2008). Discards of the commercially most important species are reported to be <10%, but Pitcher, Kalikoski et al. (2008) report that there is insufficient attention given to discards of non-commercial invertebrate species, such as echinoderms, tunicates, sponges and crabs. Specific measures in place to reduce discards include maximum mesh sizes in gillnets and minimum mesh size in trawl codends. However, the effectiveness of these measures has not been evaluated by ICES (ICES 2010). In addition, Iceland has had a quick closure system in place since 1976, whereby the authorities can close an area where inspectors observe too many (>25% by number) small (<55cm) cod in the catch (ICES 2010). According to ICES (2010), a preliminary evaluation of the temporary closure system is that it likely does not contribute significantly to the protection of juveniles. Other closures (consecutive small closures, seasonal closures, and permanent closures) have not been evaluated by ICES (ICES 2010).

Reference(s)

Christensen, A.S., T. J. Hegland, et al. (2009). The Icelandic ITQ System. Comparative Evaluations of Innovative Fisheries Management. K. H. Hauge and D. C. Wilson, Springer Netherlands: 97-118.

Guðfinnsson, E. K., J. Sigurjónsson, et al. (2010). "Statement on responsible fisheries in Iceland." Retrieved October, 2010, from http://www.fisheries.is/management/government-policy/responsible-fisheries/.

ICES (2010). Report of the ICES Advisory Committee, 2010. Copenhagen, Denmark, ICES. Books 1-11.

Pitcher, T. J., D. Kalikoski, et al. (2008). Safe Conduct? Twelve years fishing under the UN Code., WWF. Country specific analyses available at ftp://ftp.fisheries.ubc.ca/CodeConduct/CountriesCodePDF/.

Sanchirico, J. N., D. Holland, et al. (2005). "Catch-quota balancing in multispecies individual fishing quotas." Marine Policy [Mar. Policy] 30(6).

Other information (from Atlantic cod report)

Icelandic regulations prohibit the discarding of most fish specimens for which there are TACs or species for which a market value exists (Pitcher, Kalikoski et al. 2008). Exceptions include cod <50 cm long and haddock caught by hook and line and <45 cm, both of must be released. Measures in place include maximum mesh sizes in gillnets, and minimum mesh size in trawl codends. The effectiveness of these measures has not been evaluated by ICES (ICES 2010). In addition, Iceland has had a quick closure system in place since 1976, whereby the authorities can close an area where inspectors observe too many (>25% by number) small (<55 cm) cod in the catch (ICES 2010). Closures are relatively small and can last for two weeks or more, but longer closures can be implemented if deemed necessary (Christensen, Hegland et al. 2009; ICES 2010). According to ICES (2010), a preliminary evaluation of the temporary closure system is that it likely does not contribute significantly to the protection of juveniles. An exception may be where several consecutive closures effectively result in larger closures for longer time periods, but this has not been evaluated. Other closures include 2–3 week closures in spawning areas during spawning season and various permanent closures for all fisheries or for specific gears to protect juveniles and habitat. For example, fishing by bottom trawl, midwater trawl and Danish seine is prohibited within 12 miles of the northwest and north coast.[50] Neither the seasonal or permanent closures have been evaluated by ICES (ICES 2010).

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[50] http://www.fisheries.is/management/fisheries-management/area-closures/

The discard ban has been coupled with a "bycatch bank" since 1989, the purpose of which was to help commercialize fish species caught as bycatch, thereby reducing the incentive to discard (Sanchirico, Holland et al. 2005; Guðfinnsson, Sigurjónsson et al. 2010). The program has led to directed fisheries for megrim, witch-pole dab and rough dab, and trading channels for others such as starry ray, great silver smelt, grenadiers and piked dogfish (Pitcher, Kalikoski et al. 2008). Other mechanisms in place to de-incentivize discarding include rollover allowances, species quota exchanges, retrospective balancing, and temporary quota exchanges between vessels (Sanchirico, Holland et al. 2005).

Discards of the commercially most important species are reported to be <10%, but Pitcher, Kalikoski et al. 2008 report that there is insufficient attention given to discards of non-commercial invertebrate species, such as echinoderms, tunicates, sponges and crabs. Nonetheless, Pitcher, Kalikoski et al. (2008) score Iceland among the top few countries (of the 53 reviewed) for consistency with the bycatch and discard minimization guidelines of the CCRF (and within the top 20 in controlling ghost fishing).

