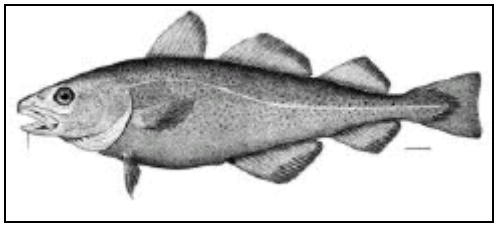
Seafood Watch
Seafood Report

MONTEREY BAY AQUARIUM®

Atlantic Cod
Gadus morhua



Courtesy NEFSC

Northeast Region (U.S. and Canada)

Final Report
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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 www.seafoodwatch.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 Choice," "Good Alternative" 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® 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 1-877-229-9990.

Disclaimer

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.

Seafood Watch® and Seafood Reports are made possible through a grant from the David and Lucile Packard Foundation.

Executive Summary

Atlantic cod is a quickly maturing species with a relatively short (~ 20 year) lifespan. Both the Gulf of Maine and Georges Bank stocks are considered overfished, and overfishing is occurring. This species' stock status is a critical conservation concern according to Seafood Watch criteria.

The primary fishing method for Atlantic cod, trawling, results in significant disturbance to the sea floor, impacting marine habitats that are important to the survival of groundfishes and other species. Trawling is also indiscriminate, and along with targeted species takes unmarketable, illegal, or undersized species that are fatally discarded, adding to the overall fishing mortality of many groundfish species. A very small portion of Cod is landed with hook and line gear, a method that has no impacts on benthic habitats and has very low bycatch rates. Groundfish managers have attempted to mitigate both habitat effects and bycatch from trawling operations by closing over 25,000 square nautical miles of ecologically sensitive habitat to trawling, increasing mesh size of trawl gear, and including discard estimates in fishing mortality analyses. In addition, managers actively study stock abundance and have implemented several regulations over the years in an attempt to maintain stock productivity. The management regime, however, has not prevented substantial and ongoing declines of cod stocks. The critical status of the stock combined with the severe impacts of trawl gear result in a seafood recommendation of **Avoid** for Atlantic cod caught in U.S. and Canadian waters.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks			√ **Canada**	√ **U.S.**
Nature of Bycatch	√ **Hook and line**	√ **Trawl**		
Habitat & Ecosystem Effects	√ **Hook and line**		√ **Trawl**	
Management Effectiveness		√		

About the Overall Seafood Recommendation:

- 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.
- 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 **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.

Overall Seafood Recommendation:

Best Choice | Good Alternative | **Avoid**

Introduction

Atlantic cod *(Gadus morhua)* is a demersal (bottom-living) species in the Gadidae family (subfamily Gadinae), or 'true cods'(Nelson 1994). There are 15 genera and over 30 species within the family Gadidae, including many of the most important commercial groundfishes (haddock, pollock, hake, whiting). Cod inhabits both sides of the Atlantic Ocean at depths down to 400 meters (m) (Fahay et al. 1999). In the Northwest Atlantic it is found from Greenland to North Carolina (Fahay et al. 1999; Mayo and O'Brien 2000). The highest concentrations of cod in U.S. waters are found around Georges Bank and the western Gulf of Maine (GOM; Fig. 1). The species inhabits pebble/gravel bottoms at depths of 10-50 m and temperatures of 0˚ – 10˚ Celsius (Fahay et al. 1999). Off the coast of Canada the highest densities of cod have been observed off Newfoundland, in the Gulf of St. Lawrence, and on the Scotian Shelf (Fahay et al. 1999).

Except for seasonal migrations to spawn and feed, cod are generally sedentary. Seasonal migration is initiated in response to shifts in water temperature (Fahay et al. 1999). Off New England, cod typically move into coastal waters during the fall and then return to deeper waters during the spring. Off Newfoundland, cod move from deep oceanic waters in the winter to relatively warm shelf waters in the summer (Fahay et al. 1999). In the Mid-Atlantic Bight and Chesapeake Bay, cod are present only during winter and spring, returning north to Nantucket Shoals when waters in the Bight exceed 20˚C (Heyerdahl and Livingston 1982).

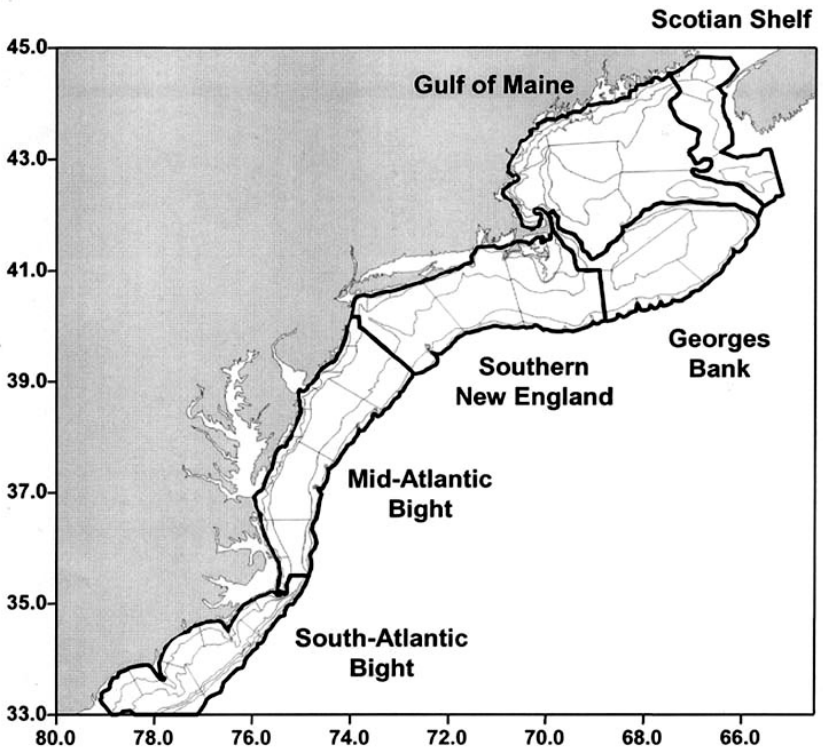


Figure 1. Map of the Northwest Atlantic, including the major fishery subregions (courtesy: NEFSC).

Historically, Atlantic cod (referred throughout this document also as 'cod') have supported some of the world's largest and most valuable fisheries. Long a mainstay of European fisheries, the search for new cod fishing grounds led European explorers to the edge of Newfoundland as early as 1000 AD. The promise of plentiful cod lured some of the earliest European settlers across the Northern Atlantic to the coasts of North America, namely New England.