Fishing practices: Management addresses the effect of the fishing method(s) on habitats and ecosystems

- Mitigative measures in place and deemed effective 🟩
- Mitigative measures in place but effectiveness is not yet demonstrated or is under debate **<u>Bottom trawl, Danish seine</u>** [✓ 🟨]
- No mitigative measures in place or measures in place but deemed ineffective 🟥
- Not applicable because fishing method is moderate or benign **<u>Bottom gillnet, bottom longline</u>** [✓ ⬜]

Key relevant information

Iceland has a policy that "Every effort shall be made to preserve the biodiversity and ecosystem of the ocean," (Pitcher, Kalikoski et al. 2008) and has implemented a program of permanent, seasonal and temporary closures. While most of these are to reduce discards of small cod and other species or for socio-economic reasons (Elena, Ragnarsson et al. 2006), specific closures have been implemented to protect three *Lophelia pertusa* reefs (Hall-Spencer and Stehfest 2009) and one area of hydrothermal vents (Elena, Ragnarsson et al. 2006; ICES 2010). Other permanent closures that may mitigate habitat damage from fishing activities include the closure of all waters within 12 miles of the North and Northwest coasts to bottom trawl, midwater-trawl and Danish seine; all waters within 12 miles of the East, South and West coasts to bottom trawlers (smaller bottom trawlers can enter waters between 4-12 miles in some areas);[51] and, in 2010, various additional areas to Danish seining.[52] Iceland has also supported the North East Atlantic Fisheries Commission, which was the first Regional Fishery Management Organization in the world to close areas of the high seas for the purpose of protecting habitat and seabed fisheries (Pitcher, Kalikoski et al. 2008). However, there are no specific measures to protect other vulnerable habitat types found in Icelandic waters, such as sponge-dominated biotopes, mearl beds and cold seeps (Elena,

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[51] http://www.fisheries.is/management/fisheries-management/area-closures/

[52] http://www.stjornartidindi.is/Advert.aspx?ID=31e2c614-3ff4-48f3-be07-7b7ee626a1d7

Ragnarsson et al. 2006; Christiansen 2010). Overall, implementing protected and no-take areas does not appear to have been a priority in Iceland, and the country is considered in the bottom 50% of 53 nations reviewed by Pitcher, Kalikoski et al. (2008) for compliance with MPA guidelines in the UN Code of Conduct for Responsible Fishing (CCRF).

Reference(s)

Elena, G., S. Ragnarsson, et al. (2006). Bottom Trawling and Scallop Dredging in the Arctic. Impacts of fishing on non-target species, vulnerable habitats and cultural heritage. Copenhagen, Denmark, Nordic Council of Ministers: 375.

Hall-Spencer, J. and K. Stehfest (2009). Assessment of Lophelia pertusa reefs in the OSPAR area: Draft. U. Joint Nature Conservation Committee, OSPAR Commission.

ICES (2010). Report of the ICES Advisory Committee, 2010. Copenhagen, Denmark, ICES. Books 1–11.

Pitcher, T. J., D. Kalikoski, et al. (2008). Safe Conduct? Twelve years fishing under the UN Code., WWF. Country specific analyses available at ftp://ftp.fisheries.ubc.ca/CodeConduct/CountriesCodePDF/

Enforcement: Management and appropriate government bodies enforce fishery regulations

- Regulations regularly enforced by independent bodies, including logbook reports, observer coverage, dockside monitoring and similar measures [✓ 🟩]
- Regulations enforced by fishing industry or by voluntary/honor system 🟨
- Regulations not regularly and consistently enforced 🟥

Key relevant information

Iceland has a surveillance system for monitoring landings, catches and vessel activity. Measures include a video monitoring system (VMS) and vessel-boarding by the coast guard to monitor catches and gear (Sanchirico, Holland et al. 2005; Asgeirsson Undated; FAO 2010). Logbooks are also required, and all catches are weighed by officials at the port of landing.[53] In addition, there are 15 port inspectors and 22 onboard inspectors to monitor catches and landings (Asgeirsson Undated). Logbook catch data is verified by these authorities by requiring the vessel to return to the same fishing area with the observer onboard (Jóhann Sigurjónsson; Director General; Marine Research Institute; pers. comm.). Given that there were 1,642 Icelandic fishing vessels at the end of 2007,[54] observer coverage would appear low (actual information about the Icelandic observer system is hard to find—Pitcher, Kalikoski et al. 2008). Pitcher, Kalikoski et al. (2008) consider the Icelandic observer scheme moderately effective, and the catch inspection, VMS, and IUU-prevention schemes all effective (IUU is not a big problem in Iceland). Overall, Iceland ranks among the best in the world in terms of complaince with the CCRF for

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[53] http://www.fisheries.is/management/fisheries-management/enforcement/

[54] http://www.fisheries.is/fisheries/fishing-vessels/

monitoring, control and surveillance (Pitcher, Kalikoski et al. 2008).