The New England groundfish fishery has thus existed since colonial times. The first colonial fishermen used small sailing dories and caught mostly cod, using hook and line gear. Fishers would salt their product as a means of preservation (Collete and Klein-MacPhee 2002). Sailboats gave way to steamships, and the use of otter trawls (from Europe) and on-board refrigeration beginning in the early 1900s revolutionized the fishery (NRC 1998). After World War I, fishers began to target a wider variety of species, including haddock, yellowtail and winter flounders, as well as Atlantic halibut. Groundfish landings decreased during World War II, and then increased in the 1960s, due in large part to effort by distant-water factory trawlers from Russia and Spain. Prompted by concerns about overfishing, the U.S. created the first 200-mile Exclusive Economic Zone (EEZ) along its Atlantic coastline in 1977, and thereafter encouraged the growth of the U.S. fishery. Canada also created a 200-mile EEZ in 1977. Conflicts persisted over the U.S./Canada maritime boundary until the establishment of the Hague Line in 1985 (NRC 1998). Once the U.S. EEZ was established, domestic fishing grew rapidly. From 1975 to 1980, the number of vessels in the U.S. groundfish fleet nearly doubled, from around 600 to over 1,100 (Brodziak and Link 2002).

U.S. Atlantic cod stocks are regulated under the New England Multispecies Groundfish Fishery Management Plan (FMP), which includes 15 different species and 24 separate stocks along the U.S. Atlantic Coast. Canadian stocks are managed by Canada's Department of Fisheries and Oceans (DFO). Cod stocks inhabiting Georges Bank are jointly managed by the U.S. and Canada.

Scope of the analysis and the ensuing recommendation:
This report focuses primarily on U.S. and Canadian cod stocks from Georges Bank and the Gulf of Maine. Therefore, the recommendation applies only to northeast (U.S. and Canadian) Atlantic cod stocks.

Availability of Science

Because cod is a valuable commodity in New England and Canadian economies, life history and abundance information for cod are readily available. Further research is needed, however, to understand the degree of mixing between cod stocks in different geographical areas, as separate stocks are managed under distinct management plans. Further research on migration patterns, spawning behavior (coinciding with oceanographic data), and genetics may better confirm the ranges of individual stocks. Intrinsic rate of increase, 'r', was found only for cod inhabiting Newfoundland's northern Grand Bank ($r = 0.135$-0.164; Hutchings 1999). It does not appear that maximum age has been validated for this species.

Market Availability

Common/Market Names
Cod may also be referred to as true cod, Atlantic cod, Icelandic cod, scrod, or whitefish.

Seasonal Availability
Frozen and dried cod are available year-round. On the New England Coast, fresh cod is available more often in milder weather months. Canadian catches are taken primarily in summer and fall (DFO 2002a)

Product Forms
Skinless/boneless frozen fillets; breaded frozen fillets; fresh (fillets or headed/gutted); smoked; dried; canned (Froese and Pauly 2004). Fresh cod is often available in small quantities in coastal New England.

Import/Export Statistics
In 2003, the U.S. imported approximately 62,692 metric tons (mt) of cod[1], worth ~ U.S. $320 million (NMFS 2004c). The biggest import sources were Canada, China, and Iceland (Fig. 2). In 2003, the U.S. exported approximately 88,736 mt of cod, worth over US $193 million (NMFS 2004c). Note that the U.S. is a net exporter of cod, but runs a trade deficit in terms of cod value. Imported products are typically higher-value processed products such as breaded fillets, while the majority of cod exports are frozen whole fish or fillets. The largest export markets for U.S. cod in 2003 were Canada, China, Japan, Germany, Denmark, the Netherlands, Norway, Portugal, Spain, and South Korea. Each of these nations imported more than 1,000 mt of U.S. cod in 2003 (NMFS 2004c).

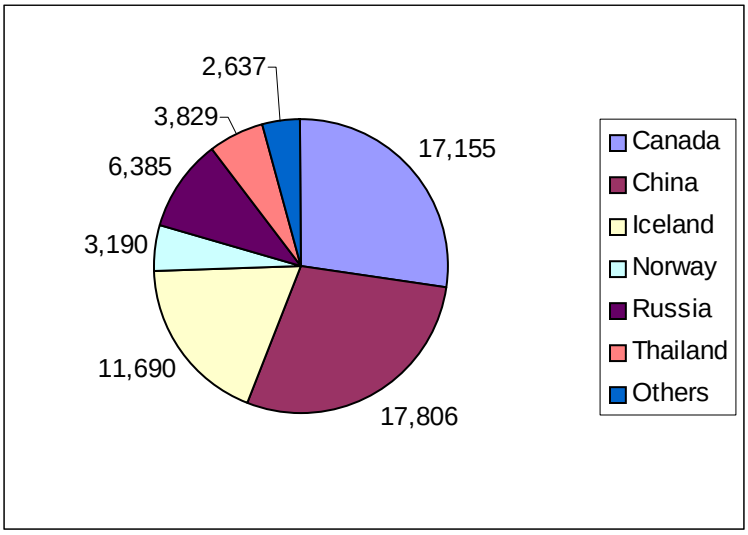


Figure 2. Imports of cod into the U.S. market, 2003 (NMFS 2004c).

[1] NOTE: U.S. Customs does not distinguish between Atlantic (*G. morhua*) and Pacific cod (*G. macrocephalus*), so all import and export data includes both species. It is probable that most cod imported from China is Pacific cod, and most cod imported from Iceland and Norway is Atlantic cod. Canada has both species so imports of cod from Canada are likely a combination of both.

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

Criterion 1: Inherent Vulnerability to Fishing Pressure

Atlantic cod reach sexual maturity between the ages of two and four years (Mayo and O'Brien 2000) and are believed to live at least 20 years (Fahay et al. 1999; Mayo 2000). Growth rates of cod have traditionally been slower in the Gulf of Maine than on Georges Bank, but appear to have increased in recent years (Mayo and O'Brien 2000). Differences in growth rate by sex have also become less pronounced in both stocks (Mayo and O'Brien 2000). Recent research has indicated that many years of exploitation has acted to genetically reduced the age and size at maturity for cod in these stocks (Barot et al (2004) and O'Brien (1999)).

Atlantic cod are highly fecund: a large female can release up to 9 million eggs in a single spawning session (Fahay et al. 1999). They breed in dense aggregations near the bottom during late winter and spring (Fahay et al. 1999); the time of spawning is temperature-dependent and may vary geographically (Collete and Klein-MacPhee 2002). After spawning, eggs are pelagic for 2-3 weeks before hatching (Fahay et al. 1999). Larvae drift in the water column for about 3 months, until they reach 4-6 cm in length and descend towards the bottom (Fahay et al. 1999). As they grow, juvenile cod seek shelter in eelgrass beds or rocky seafloor (NMFS 2004b), where they prey on small crustaceans and attempt to avoid predation by larger fishes.

Table 1. Life history parameters for Atlantic cod.

Age at Maturity	Growth Rate/Max. Size	Longevity	Fecundity	Species Range	Special Behaviors	References
A_{1st} = 2-4 yrs Median age is 1.7-2.3 yrs between 32 and 41 cm	130 cm (51 in.) TL max length; 25-35 kg (55-77 lb)	20+ years	Fecundity ranges from 2,000,000 - 3,000,000 eggs; varies with size	Greenland to Cape Hatteras, North Carolina	Seasonal migrations; dense spawning aggregations	(Fahay et al. 1999; Mayo and O'Brien 2000)

Synthesis

Cod is a quickly maturing, highly fecund gadoid that is inherently resilient to fishing pressure. There is evidence, however, that heavy fishing pressure has genetically (and permanently) decreased the age and size at maturity of cod in the Gulf of Maine and Georges Bank stocks, which may negatively impact recruitment and natural mortality in these stocks.

Inherent Vulnerability Rank:

Resilient Moderately Vulnerable Highly Vulnerable

Criterion 2: Status of Wild Stocks

Since 1950, fishing effort on northeast groundfish (including cod) has risen dramatically, while landings have declined. On Georges Bank, fishing mortality of cod doubled between 1979 and 1985 (O'Brien 2001). In 1980 and again in 1982, landings peaked at more than 53,000 mt (NMFS 2004c). Landings then declined throughout the late 1980s despite increasing fishing pressure. In the 1990s, the U.S. and Canada took major steps to cut fishing effort. In 2002, the last year for which figures are available, U.S. Atlantic cod landings totaled only 13,104 mt (NMFS 2004c).

U.S. states landing Atlantic cod in 2002 included Connecticut, Maine, Massachusetts, New Hampshire, New York, and Rhode Island (NMFS 2004c). Landings were dominated by Massachusetts, which landed about 10,826 mt. Maine landed 1,317 mt; New Hampshire 718 mt; Rhode Island about 240 mt; and New York just 2.5 mt (NMFS 2004c). New Jersey and Virginia, which each landed small amounts of cod in 2000, reported no cod landings in 2002 (NMFS 2004c).

Several different stocks have been recognized in U.S. and Canadian waters (Fahay et al. 1999). For management purposes, however, there are two stocks: one centered in the Gulf of Maine (GOM), and the other extending from Georges Bank (GB) southward. Because the International Boundary line between the U.S. and Canada runs through Georges Bank, the Georges bank stock is jointly assessed and managed by both countries. An overview of stock status parameters is provided in Table 2.

Table 2. Stock status and abundance trends for cod. Fishing mortality (F) and Biomass (B) data are as of October 2003 (Unpublished data, NEFSC). A ratio of $F_{2002}/F_{msy} > 1$ indicates overfishing is occurring.

Stock	Classification Status**	F_{2002}/F_{msy}	B_{2002}/B_{msy} (mt)	Abundance Trends	Age/Size/Sex Distributions	Degree of Uncertainty
GOM cod	Overfished; Overfishing occurring	0.33/0.23 = 1.43	23,850/ 82,800 = 28% of B_{MSY}	Increasing slightly since 2000	Truncated	Low
GB cod	Overfished; Overfishing occurring	0.43/0.18 = 2.38	26,560/ 216,800 = 12% B_{MSY}		Truncated	Low

** From (NMFS 2004b)

Georges Bank cod

As mentioned previously, this stock has been heavily exploited for the last 50 years and as a consequence, is now depleted to very low levels (i.e., 12% of B_{MSY}). The highest landings of cod on Georges Bank (> 50,000 mt) came between 1975 and 1985 (Fig. 3). There was another small peak in the early 1990s at around 30,000 mt, but the catch has since declined. The total commercial catch of cod on Georges Bank (U.S. and Canada) in 2000 was estimated to be about 9,200 mt, substantially lower than the catch rates experienced from the mid-1970s to the early 1990s (Lindebo and Soboil 2002). Although this reduction in catch is largely due to fishing restrictions, these restrictions were only implemented after observing clear indications of severe stock declines. These declines were primarily caused by long-term excessive fishing mortality

(i.e., overfishing) combined with several years of low recruitment (Mayo 2000; DFO 2002a), which resulted in reduced stock production.

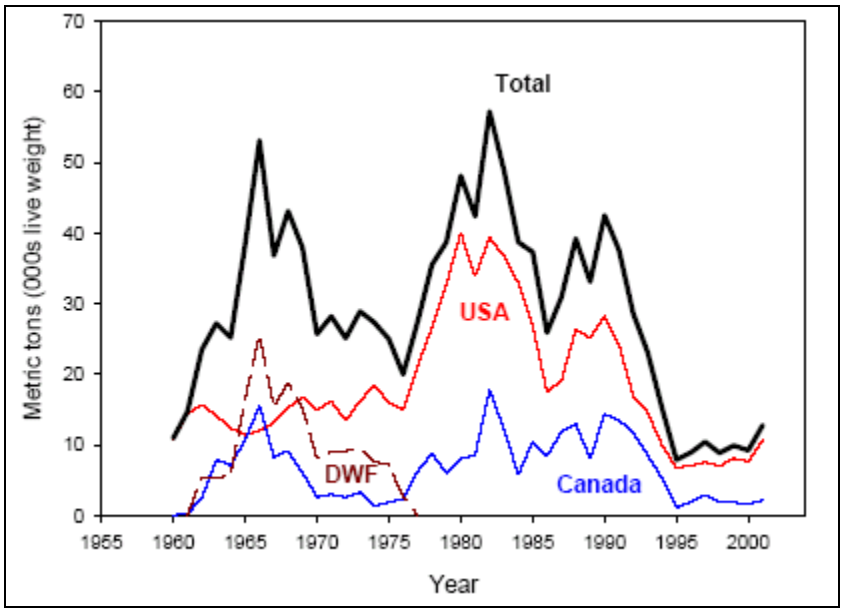


Figure 3. Total commercial landings of Georges Bank cod (NEFSC 2002).