Reference(s)

Asgeirsson, T. (Undated). Surveillance of fisheries and fish processing; arrangements and implementation in the light of technological advances. Available at http://www.sjavarutvegsraduneyti.is/media/Sjavarutvegssyning/thordurerindidoc.doc.

ICES (2010). Report of the ICES Advisory Committee, 2010. Copenhagen, Denmark, ICES. Books 1–11.

Pitcher, T. J., D. Kalikoski, et al. (2008). Safe Conduct? Twelve years fishing under the UN Code., WWF. Country specific analyses available at ftp://ftp.fisheries.ubc.ca/CodeConduct/CountriesCodePDF/.

Sanchirico, J. N., D. Holland, et al. (2005). "Catch-quota balancing in multispecies individual fishing quotas." Marine Policy [Mar. Policy] 30(6).

Management Track Record: Conservation measures enacted by management have resulted in the long-term maintenance of stock abundance and ecosystem integrity

- Management has maintained stock productivity over time OR has fully recovered the stock from an overfished condition 🟩
- Stock productivity has varied and management has responded quickly OR stock has not varied but management has not been in place long enough to evaluate its effectiveness OR Unknown [✓ 🟨]
- Measures have not maintained stock productivity OR were implemented only after significant declines and stock has not yet fully recovered 🟥

Key relevant information

Groundfish survey indices suggest abundance has decreased and then increased again over the last 25 years, but remains at about a third of the abundance in 1985 (MRI 2009a; MRI 2009b). CPUE indices suggest a similar pattern after 1991 but the most recent stock evaluation does not provide CPUE for the period 1985-1991, when the survey indices suggest the largest drop in abundance. As a full stock assessment has not been conducted for this stock and biological reference points have not been defined for the stock (MRI 2009a; MRI 2009b) it is difficult to know whether the stock has been maintained in the long term.

Reference(s)

MRI (2009a). "English summary of the State of Marine Stocks in Icelandic waters 2008/2009 – Prospects for the Quota Year 2009/2010." Retrieved October, 2010, from http://www.hafro.is/Astand/2009/35-englsummary.pdf

MRI (2009b). Hafrannsóknastofnunin Fjölrit nr. 153 (2009/2010 stock assessments in Icelandic). Accessed from http://www.hafro.is/undir.php?ID=26&REF=4.

Synthesis

Icelandic management of the mixed-stock fisheries for demersal species including plaice is generally effective or moderately effective for most factors. However, managers have consistently set TACs above those recommended by their own scientists. Furthermore, measures to reduce bycatch (discards) have not been evaluated by ICES, and some, but not all, vulnerable habitat is protected. For these reasons, management is considered moderately effective.

Evaluation Guidelines

Management is deemed to be "**Highly Effective**" if the majority of management factors are green AND the remaining factors are not red.

Management is deemed to be "**Moderately Effective**" if:

1) Management factors "average" to yellow
2) Management factors include one or two red factors

Management is deemed to be "**Ineffective**" if three individual management factors are red, including especially those for Stock Status and Bycatch.

Management is considered a **Critical Conservation Concern** and a species receives a recommendation of "**Avoid,**" regardless of other criteria if:

1) There is no management in place
2) The majority of the management factors rank red.

Conservation Concern: Effectiveness of Management

- Low (Management Highly Effective) 🟩
- Moderate (Management Moderately Effective) [✓ 🟨]
- High (Management Ineffective) 🟥
- Critical (Management Critically Ineffective) ⬛

IV. Overall Evaluation and Seafood Recommendation

Overall Guiding Principle: Sustainable wild-caught seafood originates from sources that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

Evaluation Guidelines

A species receives a recommendation of "**Best Choice**" if:
1) It has three or more green criteria and the remaining criteria are not red.

A species receives a recommendation of "**Good Alternative**" if:
1) Criteria "average" to yellow
2) There are four green criteria and one red criteria
3) Stock Status and Management criteria are both ranked yellow and remaining criteria are not red.

A species receives a recommendation of "**Avoid**" if:
1) It has a total of two or more red criteria
2) It has one or more Critical Conservation Concerns.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability		√		
Status of Stock		√		
Nature of Bycatch*		√		
Habitat & Ecosystem Effects*		√ (Bottom gillnet, bottom longline)	√ (Bottom trawl, Danish seine)	
Management Effectiveness		√		

* Bycatch and Habitat rankings are taken from the Northeast Atlantic cod report

Overall Seafood Recommendation:

Best Choice 🟩 **Good Alternative** 🟨 Avoid 🟥