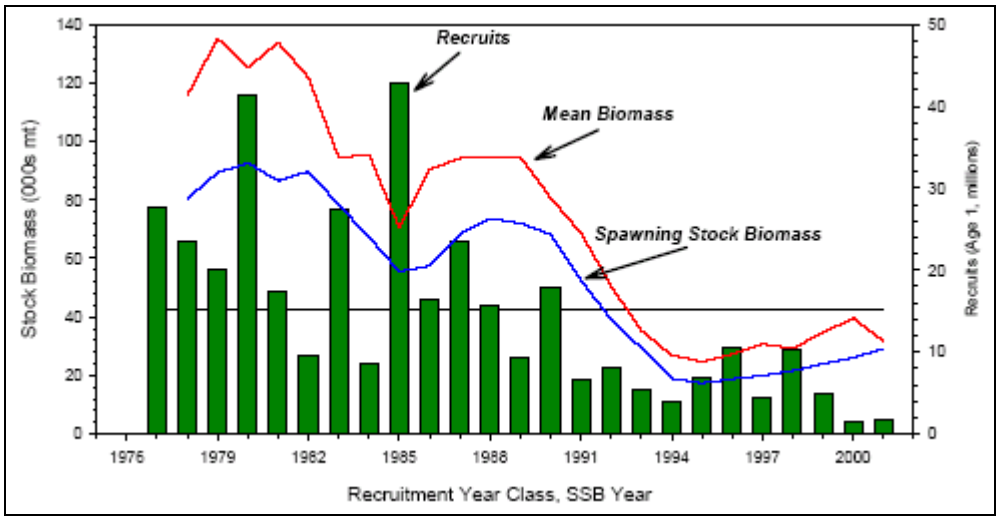


Figure 4. Trends in stock biomass and recruitment for Georges Bank Atlantic cod, 1978-2001. Horizontal line is the average recruitment for the time series (NEFSC 2002).

The Eastern Georges Bank management unit was last assessed during the seventh meeting of the Transboundary Resources Assessment Committee (TRAC) meeting in May 2003. The committee reported:

> Based on the 2003 VPA [Virtual Population Analysis], the adult (age 3+) biomass of Eastern Georges Bank cod declined from the recent high in 2001 (18,000 mt)

> to about 13,000 mt at the beginning of 2003. Fishing mortality [F] for fully recruited ages (4-6) ranged between 0.20 and 0.32 during the past five years, above the F_{ref} of 0.18. Assuming a catch in 2003 of about 2,800 mt (equal to the 2002 catch), the yield in 2004 at F_{ref} was projected to be 1,300 mt and would generate only a small improvement in adult biomass. (NEFSC 2004, p.2)

The results of the assessment (decreased biomass from 2001 to 2003, F above threshold) confirm the continued depressed nature of the Eastern GB cod stock. It is also important to note that discard mortality was not included in this assessment (NEFSC 2004). It appears that short-term (last 5 years) trends in biomass are variable and have decreased slightly. Although strict management measures implemented in 1994 reduced the fishing mortality of Georges Bank cod for both the U.S. and Canada, the stock does not appear to be responding positively.

Gulf of Maine cod

This fishery has been active since colonial times, with landings data reaching as far back as 1890 (NEFSC 2001). Total landings of GOM cod doubled between 1964 and 1968, doubled again between 1968 and 1977, and averaged over 12,000 mt per year between 1976 and 1985 (Fig. 5) (NEFSC 2001). Commercial landings reached 17,800 mt in 1991, the highest level since the early 1900s (NEFSC 2001). In 1992 total landings declined sharply to 10,891 mt, and have since decreased steadily to 1,636 mt in 1999 before increasing to 3,730 mt in 2000[2] (NEFSC 2001).

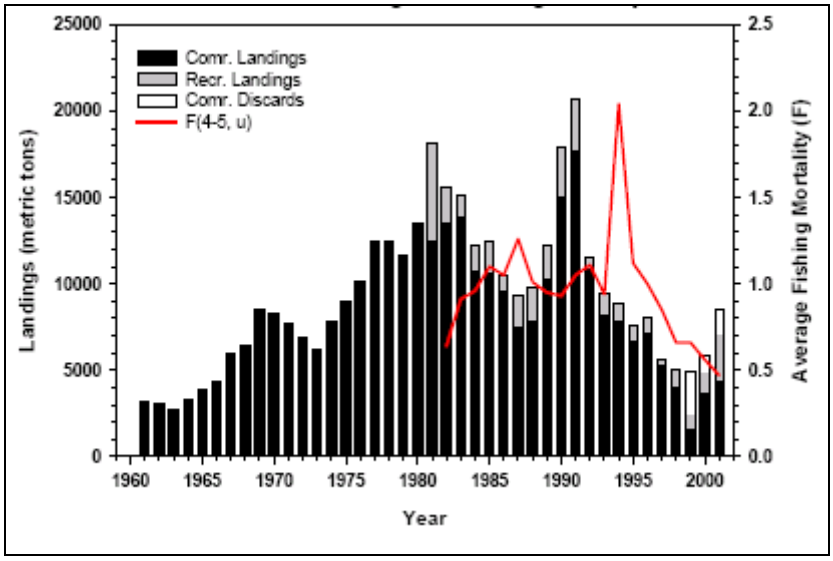


Figure 5. Trends in commercial and recreational landings and fishing mortality (F) for Gulf of Maine cod (NEFSC 2002).

[2] The sharp decline in landings between 1998 and 1999 and the subsequent increase in 2000 likely reflect the implementation of reduced trip limits during 1999 and the subsequent relaxation of these limits in early 2000 (NEFSC 2001).

The Gulf of Maine cod stock was last assessed (formally) in 2001 (33rd Stock Assessment Workshop; SAW). The assessors incorporated age composition of landed catch and discards (from U.S. commercial and recreational landings), vessel trip reports, New England Fisheries Science Center (NEFSC) and Massachusetts Division of Marine Fisheries (DMF) survey data, and standardized U.S. fishing effort data (NEFSC 2001). In that year, SSB (Spawning Stock Biomass) was less than half of SSB_{MSY} (82,830 mt) and fully recruited fishing mortality (F) was about 2 times F_{MSY} (0.225; NEFSC 2002).

Stock biomass decreased through the early to mid-1990s, but has been increasing since 2000 (Fig. 6). Spawning stock biomass (SSB) went from 24,200 mt in 1990 down to 10,600 mt in 1998 but by 2000 increased to just over 22,000 mt. Total stock biomass (ages 1+) declined from almost 42,000 mt in 1990 to 15,300 mt in 1997 (NEFSC 2001), and in 2003 was estimated to have increased to 23,850 mt. However, this estimate is still well below the biomass (82,000 mt) at maximum sustainable yield (MSY; see Table 2).

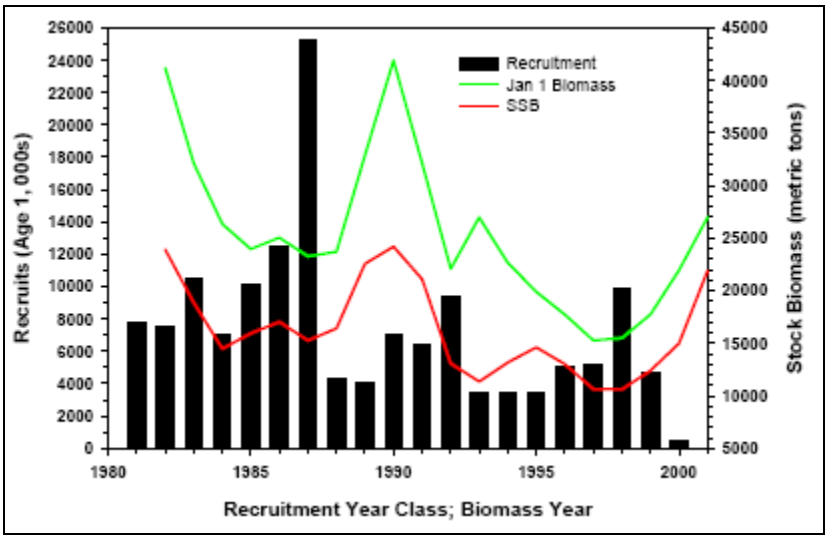


Figure 6. Recruitment (age 1) and biomass trends of cod in the Gulf of Maine (NEFSC 2002).

Although improvements in abundance have been seen since about 2000, stock biomass is still quite low relative to that of the 1960s and 1970s (NEFSC 2001). Biomass however may increase further if fishing mortality is reduced (NEFSC 2002). The success of incoming year-classes will influence the degree of recovery of this stock. Unfortunately, the 1999 and 2000 year classes (which would produce a fully recruited size class in 2004) are not expected to be strong (NEFSC 2002).

Canadian stock status

Seven of the nine Canadian stocks are in ongoing decline; two Canadian stocks are considered to be recovering or stable (Rice et al. 2003). In May 2003, Canada's government declared one cod stock "endangered" and another "threatened", immediately halting all fishing of those stocks (ENS 2003). The most recent stock status report for Eastern GB cod indicated that biomass had decreased from 2001 to 2003, and that with poor recruitment and exploitation rates at current levels, "improvement in stock status is not expected in the near term" (DFO 2003).

Synthesis

Both the GB and GOM cod stocks are overfished, and overfishing is occurring. Recruitment for both stocks in recent years has been weak, further reducing the ability of the stocks to recover. As of October 2003, the GB and GOM stocks need biomass increases of 716% and 247%, respectively, to rebuild to biomass at MSY. Therefore, the stock status of these two cod stocks rank as a critical conservation concern. Stock status of Canadian cod is considered poor, except for the Georges Bank stock, which is in critical condition according to Seafood Watch criteria (same as U.S. stock).

Status of Stocks Rank:

Healthy Moderate/Rebuilding **Poor** **Critical**

Canada (Excluding GB) **U.S. (Including GB)**

Criterion 3: Nature of Bycatch

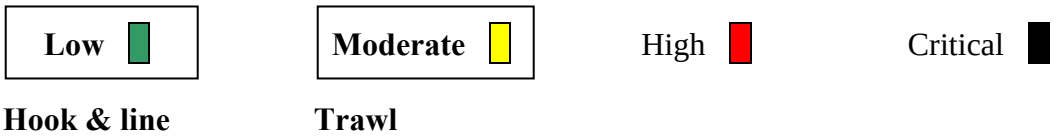
Seafood Watch® defines sustainable wild-caught seafood as marine life captured using fishing techniques that successfully minimize the catch of unwanted and/or unmarketable species (i.e., bycatch). Bycatch is defined as species that are caught but subsequently discarded (injured or dead) for any reason.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

Due to the mixed species nature of the Atlantic Groundfish Fishery, as well as the gear type used (bottom/otter trawl), bycatch and subsequent discarding of unmarketable or otherwise illegal (e.g., undersized) species occurs frequently. In addition, trip limits, a management tool used to regulate catch, often forces otherwise market-worthy fish to be discarded. Managers have mitigated this somewhat by increasing the allowable mesh size in the trawl gear, reducing the catch of smaller-sized fishes; however, the minimum size for cod has increased in recent years (22 in.in 2002 vs. 19 in. in previous years; NEFSC 2004), which could potentially result in an increase in the number of discards.

In addition to fish bycatch, there have also been a small number of observed interactions with marine mammals and sea turtles in the Northeastern trawl fisheries. In 2003, Fishery Observers on 590 trawling (bottom/otter trawl) trips recorded a total of 21 interactions with marine mammals, and 4 interactions with sea turtles (NMFS 2004a). According to the Multispecies Groundfish FMP, trawlers are required to report all discards via logbooks and use bycatch reduction devices (BRDs) such as the Nordmore grate and mesh panels (NOAA 2002). Observer coverage is only about 5%, however, and numbers of total discards may be underestimated.

An important exception is hook and line fishing gear which is thought to result in minimal bycatch.

Nature of Bycatch Rank:



Criterion 4: Effect of Fishing Practices on Habitats and Ecosystems

Habitat Effects

In both the U.S. and Canada, most cod are captured with various types of demersal trawl gear (mainly otter trawls; Figs. 7 & 8) tailored to the habitats of target species or species assemblages. Trawling impacts sea-floor communities by scraping the ocean bottom causing: 1) sediment re-suspension (turbidity) and smoothing; 2) removal and/or damage to non-target species; and 3) destruction of three-dimensional habitat (biotic and abiotic; Auster and Langton 1999). 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. Although studied to a lesser extent than otter trawls, mid-water trawls may also reduce available habitat by disturbing aggregations of gelatinous zooplankton and other floating matter, which has been shown to provide pelagic habitat for fish aggregations (Auster *et al.* 1992; Brodeur in press *in* NEFMC 1998).

Several studies on the effects of bottom trawling have focused on the heavily trawled fishing grounds in the Northwest Atlantic (Collie et al. 1997; Collie et al. 2000). Prena et al. (1999), for example, conducted an experimental trawl study on the Grand Banks off Newfoundland and reported that "otter trawling on a sandy bottom ecosystem can produce detectable changes on both benthic habitat and communities, in particular a significant reduction in the biomass of large epibenthic fauna." At a workshop to assess the effects of fishing gear on marine habitats off the Northeastern U.S., experts concluded that the "greatest impacts from otter trawls occur in low and high energy gravel habitats and in hard clay outcroppings" (NOAA 2002; p 24). Based on the results of this and other studies, it is apparent that otter/bottom trawling may alter the surrounding ecosystem, as well as reduce survival of the target species, by reducing or altering available habitat and food resources.

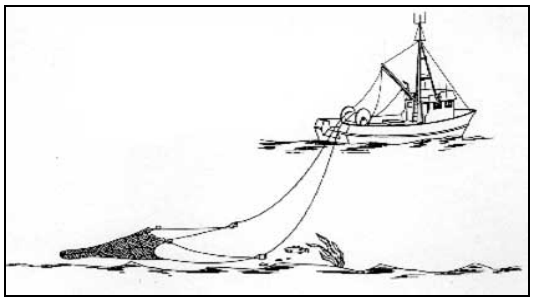


Figure 7. General diagram of an otter trawl, courtesy Matt Squillante, Monterey Bay Aquarium.

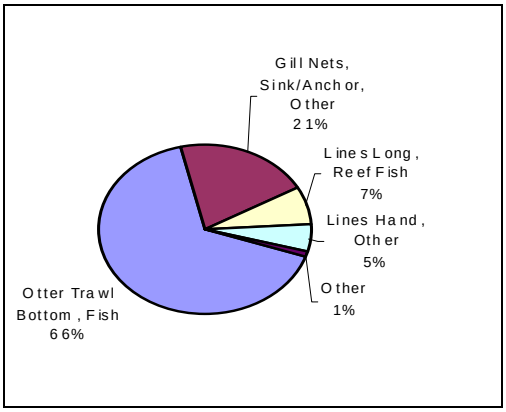


Figure 8. U.S. commercial cod landings by major gear type (NMFS 2004c)

Bottom trawl disturbance of the seabed 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 trawls vs. scallop dredge) and some sediment types (and their associated ecosystems) are more resilient to disturbances caused by trawling. In a review of fishing effects, Collie et al. (2000) found that fauna associated with sandy (coarser) sediments were less affected by disturbance than those in soft, muddy (biogenic) sediments. Recovery rate appears to be slower in muddy and structurally complex habitats, while mobile sandy sediment communities can withstand 2-3 trawl passes per year without significant (adverse) change (Collie et al. 2000). The bathymetry of the Atlantic Continental Shelf, and habitat preferences of cod (pebble/gravel; Fahay 1999), is such that groundfish trawlers targeting cod (or other groundfish) off the U.S. East Coast encounter both types of substrate (see Appendix I). Otter trawling has been ranked as causing less disturbance to the sea floor than other types of trawling, such as inter-tidal and scallop dredging (Collie et al. 2000; NOAA 2002), but it is probable that repetitive trawling in these areas causes significant, and likely adverse change to seabed ecosystems along the U.S. East Coast.

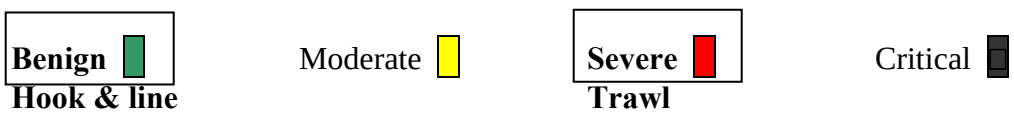
Ecosystem Effects

The fishing grounds of the Gulf of Maine, Georges Bank, and the continental shelf off New England represent one of the most productive oceanic ecosystems in the world. Tidal cycles and strong current flows lead to an extremely productive clockwise gyre in which a diverse array of life flourishes. Analyses of food web structure show that this area is rich in species diversity and abundance, and has a high degree of complexity and connectivity (Brodziak and Link 2002). Consequently, heavy fishing pressure over the last few centuries has resulted in a notable shift from a largely benthic fish community towards a largely pelagic fish community (Fogarty and Murawski 1998; Brodziak and Link 2002). It is extremely difficult to quantify the effects of this shift, but certain outcomes have been postulated, such as changes in predator-prey interactions and species survival rates, and decreases in overall productivity and perturbation of food web dynamics (Brodziak and Link 2002). One example is the increased predation on groundfish larvae by small pelagic species such as mackerel and herring, and a shift in the dominant fish predator from cod to spiny dogfish during the 1980s (Brodziak and Link 2002). In addition to fishing impacts, natural and anthropogenic environmental impacts (e.g., temperature shifts) may also be resulting in changes to the ecosystem. Separating the effects of fishing and the effects of environmental changes may be close to impossible.

Synthesis

Based on the published literature noting the adverse effects of trawling on the various habitat types where cod are found, as well as the substantial amount of fishing effort along the continental shelf over the last 50 years, it is reasonable to conclude that trawling for groundfish (including cod) has substantially altered a large portion of the seabed and the ecosystem. The degree of recovery from these actions is largely unknown and the effect of these fishing practices on habitats and ecosystems is therefore ranked “Severe”. One exception is cod caught by hook and line, a gear type which does not impact habitat.

Effect of Fishing Practices Rank:



Criterion 5: Effectiveness of the Management Regime

The U.S. Atlantic Groundfish Fishery was largely unregulated until the 1950s, when the newly-formed (1949) International Commission for Northwest Atlantic Fisheries (ICNAF) began to set certain restrictions in response to concerns about wasteful bycatch and declines in groundfish abundance (Fogarty and Murawski 1998). ICNAF managers used a harvest strategy involving trip limits or total allowable catch (TAC) and annual quotas, but these regulations were largely disregarded by fishermen and landings were consistently higher than target levels. Fishery-independent surveys were implemented in 1963, and the first formal stock assessments of cod were conducted in 1971 (NRC 1998). In 1977, the New England Fishery Management Council (NEFMC) gained control over the fishery (as mandated by the Magnuson Fisheries Conservation and Management (MFCM) Act, passed in 1976). In 1982 the NEFMC implemented the Multispecies Groundfish FMP, which contained a suite of indirect effort control measures such as minimum mesh size and fish size restrictions, and seasonal area closures (NRC 1998). Despite these attempts at regulating the fishery, exploitation rates could not be sustained, and populations declined severely in the late 1980s and early 1990s. In response to stock collapse, more restrictive measures were put into place, severely affecting coastal fishing communities. In 1994, a moratorium on groundfish fishing (all mobile gears) was implemented for a large area of Georges Bank and Southern New England (Fogarty and Murawski 1998).

In May 2000, the Conservation Law Foundation (CLF) filed a lawsuit against the National Marine Fisheries Service (NMFS) charging that approved groundfish catch levels were too high and thus violated federal law by risking further depletion of New England groundfish populations. In December 2001, a federal district court judge upheld CLF's allegations that NMFS did not act to prevent overfishing and decrease bycatch in the New England groundfish fishery. The court found that NMFS was violating the federal Sustainable Fisheries Act of 1996 by failing to obey its own regulation that mandates rebuilding fish populations and prohibits the continued overfishing of cod and other groundfish off the coast of New England[3].

In response to a 2002 court order, the New England Fishery Management Council updated its groundfish management plan, which was implemented in May 2004. This new amendment (Amendment 13) further restricts fishing effort through days-at-sea (DAS) allocations, gear modifications, and adjusted biological reference points (Table 3). A further management measure, Framework 40A, is an attempt to provide additional fishing opportunities to target healthier stocks with minimal impact to other depleted species or their habitat (NEFMC 2004). One such fishery is for longline-caught haddock in an area previously closed to protect depleted cod and haddock stocks. An experimental hook-and-line fishery operating in the fall of 2003 and winter 2004 (using alternative bait such as herring, a fabricated bait) was shown to result in minimal bycatch of cod[4].

Managers assess stock abundance of groundfish species at regular intervals, analyzing both fishery-dependent (catch records, effort, etc.) and fishery-independent (NMFS trawl surveys,

[3] Taken from: http://www.clf.org/advocacy/fisheries_lawsuit.htm

[4] Paul Parker. 2004. Personal commun. Executive Director. Cape Cod Commercial Hook Fishermen's Association. 210 Orleans Road, North Chatham, MA 02650.

tagging studies, etc.) data. Age-based data are available for the most commercially important species, and is used to model stock structure, recruitment capability, and overall biomass.

Table 3: Summary of management regulations for Atlantic cod.

Jurisdiction and Agencies	TAC	Size Limits*	Trip Limits*	Gear Restrictions*	Closed Seasons/Areas
NMFS/ NEFSC/ NERO (NOAA Northeast Fisheries Office)	Yes (in-season adjustable)	22 inches (56 cm)	GOM: 800 lbs (362.9 kg)/24-hr (DAS) period or maximum of 4,000 lbs (1,818.2 kg) per trip; GB: 1,000 lbs (453.6 kg)/DAS or max. of 10,000 lbs per trip	Yes, 6-inch (15.2-cm) diamond mesh or 6.5-inch (16.5-cm) square mesh	Yes, see Fig. 9

* 50 CFR Part 648 as of May 7, 2004 (http://www.nero.noaa.gov/nero/regs/index.html)

Before 1994, information on U.S. cod catches was obtained by landings reports submitted voluntarily by cod processors and dealers. Port agents conducted interviews with a sampling of fishing captains to determine fishing location and effort (O'Brien 1997). In 1994, when groundfish moratoriums were implemented, the National Marine Fisheries Service (NMFS) instituted a mandatory reporting system. Logbooks were required of all fishing vessels and dealer reports of all dealers (O'Brien 1997). Landings, catch-and-effort data, and catch locations are now obtained from these sources and compiled into a NMFS database (O'Brien 2001).

By law (Magnuson-Stevens Fishery Conservation and Management Act/Sustainable Fisheries Act; MSFCMA/SFA 1996), the Fisheries Councils are required to prevent, mitigate, or minimize any adverse effect from fishing, to the extent practicable, if there is evidence that a fishing practice is having an identifiable adverse effect on Essential Fish Habitat (EFH; NEFMC 1998). To conform to this requirement, the NEFMC has closed certain areas to fishing entirely (Fig. 9) and limited fishing effort to a certain number of DAS per year in other areas for each groundfish permit holder. The system of closed areas on Georges Bank protects approximately 6,500 square nautical miles year-round by completely closing this area to fishing. In the Gulf of Maine, approximately 13,000 square nautical miles of habitat are protected during temporary closures, and an additional 1,200 square nautical miles are closed year-round (NEFMC 1998). In addition to these measures, NEFMC, through Amendment 9 to the Groundfish FMP, prohibited the use of "street-sweeper" trawl gear (whose entire footrope length is in contact with the bottom) which is thought to be so efficient as to nullify DAS protections (NEFMC 1998). Amendment 13 has also implemented a trawl rope diameter (including rockhopper gear) of no more than 12 inches.

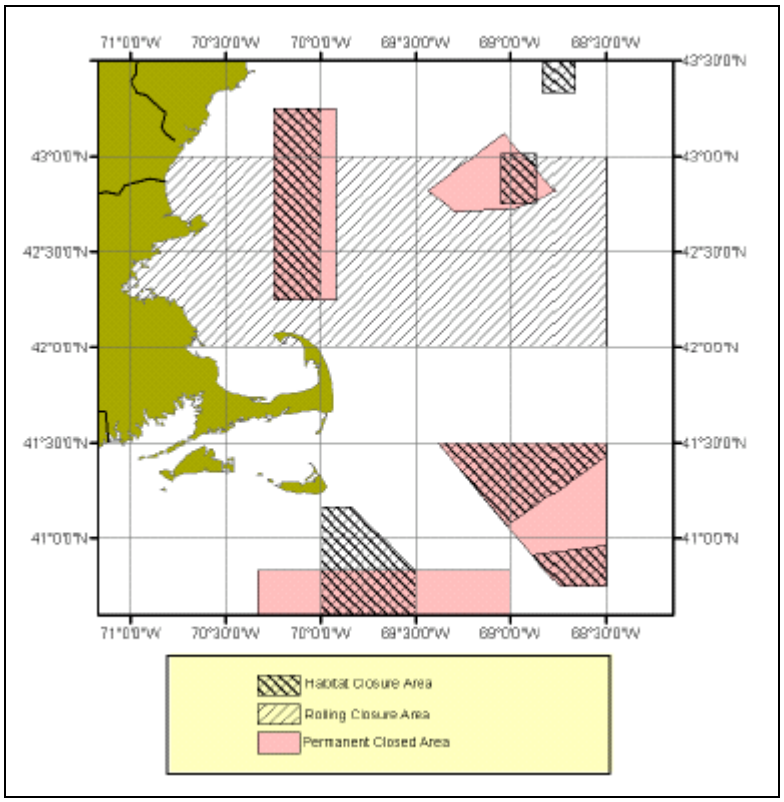


Figure 9. Rolling and permanent closed areas for the Northeast Multispecies Fishery (NOAA 2004).

Canadian Management

Canada's Department of Fisheries and Oceans (DFO) manages the eight cod stocks within Canada's territorial waters, and cooperates with the United States National Marine Fisheries Service (NMFS) to manage the transboundary Georges Bank stock. Staff at DFO through the Pacific Scientific Advice Review Committee (PSARC) routinely conducts stock assessments. Canada's groundfish are managed through an individual transferable quota (ITQ) system, and the DFO has introduced the Dockside Monitoring Program (DMP) to verify and report landings on a timely basis (DFO 2001). Fishermen's organizations are now required to contract, at their own expense, independent monitoring companies situated throughout the Scotia-Fundy Sector to carry out dockside monitoring, as required by DFO (DFO 2002c). Other management measures include: a prohibition on discarding undersize target species; gear restrictions; seasonal closures; and no-fishing zones to protect habitat (DFO 2002b). Canada's Coast Guard monitors fishing vessels. Stocks outside Canada's 200-mile EEZ fall under the jurisdiction of the Northwest Atlantic Fisheries Organization (NAFO), an international body created by treaty between several fishing nations.

Synthesis

Managers (U.S. and Canadian) of Northeastern Groundfish resources assess stocks on a timely basis (annually or semi-annually) and use both fishery dependent and independent data to determine stock status and fishing mortality, which they evaluate against biological reference points. Managers require specific mesh sizes and gear types to reduce discard, and implement seasonal and permanent closure areas to mitigate trawling impacts. Management has not,

however, prevented the extreme decline of cod stocks and until full recovery is realized is therefore considered moderately effective.

Effectiveness of Management Rank:

Highly Effective  **Moderately Effective**  Ineffective  Critical 

Overall Evaluation and Seafood Recommendation

Atlantic cod is a quickly maturing species with a relatively short (~ 20 year) lifespan. Both the Gulf of Maine and Georges Bank stocks are considered overfished, and overfishing is occurring. This species' stock status is a critical conservation concern.

The primary fishing method for Atlantic cod, trawling, results in significant disturbance to the sea floor, impacting marine habitats that are important to the survival of groundfishes and other species. Trawling is also indiscriminate, and along with targeted species takes unmarketable, illegal, or undersized species that are fatally discarded, adding to the overall fishing mortality of many groundfish species. A very small portion of Cod is landed with hook and line gear, a method that has no impacts on benthic habitats and has very low bycatch rates. Groundfish managers have attempted to mitigate both habitat effects and bycatch from trawling operations by closing over 25,000 square nautical miles of ecologically sensitive habitat to trawling, increasing mesh size of trawl gear, and including discard estimates in fishing mortality analyses. In addition, managers actively study stock abundance and have implemented several regulations over the years in an attempt to maintain stock productivity. The management regime, however, has not prevented substantial and ongoing declines of cod stocks. The critical status of the stock combined with the severe impacts of trawl gear result in a seafood recommendation of **Avoid** for Atlantic cod caught in U.S. and Canadian waters.

Table of Sustainability Ranks

	Conservation Concern			
Sustainability Criteria	**Low**	**Moderate**	**High**	**Critical**
Inherent Vulnerability	√			
Status of Stocks			√ **Canada**	√ **U.S.**
Nature of Bycatch	√ **Hook and line**	√ **Trawl**		
Habitat & Ecosystem Effects	√ **Hook and line**		√ **Trawl**	
Management Effectiveness		√		

Overall Seafood Recommendation:

Best Choice ■ Good Alternative ■ **Avoid** ■

Acknowledgements

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Scientific review does not constitute an endorsement of the Seafood Watch® program on the part of the reviewing scientists or its seafood recommendations. Seafood Watch® is solely responsible for the conclusions reached in this report and the ensuing seafood recommendations.

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Appendix I. Geomorphology of the New England fishing grounds. From (NEFSC 1998).

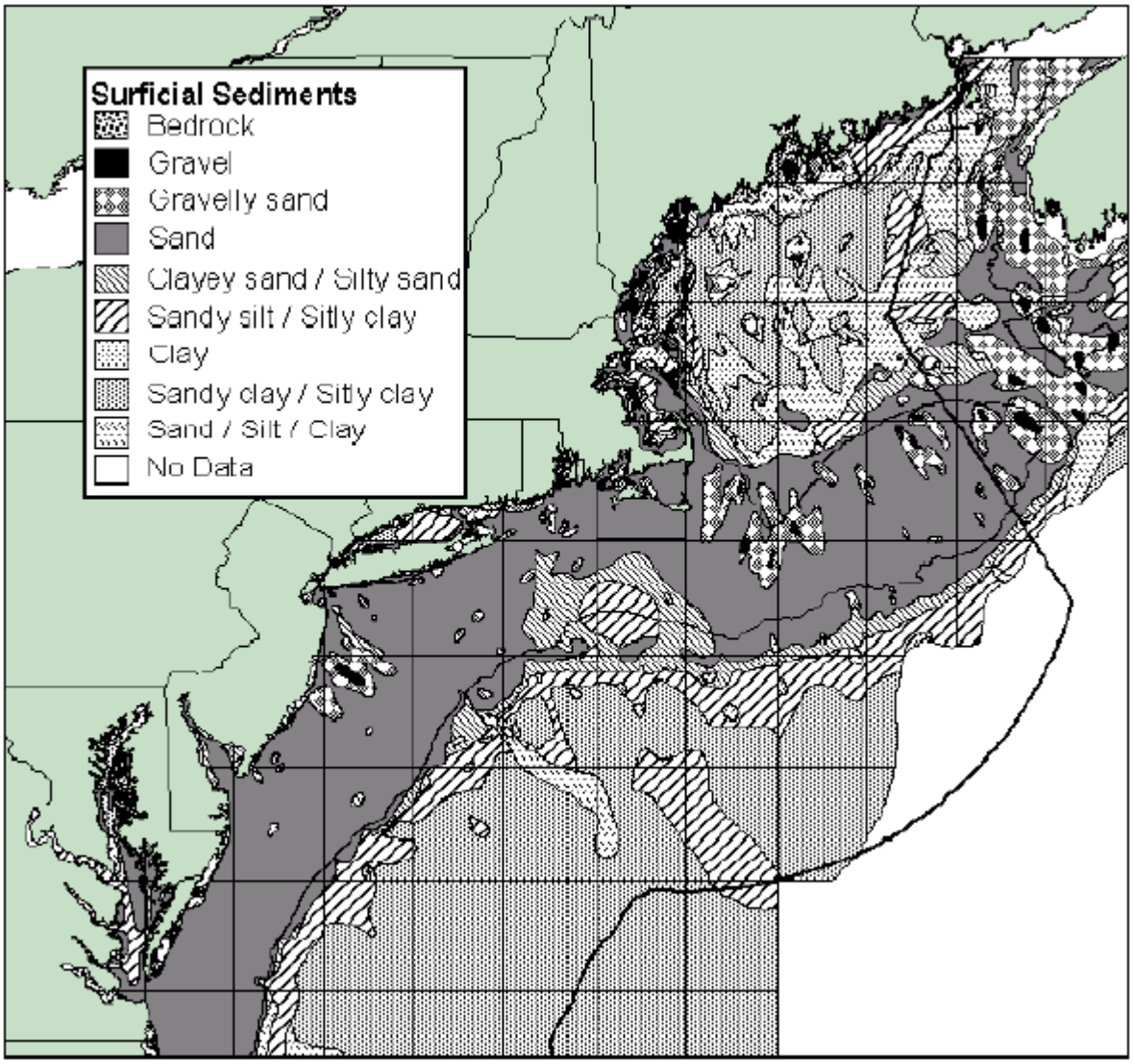

Figure A1. Map showing distribution of sediments in the Gulf of Maine, Georges Bank, and Southern New England.